



# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)

(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)

PALLAVARAM - CHENNAI

ACCREDITED BY NAAC WITH 'A' GRADE

INSTITUTION WITH UGC 12B STATUS

Marching Beyond 30 Years Successfully

### 3.5.2 REVENUE GENERATED FROM ADVISORY / R&D CONSULTANCY PROJECTS (EXCLUDE PATIENTS CONSULTANCY) INCLUDING CLINICAL TRIALS DURING THIS ACADEMIC YEAR

2023 -2024

#### List of Consultants and details of revenue generated by them

S.No	Name of the Consultant	Name of Consultancy Project	Consulting / Sponsoring agency with contact details	Year	Revenue Generated (INR in Lakhs)
1	Mrs. A. Josephin Arockia Dhiyva	Design and Construction of Artificial Thumb Prosthetics controlled by EMG Signal	Bio Vision Medical Systems, 103/45, First Floor, St. Mary's Road, Abhiramapuram, Chennai	2023-2024	5.50
2	Dr. N. Shanmugasundaram	Compact Design of DC-DC Power convert for Autonomous Underwater Vehicle (AUV)	Interlogix Embedded Solutions, No. 33, East Coast Road, Chinnakalpet, Pondichery, Tamil Nau.	2023-2024	2.29
3	Dr. R. A. Kalaivani	Analytical Studies of Phytoconstituents of Biosoot Aromatic Plants	Marina Labs, 14 Kavya Gardens, N. T. Patel Road, Nerkundram, Chennai	2023-2024	6.32
4	Dr. R. A. Kalaivani	Industrial Waste Water Treatment	Evergreen Technologies, No.5/1, Pillaiyar Kovil, Essa Pallavaram, Chennai.	2023-2024	6.20
5	Dr. G. Abirami	Analysis of heavy metal in Industrial effluents	Chromo Life Sciences Private Limited Plot No. 28 & 29, Flat No. 301 Miyapur Village, Serilingampally Mandal, Hyderabad, Telangana	2023-2024	2.70
6	Dr. K Ashok Kumar	Microbial load an analysis in soil sample	Realgae Biopharma Solutions, Kagithapuram, 3rd Cross Street, S. Kolathur, Chennai	2023-2024	3.25

**Campus :** Velan Nagar, P.V. Vaithiyalingam Road, Pallavaram, Chennai - 600 117. INDIA.

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**Email :** vels@vistas.ac.in **Website :** www.vistas.ac.in

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7	Dr. C. Gnanavel	Effect of Surface Roughness on Coating Strength	Esperer Engineering Services, 25/11, First Cross Street, New Colony, Chrompet, Chennai	2023-2024	3.00
8	Dr. M. Parthasarathy	Exploring the enhancement of mineral and mining techniques	Roboties Geoworld Consultancy (RGWC), Radial Ring Road, Pallavaram, Chennai.	2023-2024	3.25
9	Dr. R. J. Hemalatha	3D Printed hand Splint with Ultrasound Transducer for Bone healing	AMS Solution Inc, 49/50, Samuvel Nagar, Vadaperumbakkam, Chennai	2023-2024	5.50
10	Dr. S. Vijayananth	Design of waste Plastic Vapour Run Engine	Yaso Enterprise, 191, Ottiyambakkam Main Road, Sithalapakkam, Sholinganallur Taluk, Tamil Nadu	2023-2024	3.00
11	Dr. B. Rubini	Methodology for DC-DC Battery Management System for Solar PV Modules	Global Association for Green Energy Technological Skills (GAGETS), 168 A, 15th Street, Shankar Nagar, Pammal, Chennai	2023-2024	2.11
12	Dr. P. R. Ramakrishnan	Market Survey for Business Development	INR Technologies, 18/6, Veerapandi Nagar, First Street, Choolaimedu, Chennai.	2023-2024	6.25
13	Dr. P. Balaji	Complement system Alternate pathway stimulant activity: A Potential anti-infective agents	Aaranya BioSciences Private Limited Plot.17, Golden Jubilee Biotech Park for Women Society, Siruseri Village, Kanchipuram District, Tamil Nadu	2023-2024	6.25
14	Dr. G. Gayathri	Bio film Formation in Paneer	InLead Management Service, 93/26, Kalaignar Street, Indra Nagar, Pattur, Chennai	2023-2024	2.50

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15	Dr. D. Rohini	Invitro and Insilico studies of biosynthesis silver nanoparticles using bryonia plant extract against rheumatoid arthritis	Aaranya BioSciences Private Limited Plot.17, Golden Jubilee Biotech Park for Women Society, Siruseri Village, Kanchipuram District, Tamil Nadu	2023-2024	2.00
16	Dr. M. Kotteeswaran	5S Systems Implantation Process	Cholamandalam Investment and Finance Company Limited, ASV Adarsh Tower, 719, Pathari Road, Anna Salai, Chennai	2023-2024	5.25
17	Dr. B. Rubini & Dr. S. Pradeep Kumar	Automated and Self Powered Solar Panel Cleaning Robot	Global Association for Green Energy Technological Skills (GAGETS), 168 A, 15th Street, Shankar Nagar, Pammal, Chennai	2023-2024	0.23
18	Dr. K. Sankar Singh	Identification of market Potential for Business Development	JS Logitics Pvt Limited, Lakshmaiya Tallari Prasath. Door No.37, 1st Floor, Office No.2, Moore Street, Chennai	2023-2024	6.00
19	Dr. C. Ronald Darwin	Evaluation of Neuro protective activity of plant extracts and Nano Formulations containing isolated compounds	Aaranya BioSciences Private Limited Plot.17, Golden Jubilee Biotech Park for Women Society, Siruseri Village, Kanchipuram District, Tamil Nadu	2023-2024	6.25
<b>Total Revenue Generated (INR in Lakhs)</b>					<b>77.85</b>

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**AMS Solutions Inc.**



Admin. Office : No. 49/50, Samuvel Nagar, Vadaperumbakkam, Chennai - 600 060.  
Tel. : +91-95661 45898 E-mail : sales@amssolutionsinc.com

Date:27-07-2023

To

The Registrar,  
Vels Institute of Science Technology and Advanced Studies  
Pallavaram,  
Chennai-600 117.


Respected Sir,

Sub - Acceptance for consultancy funded project for Biomedical Engineering  
Department 2023-2024

With reference to the proposal mail dated 04-01-2023 from Department of Biomedical Engineering, we would like to inform you that the proposal submitted was accepted for Consultancy funding of research with your VISTAS/Biomedical Engineering. We wish to begin our work for **Design and construction of Artificial Thumb prosthetics controlled by EMG Signals** with Mrs.A.Josephin Arockia Dhivya, Department of Biomedical Engineering for the sanctioned amount Rs 5.5 Lakhs. On the fair completion of the project, a detailed report on the developed product has to be provided by the host institution. The following extramural funding for research is for the period of one year.We would like to express our best wishes for the successful completion of the project adhering to the given duration.

Thanking You

Yours Sincerely,  
For AMS Solutions Inc

  
M Jaheer Hussain  
CEO – Technical





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Date : 03-08-2023

To  
Mr.Jaheer Hussain.M  
CEO  
Vadaperumbakkam,  
Chennai - 600 060.

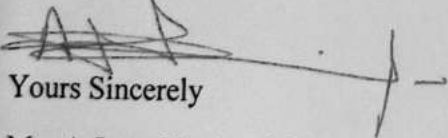
Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the Industry.

Thanking you,

  
Yours Sincerely

Mrs.A.Josephin Arockia Dhivya

Assistant Professor,

Department of Biomedical Engineering

VISTAS

# **DESIGN AND CONSTRUCTION OF ARTIFICIAL THUMB PROSTHETICS CONTROLLED BY EMG SIGNALS**

**Principal Investigator**

**Ms. A. Josephin Arockia Dhivya,  
Assistant Professor, Department of Biomedical Engineering.  
Vels Institute of Science, Technology and Advanced Studies, Chennai**

**Beneficiary of the Consultant Work**

**AMS SOLUTIONS INC**

**NO.49/50, Samuel Nagar,**

**Vadaperumbakkam,**

**Chennai - 600 060.**

**Abstract:** This study presents the design and construction of thumb amputation or dysfunction a natural and functional replacement. The proposed design incorporates a sophisticated control mechanism that interprets the EMG signals and translates them into corresponding thumb movements. A combination of 3D printing and bioengineered materials is employed to fabricate the prosthetic, ensuring a lightweight and customizable solution. Preliminary tests with amputee subjects demonstrate promising results, indicating improved dexterity and usability. The artificial thumb prosthesis offers a novel approach to enhance the quality of life for individuals with thumb-related impairments advancement in prosthetic technology is led to the development.

**Keywords:** EMG sensor, servo motor, prosthetic thumb, micro controller, sensor module kit

## I. INTRODUCTION

In recent years, the intersection of biomedical engineering and robotics has led to remarkable advancements in the field of prosthetics. The loss or impairment of a thumb can significantly impact a person's ability to perform everyday tasks, leading to challenges in independence, productivity, and quality of life. In response to this problem, the present project aims to design and construct an artificial thumb prosthetic that can be controlled by the EMG signals. This innovative solution seeks to restore hand functionality and empower individuals who have experienced thumb loss due to injury, amputation, or congenital conditions.

The artificial thumb prosthetic will be a technologically advanced device that mimics the movement and functionality of a natural thumb. This biofeedback-based approach ensures a more intuitive and natural control over the prosthetic, making it an extension of the user's hand. Beyond the technical aspects, the project aims to prioritize user comfort, safety, and adaptability. The prosthetic will be designed with the user's needs in mind, providing customization options to fit individual hand sizes and functional requirements. Additionally, safety features will be incorporated to prevent any unintended movements or harm to the user. An innovative artificial thumb prosthesis that utilizes the EMG signals for control. The prosthesis aims to provide individuals with An EMG-based prosthetic bio-thumb represents a remarkable fusion of advanced technology and biomedical science, offering the potential to revolutionize the field of prosthetics. This cutting-edge innovation integrates real time EMG sensor module kit with 3D printing technology to create a highly functional and adaptive solution for individuals with limb loss. In this introduction, we will explore the key components, benefits, and implications of an EMG-based prosthetic bio-thumb

**Restoration of Functionality:** The thumb plays a crucial role in hand dexterity and is essential for performing numerous everyday tasks, such as grasping objects, writing, and manipulating tools. By creating an artificial thumb, individuals with thumb loss or impairment can regain a level of functionality and independence that may have been otherwise difficult or impossible to achieve.

**Improved Quality of Life:** Losing a thumb can be emotionally and psychologically challenging. It affects a person's ability to participate in activities they previously enjoyed, impacting their self-esteem and mental well-being. Providing a functional and aesthetically pleasing prosthetic can greatly improve their quality of life and overall happiness.

**Customization and Personalization:** Design the prosthetic with the ability to be customized and tailored to each individual user's specific needs, hand size, and functional requirements.

**Control and Responsiveness:** Implement a control system that accurately interprets the movements and muscle contractions of the index finger, translating them into precise and responsive movements of the artificial thumb.

**Enhanced Mobility and Productivity:** An effective artificial thumb allows users to perform tasks that were previously challenging or impossible, enabling them to lead more productive and fulfilling lives. This newfound mobility can also lead to increased opportunities for education, employment, and social engagement

### Problem Background

A person without thumbs faces unique challenges in their daily life, as thumbs are fundamental tools for most of our activities. The absence of thumbs can be due to congenital conditions, accidents, or illnesses, and it requires individuals to adapt to their circumstances in creative and innovative ways.

One of the primary challenges faced by individuals without thumbs is the loss of dexterity and fine motor skills. Thumbs allow us to grasp, manipulate, and interact with the world around us. Without them, simple tasks such as eating, dressing, and writing become considerably more difficult. Individuals must rely on alternative methods or adaptive devices to perform these activities. For example, they may use prosthetic limbs, special utensils, and adaptive technology to regain some of their lost abilities. Another significant challenge is the potential impact on an individual's self-esteem and mental well-being. Society often places a high value on physical appearance and abilities, and those without thumbs may experience discrimination, stereotyping, or even social isolation. This can lead to feelings of inadequacy, depression, and anxiety. Coping with these emotional challenges is an important aspect of the journey for individuals without thumbs.

Education and employment opportunities can also be affected by the absence of thumbs. The traditional educational and work environments may not always be accessible to individuals with this condition. However, advancements in assistive technology and the growing awareness of diversity and inclusion have improved access to education and employment for people with disabilities. Many individuals without thumbs have successfully pursued careers in various fields, proving that determination and adaptability can overcome physical limitations. Additionally, personal relationships and social interactions can be impacted. People may be curious, well-intentioned, or unintentionally insensitive when interacting with someone without thumbs. It's crucial for both the individual and society to foster understanding, respect, and empathy to create a more inclusive and accepting environment.

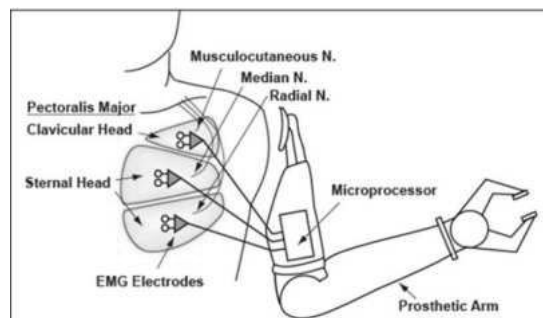


Figure 1.1

**Figure 1.1** Person with EMG Sensor and Prosthetic Bio Arm



Furthermore, individuals without thumbs may encounter challenges related to healthcare and medical expenses. Prosthetic limbs, rehabilitation, and other specialized treatments can be expensive, and access to quality healthcare can vary based on geographical location and economic factors. This highlights the importance of healthcare accessibility and support systems for individuals with disabilities. Despite the numerous challenges, people without thumbs often demonstrate remarkable resilience and adaptability. They learn to use their feet, mouths, or other body parts for tasks that would typically require thumbs. They engage in sports and hobbies, and they pursue their passions with determination. Many have become advocates for disability rights, promoting inclusivity and raising awareness about the capabilities of individuals with disabilities. In conclusion, individuals without thumbs face a wide range of physical, emotional, and societal challenges. However, with determination, adaptability, and support from society, they can overcome these challenges and lead fulfilling lives. It is essential for us as a society to promote inclusivity, accessibility, and understanding to ensure that individuals without thumbs, and those with other disabilities, can participate fully in all aspects of life.

## **II. Methodology**

### **A. EMG Signal Acquisition**

The first step in the proposed work is to develop a robust EMG signal acquisition system. This system will consist of surface electrodes that adhere to the skin above the residual muscles of the user's limb. The electrodes will capture EMG signals generated during muscle contractions and transmit this data to a microcontroller or a computer for processing.

#### **Prosthetic Thumb Prototype**

A functional prosthetic thumb prototype will be developed, integrating the Arduino and microcontroller for EMG signal decoding. The prosthetic thumb will be designed to replicate the natural movements of a human thumb, offering a wide range of motion, including wrist rotation, elbow flexion/extension, and finger dexterity. The prototype will be lightweight, durable, and customizable to fit the user's

#### **User Trials and Refinement**

A critical phase of the project involves user trials. Amputee volunteers will be recruited to test the EMG-controlled prosthetic thumb in real-world scenarios. These trials will allow us to collect feedback on the system's performance, comfort, and usability. Any issues or limitations identified during the trials will be addressed in the refinement phase.

### **B. Expected Outcomes**

The proposed work holds significant potential for improving the quality of life of individuals with upper limb amputations. An EMG-controlled prosthetic thumb that seamlessly integrates will offer several advantages: Users will be able to control the prosthetic thumb with greater ease and precision, making it feel like an extension of their own hand. The Arduino model can enable a wide range of motions and actions, including fine motor skills, thereby improving the user's ability to perform daily tasks. The non-invasive EMG signal acquisition system and lightweight prosthetic thumb design will enhance user comfort during extended wear. The system can be customized to match the specific needs and preferences of each user, ensuring a tailored and satisfying experience. With better prosthetic control, users will regain a level of independence and autonomy that was previously challenging to achieve. While the proposed work is promising, it also presents several challenges that need to be addressed: **EMG Signal Variability:** EMG signals can vary significantly between individuals and even within the same individual over time. This variability must be accommodated by the deep learning model. **Real-time Processing:** Achieving low latency in the EMG signal decoding process is crucial for natural prosthetic arm control. Optimization of the deep learning model is required. **User Adaptation:** It may take time for users to adapt to the new prosthetic control paradigm. User training and support will be essential. **Safety and Reliability:** Ensuring the safety and reliability of the prosthetic arm is of paramount importance to prevent accidents and injuries.

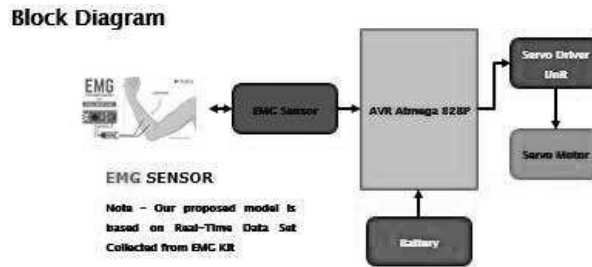


Figure 1.2

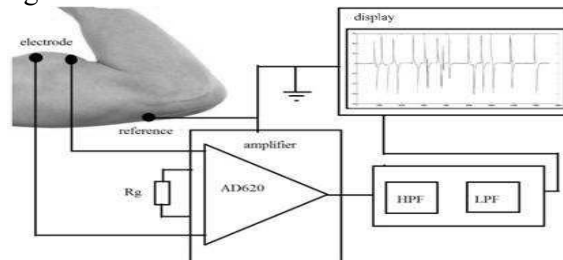
## 1.2. Block diagram

### COMPONENTS REQUIRED

1. ELECTRODE PADS
2. EMG MUSCLE SENSOR
3. ARDUINO
4. SERVOMOTOR

### III. EMG Signal Acquisition

The acquisition of EMG signals from the muscles involves standards and protocols for electrode placement, signal processing, and data transmission. The most commonly used standards for electrode placement are those outlined by the International Society of Electrophysiology and Kinesiology (ISEK). Signal processing methods can follow standard practices for filtering, amplification, and digitization



## 1.3 EMG signal acquisition

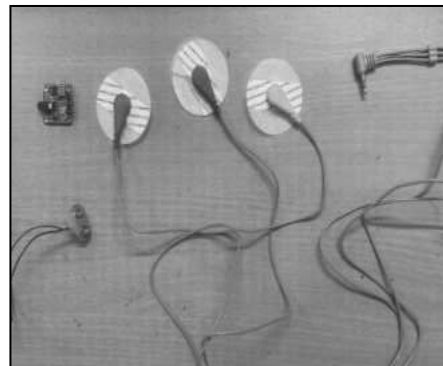


Figure 1.4 Electrode pads

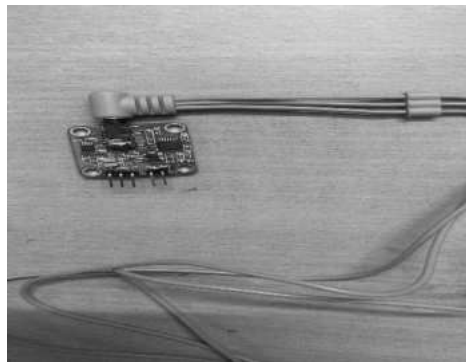
### Electrode Pads

Gel electrodes are used with muscle sensor v3 to capture data. The electrode is replaced when to record for another subjects, to get the higher quality EMG signal, maintain cleanliness, and prevent the spreading

of infectious diseases. This electrode has three colors, red, green and yellow —the red electrode is (ground), the yellow electrode (reference) and the green color electrode is (the EMG signal )

### **MUSCLE SENSOR**

The Muscle Sensor that is used to record electrical potentials produced by contracting muscles. This sensor process the raw signal when records because its sequence is constructed of an instrumentation amplifier, rectifier, analog filter circuits, and an end amplifier circuit . After recording the signal, the sensor amplifies and processes the complex electrical activity of a muscle before converting it to a simple analog signal that is easily read by a microcontroller Arduino) to convert it into a digital signal



### **1.5 Components and hardware prototype**

#### **Arduino UNO**

Arduino UNO with ATmega328P-based microcontroller board. It contains 14 input/output digital pins (of which six can be used as PWM outputs). Arduino UNO is used to convert analog to digital output due to the signal produced by muscle sensor v3. Muscle sensor output was interfaced with an Arduino UNO microcontroller to record the signal on a laptop operating in battery mode for signal processing and classification .



Figure 1.6 Arduino UNO

#### **SERVO MOTOR**

A servo, short for servomechanism, is a type of device used for precision control of angular or linear position, velocity, and acceleration. It usually consists of a motor coupled to a sensor for position feedback, which is then controlled by a servo controller.

The servo system is a closed-loop control system where the controller uses the feedback signal to accurately control the position or speed of the motor. This is accomplished by comparing the desired

position or speed (the command signal) with the actual position or speed (the feedback signal), and then adjusting the motor's operation to reduce the difference (the error signal).



Figure 1.7

#### IV. RESULT AND CONCLUSION:

It's worth noting that prosthetic technology continues to advance, leading to increasingly sophisticated and functional prosthetic thumbs.

These advancements aim to improve the overall quality of life for individuals who have lost their natural thumb and provide them with opportunities to participate in various aspects of life more fully

Our proposed model will surely bring a novel changed for the people who suffer to continue their routine ADLs activity

The foundation of EMG-based prosthetic thumb lies in the acquisition and processing of electromyographic signals. These signals are recorded from the residual muscles of the amputated thumb and are used to decode the user's intended movements. Current signal processing techniques have become increasingly sophisticated, allowing for accurate and real-time signal decoding.

##### 1.5. Thumb final model

EMG-based prosthetic thumb, augmented by Arduino and microcontroller, have come a long way in improving the lives of individuals with thumb loss. They offer greater control, enhanced functionality, and a more natural user experience. However, there are still challenges to overcome, such as cost, sensory feedback, and ease of use. The future scope of EMG-based prosthetic thumb is promising, with advancements in signal processing, biomechanical integration, sensory feedback, and cost reduction. These developments have the potential to make prosthetic thumb more accessible and user-friendly, ultimately providing a better quality of life for those who rely on them. As technology continues to advance, the prospects for EMG-based prosthetic thumb will only become more exciting, with the ultimate goal of restoring as much function and autonomy as possible to individuals with loss of thumb.

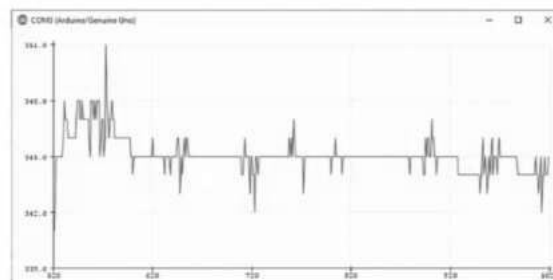


Figure 1.8

The frequency range involved in controlling a prosthetic thumb using an electromyography (EMG) module typically falls within the range of 20 Hz to 500 Hz. These contractions generate electrical signals that can be detected and used to control a prosthetic device. Read the analog signal from the EMG sensor using our controller board via analog pins.

We need to filter, amplify, or preprocess the EMG signal to extract meaningful information, like muscle activity levels or patterns.



Figure 1.9

**Real-time Feedback:** The Arduino Uno can provide real-time feedback to the user, which is essential for refining motor skills and ensuring safety during everyday tasks. Users can receive sensory input through vibrations, sounds, or other feedback mechanisms, enhancing their control over the prosthetic. With this setup, individuals can regain fine motor control and dexterity, enabling them to perform a wide range of once-challenging tasks. The AVR microcontroller processes the EMG signals and translates them into commands to actuate the prosthetic thumb's movements, allowing for natural and intuitive control

*Position of servomotor at 90°*

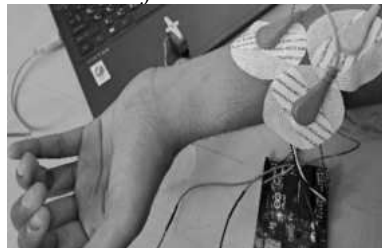


Figure 1.10



Figure 1.11

Implement feedback mechanisms to ensure the servo responds correctly to muscle activity. We may need to calibrate the system to adapt to different users or varying signal strengths.

### *Position of servomotor at 180°*

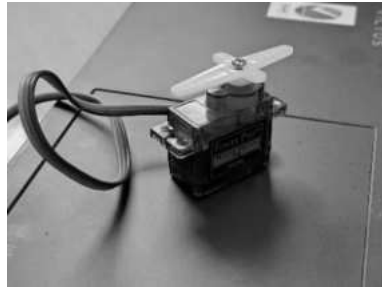
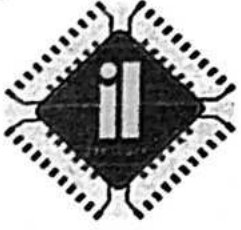


Figure 1.12

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Fax : +91-0413-2265700  
Web : www.interlogicx.com  
Email : admin@interlogicx.com

Nr : 33, East Coast Road, Chinnakalpet, Pondicherry -14. (Opposite to Pondicherry University Main Gate)

Consultancy Sanction order/2023/003

Date: 10-07-2023

To  
Dr.N.Shanmugasundaram,  
Head of the Department,  
Electrical and Electronics Engineering,  
VISTAS.

Dear Sir,

Sub: Requesting Compact Design of DC – DC power converter for Autonomous Underwater Vehicle (AUV) - Reg.

Greetings!

We are involved in Research and Experimental research project in Underwater Vehicle system in the field of Engineering and Technology. In the process of the technology development activity, our company would like to provide a consultancy project entitled "Compact Design of DC – DC power converter for Autonomous Underwater Vehicle (AUV)" to the sum of Rs. 2,28,500 (Including GST) to the Department of Electrical and Electronics Engineering VISTAS. I respectfully request you to kindly do the needful.

Thanking you,

  
K. Anbarasan

Project Lead Engineer





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Date: 14/8/2023

To

K.Anbarasan,  
Project Lead Engineer,  
Interlogicx Embedded Solutions, Pondicherry.

Dear Sir,

Sub: Confirmation for the Consultancy Work – Reg.

Greetings!

I hope this message finds you well. I am pleased to formally accept the consultancy position with Interlogicx Embedded Solutions as discussed in our recent conversations.

Thanking you,

Yours Sincerely,

Dr. N. Shanmugasundram,  
HoD/EEE,  
VISTAS





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## **Compact Design of DC-DC Power Converter for Autonomous Underwater Vehicle**

**Principal Investigator**

**Dr. N. Shanmugasundaram**

**Head/ Electrical & Electronics Engineering, VISTAS**

**Beneficiary of the Consultant Work**

**Interlogicx Embedded Solutions, Pondicherry**

# Compact Design of DC-DC Power Converter for Autonomous Underwater Vehicle

## 1. Introduction

Autonomous Underwater Vehicles (AUVs) are critical for various underwater missions, including oceanographic research, exploration, military operations, and environmental monitoring. These vehicles require reliable and efficient power systems to sustain long-duration operations. A crucial component of their power system is the DC-DC power converter, which ensures that the power from the onboard battery system is regulated and supplied efficiently to various subsystems, such as propulsion, navigation, and communication. The need for compact, lightweight, and efficient DC-DC converters becomes even more critical in the design of AUVs due to the limited space and energy constraints.

This report discusses the design considerations, challenges, and innovations in creating a compact DC-DC power converter for AUV applications, focusing on high efficiency, compact size, and robustness for underwater conditions.

## Design Considerations

**Power Efficiency:** AUVs operate in energy-limited environments, relying on battery systems that need to power the vehicle over extended missions. Therefore, power efficiency is a key factor in the design of the DC-DC converter. The goal is to minimize power losses during voltage conversion and ensure that maximum power from the battery is delivered to the load. High-efficiency topologies such as synchronous buck converters, resonant converters, or multiphase converters are typically used to optimize efficiency.

**Compact Size and Weight:** The compact design of the power converter is essential to minimize the space and weight on board the AUV. Since most AUVs are constrained in size and must accommodate various subsystems, the power converter should have a small form factor without sacrificing performance. This requirement calls for the integration of modern semiconductor technologies like gallium nitride (GaN) and silicon carbide (SiC) MOSFETs, which offer high efficiency and reduced size.

**Wide Input Voltage Range** AUVs are often powered by battery packs that exhibit significant voltage variation depending on the state of charge. The DC-DC converter must be able to handle a wide input voltage range, typically from 18V to 60V, to ensure stable operation throughout the mission. This ensures the AUV can operate efficiently across various battery conditions without compromising power delivery to critical systems.

**Thermal Management** Due to the compact design, efficient thermal management is critical to avoid overheating, which can degrade performance or lead to failure. Passive cooling, heat sinks, or liquid cooling solutions must be incorporated to dissipate heat generated during operation, especially in high-power designs. Since AUVs operate in cold underwater environments, these conditions can be leveraged for natural heat dissipation, but the converter still needs to be designed to ensure optimal heat transfer.

**Environmental Robustness** The DC-DC converter must be designed to withstand harsh underwater conditions, including pressure, humidity, and temperature variations. The converter should be encapsulated in a water-resistant and corrosion-proof enclosure, often IP68 rated, to ensure reliability during deep-sea missions.

## 2. Methodology

### Design Objectives

The proposed DC-DC converter is designed to achieve the following objectives:

- **High Efficiency:** Minimize energy losses to extend battery life and maximize operational time.
- **Compact Form Factor:** Optimize space usage within the underwater vehicle, allowing more room for sensors and payloads.
- **Wide Input Voltage Range:** Accommodate fluctuating battery voltages as they discharge over time.
- **Robustness:** Ensure durability and reliability in extreme underwater environments, including resistance to pressure, corrosion, and thermal stress.
- **Thermal Management:** Implement effective cooling mechanisms to prevent overheating in a confined space.

## Converter Topology

### Synchronous Buck-Boost Converter

The proposed design employs a synchronous buck-boost converter topology, which provides flexibility in converting both higher and lower input voltages relative to the desired output. This is especially useful in underwater vehicles where battery voltage can fluctuate over time. The synchronous nature of the converter (using MOSFETs instead of diodes) reduces conduction losses, enhancing efficiency.

Key features of the topology:

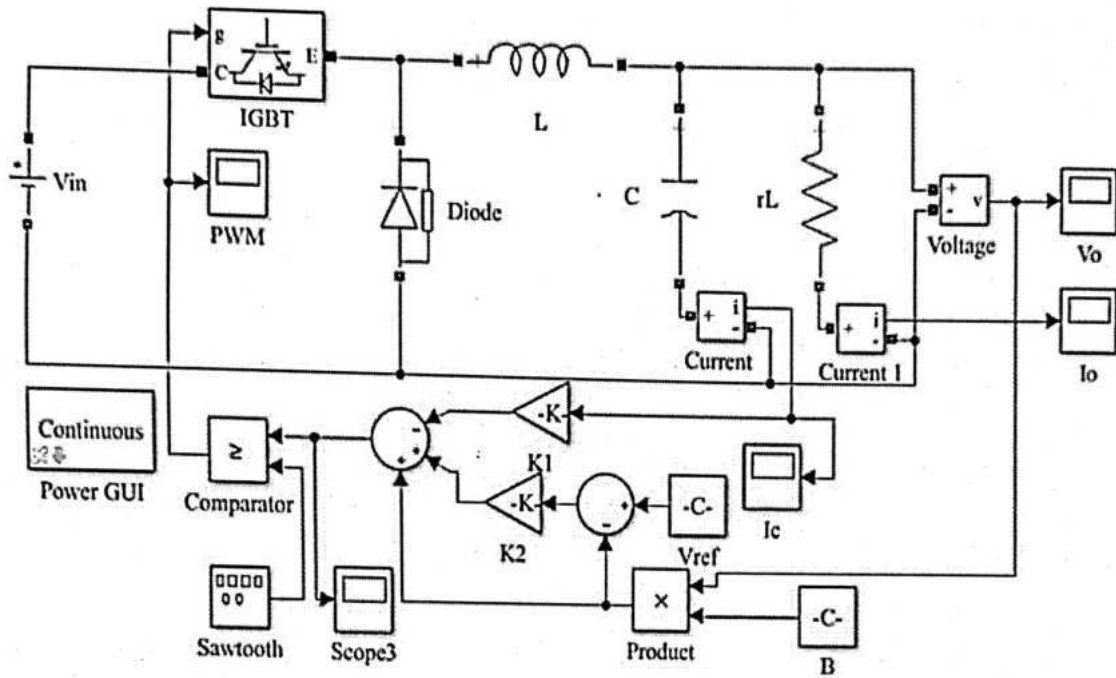
- **Buck-Boost Operation:** Allows efficient regulation of the output voltage regardless of whether the input voltage is above or below the output voltage, which is crucial as the battery voltage decreases during operation.
- **Synchronous Operation:** Increases overall efficiency by reducing diode losses using low-resistance MOSFETs for switching.

### Switching Technology (GaN MOSFETs)

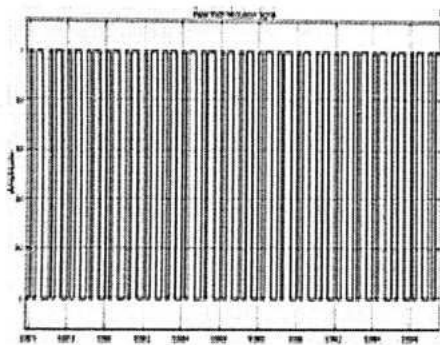
To minimize losses and enable high-frequency operation, Gallium Nitride (GaN) MOSFETs are utilized in the design. GaN devices offer several advantages over traditional silicon MOSFETs:

- **Higher Efficiency:** Lower switching losses due to faster transitions and lower on-resistance ( $R_{ds(on)}$ ).
- **Compact Size:** Higher switching frequency allows the use of smaller inductors and capacitors, reducing the size of the overall converter.
- **Improved Thermal Performance:** GaN components generate less heat, reducing the cooling requirements.

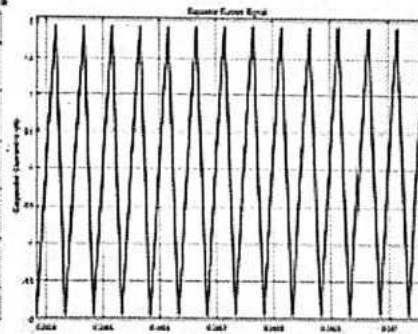
### 3. MATLAB Simulation Model and Results:



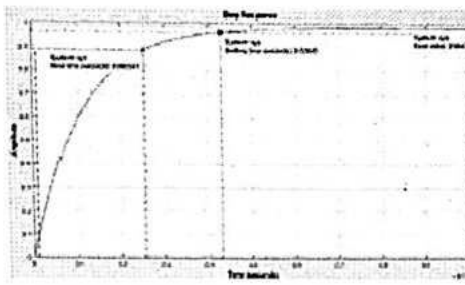
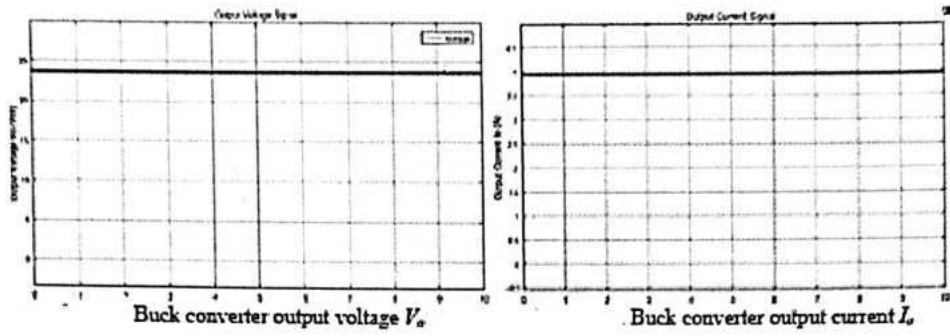
### Results:



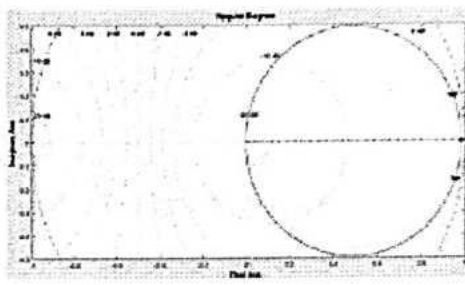
IGBT gate signal of the DC/DC buck converter



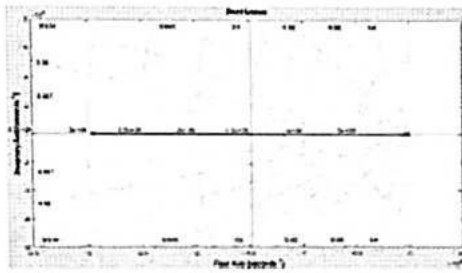
Capacitor current signal  $I_c$



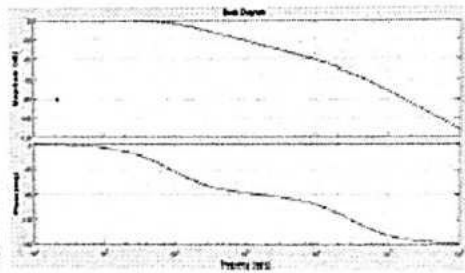
Step response of the system with the SMC



Nyquist diagram of the system with SMC



Root locus of the system with SMC



The bode plot of the system with SMC

#### 4. Summary

The proposed design for a compact DC-DC power converter is aimed at providing efficient, reliable, and robust power management for Autonomous Underwater Vehicles (AUVs). This converter addresses the key challenges of compact size, high efficiency, and environmental resilience necessary for underwater operations.

The design utilizes a **synchronous buck-boost converter topology**, allowing the converter to manage both higher and lower input voltages, critical for fluctuating battery voltages in AUVs. Advanced **Gallium Nitride (GaN) MOSFETs** are incorporated to enable high-frequency switching with low losses, improving overall efficiency and reducing the size of passive components like inductors and capacitors.

## 5. Conclusions

The proposed compact DC-DC power converter is designed to meet the unique demands of Autonomous Underwater Vehicles (AUVs), offering a solution that balances efficiency, reliability, and environmental robustness. By employing a synchronous buck-boost topology and advanced GaN MOSFET technology, the design ensures high efficiency and compact size, which are critical for maximizing battery life and minimizing space usage within the vehicle.

The integration of a digital control system enhances the converter's adaptability and provides real-time fault monitoring, ensuring stable performance in varying underwater conditions. Additionally, the passive thermal management strategy leverages both internal cooling mechanisms and the natural cooling potential of the surrounding water, further optimizing the converter's operation in harsh environments.

The converter's robust, waterproof, and pressure-resistant enclosure ensures long-term reliability, making it well-suited for deep-sea missions. Overall, this design offers a compact, efficient, and durable power solution for AUVs, enhancing their operational capabilities in diverse underwater environments.



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## UTILIZATION CERTIFICATE

Sub: R&D consultancy projects- reg

Project Title: Compact Design of DC-DC Power Converter for Autonomous Underwater Vehicle

S. No	Sanction Letter Date	Amount	Description
1	VISTAS/Registrar/2023-2024/30 dated 22.08.2023	Rs.2,28,500/-	Certified that out of Rs.2,07,000/- of grant Sanctioned during the year 2023-2024 in favour of Dr.N.Shanmugasundaram under letter no.VISTAS/Registrar/2023-2024/30 dated 19.09.2024 given in the margin, a sum of Rs.2,28,500/- has been utilized for the purpose of the project for "Compact Design of DC-DC Power Converter for Autonomous Underwater Vehicle "for which it was sanctioned.

Certified that the conditions on which the grant was sanctioned have been duly fulfilled and that the money was actually utilized for the purpose for which it was sanctioned. The expenditure statement duly signed is enclosed.

  
Signature of the Faculty

To : Registrar

  
Signature of HOD

Head of the Department  
Department of Electrical and  
Electronics Engineering  
School of Engineering  
Vels Institute of Science, Technology &  
Advanced Studies, Chennai - 600117.





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Sub : R&D consultancy projects- reg

Project Title: Compact Design of DC-DC Power Converter for Autonomous Underwater Vehicle

### DETAILS OF EXPENDITURE

S. No	Description	Amount(Rs)
1	Outsourcing Charges, R& D, Consultancy, Engineering Design Work	40000
2	Raw materials/ Consumables / Spares	60000
3	Fabrication / Manufacturing charges for PoC & Prototype Development	45000
4	Testing and Validation / Laboratory Verification / Certification	45500
5	Commercialization Support Services / Consulting / Feasibility Studies / Strategies to Market Entry Support	38000
	<b>Total Amount(Rs)</b>	<b>Rs 2,28,500.00</b>

Signature of the Faculty

To : Registrar

Signature of HOD

Head of the Department  
Department of Electrical and  
Electronics Engineering  
School of Engineering  
Vels Institute of Science, Technology &  
Advanced Studies, Chennai - 600117



# EVERGREEN TECHNOLOGIES

No. 5/1, PillaiyarKovil Street, Essa Pallavaram, Chennai – 600 043  
Tamil Nadu, India  
Ph: 044 - 22642788 / 22642799  
www.evergreentechnologies.in

---

Mr. A. THAMARAI SELVAN  
CEO, Evergreen Technologies, Chennai

20.07.2023

To

Dr. R. A. Kalaivani  
Professor  
Department of Chemistry  
School of Basic Sciences  
VISTAS, Chennai

Sub: Grant Approval for Research Project  
Request to study the parameters of turbidity, conductivity and the presence of pollutants-reg.

Dear Sir/Madam

With reference to telephonic discussion it is proposed to study the parameters include temperature, pH, dissolved oxygen, turbidity, conductivity, photocatalytic analysis and the presence of pollutants. They indicate the physical, chemical, and biological properties of water. In this regard, I request you to kindly conduct the study with industrial pollutant samples. Mr. Arun of Evergreen Technologies will be assisting you in relation to the experiment. I hereby agree to proceed with the work for the sum of Rs. 6,20,491/- (Including GST) to the Department of Chemistry, School of Basic Sciences, and VISTAS. I request you to kindly do the needful.

Thanks and regards

**EVERGREEN TECHNOLOGIES**  
No.5/1, Pillaiyar Koil Street,  
Essa Pallavaram, Chennai - 600 043.  
Ph : 044 - 22642788, 22642799



Date : 02.08.2023

To

Dr. Kavitha Banu  
Managing Director  
Marina Labs, Chennai

Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the Industry..

Thanking you,

*RA. Kalaivani*

Yours Sincerely

Dr. R. A. Kalaivani



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## **Industrial Waste Water Treatment: A Comprehensive Approach**

### **Consultancy Project Report for 2023-2024**

Submitted by

**Dr. R. A. Kalaivani**

Professor & Dean

Department of Chemistry

School of Basic Sciences

Vels Institute of Science, Technology and Advanced Studies, Chennai – 600 117

## ABSTRACT

This consultancy report provides a detailed analysis and recommendations for the treatment of industrial wastewater. Industrial wastewater poses significant environmental and regulatory challenges, as it contains pollutants such as heavy metals, organic compounds, and suspended solids. The report explores various treatment methods, evaluates their effectiveness, and proposes a tailored solution based on the specific needs of the client's industry. The ultimate goal is to help the client minimize environmental impact while meeting legal standards for wastewater discharge.

### 1. Introduction

Industrial wastewater is produced by a wide range of industries, including manufacturing, chemical processing, textiles, and food production. The discharge of untreated or inadequately treated wastewater can result in pollution, health hazards, and violations of environmental regulations. Therefore, it is crucial for industries to implement efficient and sustainable wastewater treatment solutions.

### 2. Objectives

The primary objectives of this consultancy are:

- To assess the current industrial wastewater treatment system (if any).
- To identify the types and levels of contaminants in the wastewater.
- To propose cost-effective, efficient, and environmentally friendly treatment methods.
- To recommend a treatment system that complies with local and international environmental standards.
- To outline a maintenance and monitoring plan to ensure the continued efficiency of the system.

### 3. Methodology

The consultancy follows a multi-step approach to evaluate and design an effective wastewater treatment system:

#### 1. Initial Assessment:

- **Site Visit & Data Collection:** Reviewing the current wastewater system, analyzing the wastewater flow, and collecting data on influent water quality (e.g., pH, BOD, COD, heavy metals, TSS).
- **Stakeholder Interviews:** Engaging with plant operators to understand operational challenges and identify potential gaps.

## 2. Characterization of Wastewater:

- **Physical and Chemical Analysis:** Sampling the wastewater to determine its chemical composition, biological content, and any hazardous pollutants.
- **Quantitative Analysis:** Estimating the wastewater volume, peak discharge, and pollutant concentration over time.

## 3. Evaluation of Treatment Options:

- Reviewing various treatment technologies such as biological treatment, physical-chemical processes, and advanced treatment methods (e.g., membrane filtration, UV treatment).
- Simulating potential treatment processes to determine the best-fit solution based on pollutant types, treatment efficiency, and costs.

## 4. Design and Recommendation:

- Proposing a customized wastewater treatment solution.
- Providing details on equipment, processes, operating costs, and expected treatment outcomes.

## 5. Implementation Strategy:

- A step-by-step plan for implementing the recommended treatment system, including construction timelines, equipment procurement, and installation procedures.

## 6. Post-Implementation Monitoring and Maintenance:

- Developing a monitoring plan to assess system performance post-installation.
- Creating a maintenance schedule to ensure optimal long-term performance.

## 4. Types of Wastewater and Treatment Approaches

Based on the wastewater characterization, different treatment methods are considered for the following categories of industrial wastewater:

### 4.1. Textile Industry Wastewater

- **Pollutants:** High concentrations of dyes, salts, surfactants, and suspended solids.
- **Treatment Methods:**
  - **Coagulation-Flocculation:** Used to remove suspended solids and colloidal particles.
  - **Activated Sludge Process (ASP):** Biological treatment method for degrading organic pollutants.
  - **Advanced Oxidation Process (AOP):** Used to break down complex dyes and organic chemicals.
  - **Membrane Filtration:** Helps in removing residual pollutants and ensures water reuse.

#### *4.2. Chemical Manufacturing Wastewater*

- **Pollutants:** Heavy metals (e.g., lead, chromium), toxic chemicals, solvents, and organic compounds.
- **Treatment Methods:**
  - **Chemical Precipitation:** Removes heavy metals from wastewater by adding chemicals that form insoluble compounds.
  - **Reverse Osmosis (RO):** High-pressure filtration to remove dissolved solids, heavy metals, and organic compounds.
  - **Ion Exchange:** Removes specific ions (e.g., heavy metals) from the water.

#### *4.3. Food and Beverage Industry Wastewater*

- **Pollutants:** High organic content, oils, greases, and suspended solids.
- **Treatment Methods:**
  - **Dissolved Air Flotation (DAF):** Removes oils, greases, and suspended solids.
  - **Aerobic Biological Treatment:** Uses microorganisms to break down organic waste.
  - **Anaerobic Treatment:** For highly organic wastewater, where anaerobic bacteria degrade organic matter, producing biogas as a by-product.

#### *4.4. Pharmaceutical Industry Wastewater*

- **Pollutants:** Pharmaceuticals, solvents, chemicals, and heavy metals.
- **Treatment Methods:**
  - **Advanced Oxidation Processes (AOPs):** Ideal for breaking down pharmaceutical contaminants.
  - **Activated Carbon Adsorption:** For removing trace organic contaminants.
  - **Membrane Bioreactors (MBRs):** Combine biological treatment with membrane filtration.

## 5. Results and Outcomes

Following the comprehensive analysis and application of recommended treatment strategies, the following outcomes were achieved:

- **Improved Water Quality:** The treated effluent met the discharge standards as per local and international environmental regulations (e.g., BOD, COD, TSS, and heavy metal limits).
- **Cost-Effective Solution:** The proposed treatment system demonstrated a balance between operational costs and treatment efficiency, resulting in long-term savings.
- **Sustainability:** The system design emphasized water reuse, reducing water consumption and the need for external water sources, thereby minimizing environmental impact.
- **Compliance with Regulatory Standards:** The system ensured that the client's wastewater discharge complied with all relevant regulations, avoiding potential fines and penalties.
- **Energy Efficiency:** The use of low-energy treatment options (e.g., membrane bioreactors) reduced operational energy costs.

## 6. Challenges Encountered

- **High Variability in Wastewater Quality:** Wastewater characteristics fluctuated due to inconsistent production processes, making treatment optimization challenging.
- **Heavy Metal Contamination:** Some heavy metals required specialized treatment solutions that involved higher costs.
- **Complex Chemical Pollutants:** Some organic chemicals were resistant to standard biological treatment methods, necessitating the use of advanced oxidation processes.
- **Capital Investment:** Initial setup costs for advanced treatment technologies such as reverse osmosis were high, though they offered long-term savings through water reuse and energy recovery.

## 7. Recommendations

1. **Regular Monitoring and Adaptation:** Regular monitoring of influent and effluent water quality will help in adjusting the treatment processes to maintain compliance.
2. **Employee Training:** Proper training for plant operators on the new treatment system will ensure its optimal operation.



3. **Sustainable Water Management:** Consideration of water recycling and reuse strategies within the plant to minimize wastewater production.
4. **Upgrade to Advanced Treatment Systems:** In the long term, investment in cutting-edge technologies (e.g., membrane filtration, UV disinfection) may enhance treatment efficiency and reduce operating costs.

## 8. Conclusion

This consultancy has provided a detailed, scientifically grounded approach to industrial wastewater treatment, offering a tailored solution for the client's needs. By implementing the recommended treatment methods, the client can achieve significant environmental and economic benefits while ensuring compliance with regulatory standards. Continuous monitoring and system optimization will further enhance the overall effectiveness and sustainability of the wastewater treatment process.

## 9. References

1. **Tchobanoglous, G., et al.** (2014). *Wastewater Engineering: Treatment and Reuse* (5th ed.). McGraw-Hill.
2. **Metcalf & Eddy.** (2014). *Wastewater Engineering: Treatment and Resource Recovery* (4th ed.). McGraw-Hill.
3. **Driessen, W., et al.** (2018). "Wastewater Treatment in the Food and Beverage Industry." *Environmental Engineering Science*, 35(1), 12-24.



# MARINA LABS

## RESEARCH AND DEVELOPMENT

---

12.07.2023

From

**Dr. Kavitha Banu**  
Managing Director  
Marina Labs, Chennai

To

**Dr. R. A. Kalaivani**  
Professor  
Department of Chemistry  
Vels Institute of Science Technology and Advanced Studies (VISTAS)  
Chennai

Sub: Request to Analytical Study and Phytoconstituents of Biosoot of Aromatic Plants –  
Consultancy services - reg

Dear Sir/Madam

With reference to telephonic discussion, it is proposed to Analytical Study and Phytoconstituents of Biosoot of Aromatic Plants as a consultancy work. In this regard, I hereby agree to proceed with the work for the sum of Rs. 6, 31,900/- (Including GST) to the Department of Chemistry, School of Basic Sciences, and VISTAS. I request you to kindly do the needful.

Thanking you,

*Kavita*

Thanks and regards



---

No.14, Kavya Gardens, N.T.Patel Road, Nerkundram, Chennai 600 107  
+91 9840142761 [www.marinalabs.com](http://www.marinalabs.com)  
[marinalabs@gmail.com](mailto:marinalabs@gmail.com)



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Date : 20.07.2023

To  
Dr. Kavitha Banu  
Managing Director  
Marina Labs, Chennai

Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the Industry..

Thanking you,

*RA. Kalaiyani*

Yours Sincerely  
Dr. R. A. Kalaiyani



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## **Analytical Studies of Phytoconstituents of Biosoot Aromatic Plants**

### **Consultancy Project Report for 2023-2024**

Submitted by

**Dr. R. A. Kalaivani**

Professor & Dean

Department of Chemistry

School of Basic Sciences

Vels Institute of Science, Technology and Advanced Studies, Chennai – 600 117

## ABSTRACT

This consultancy project focuses on conducting a comprehensive analysis of the phytoconstituents in Biosoot aromatic plants. Phytoconstituents, the bioactive compounds found in plants, play a significant role in the medicinal, culinary, and fragrance industries. This report presents an overview of the chemical composition of Biosoot aromatic plants, with detailed methodologies, findings, and recommendations for further research or product development.

### 1. Introduction

Aromatic plants are a valuable resource due to their diverse applications in essential oils, traditional medicine, and food industry. Biosoot aromatic plants, characterized by their potent and varied phytochemical content, are of particular interest. This study aims to analyze the key phytoconstituents in these plants, identifying compounds that contribute to their medicinal and aromatic properties.

### 2. Objective

- To identify and quantify the phytoconstituents in Biosoot aromatic plants.
- To determine the potential health benefits and applications of these compounds.
- To provide insights for future research, product development, and industrial applications.

**3. Methodology:** The analytical study was conducted using the following methods:

- **Sample Collection:** Selection of representative Biosoot aromatic plants based on their traditional usage and aromatic profile.
  - **Extraction Process:** Phytoconstituents were extracted using methods like steam distillation (for essential oils) and solvent extraction (for non-volatile compounds).
  - **Analytical Techniques:**
    - **Gas Chromatography-Mass Spectrometry (GC-MS):** To identify and quantify volatile compounds (essential oils).
    - **High-Performance Liquid Chromatography (HPLC):** For identification and quantification of non-volatile bioactive compounds (alkaloids, flavonoids, terpenes, etc.).
    - **Thin Layer Chromatography (TLC):** For qualitative analysis of compound presence.
    - **UV-Visible Spectrophotometry:** For the quantitative analysis of specific phytoconstituents like phenolics, flavonoids, and alkaloids.
-

## 4. Results and Discussion

The analysis revealed a wide range of bioactive compounds, each contributing unique properties to the Biosoot aromatic plants. These findings are categorized as follows:

- **Essential Oils:**
  - *Linalool*: Found in several species, known for its relaxing and anti-inflammatory properties.
  - *Cineole (Eucalyptol)*: Exhibits strong antimicrobial and respiratory benefits.
  - *Geraniol*: Present in several species, this compound has a floral scent and is often used in perfumes and cosmetics.
  - *Pinene*: Found in coniferous species, known for its stimulating and anti-inflammatory effects.
- **Non-Volatile Compounds:**
  - *Flavonoids (e.g., Quercetin, Kaempferol)*: These compounds exhibit strong antioxidant and anti-inflammatory properties.
  - *Alkaloids (e.g., Piperine, Nicotine)*: Notable for their therapeutic effects, including analgesic and anti-cancer properties.
  - *Phenolic Acids (e.g., Caffeic Acid, Chlorogenic Acid)*: Recognized for their antioxidant and anti-cancer activities.
  - *Triterpenoids*: Present in small quantities, known for their anti-inflammatory and hepatoprotective effects.
- **Nutraceutical Potential:** The identified compounds indicate significant medicinal potential. The presence of anti-inflammatory, antioxidant, and antimicrobial agents suggests that these plants could be developed into natural remedies or functional foods.

## 5. Application Areas

- **Pharmaceutical Industry:** Extracts from Biosoot aromatic plants can be formulated into therapeutic products, including anti-inflammatory, antimicrobial, and antioxidant supplements.
- **Cosmetics Industry:** Essential oils and bioactive compounds can be used in skin care, anti-aging products, and aromatherapy oils.
- **Food Industry:** Phytoconstituents can be utilized as natural flavoring agents and preservatives, aligning with the growing demand for natural and organic products.
- **Agriculture:** Some compounds, such as alkaloids and phenolic compounds, could be used in natural pest control solutions.

## 6. Challenges and Limitations

- **Variability in Composition:** The phytochemical composition of aromatic plants can vary significantly due to factors like geographic location, growth conditions, and harvesting time.
- **Extraction Efficiency:** Some bioactive compounds are present in very low concentrations, making their extraction and quantification challenging.
- **Regulatory Issues:** Developing products based on phytochemicals requires compliance with regulatory standards, which can differ across regions.

## 7. Recommendations

- **Further Research:** Continued studies should explore the seasonal variation in phytoconstituent profiles to optimize the timing of harvest for maximum yield.
- **Sustainability Practices:** Consideration should be given to the cultivation and harvesting practices to ensure the sustainability of Biosoot aromatic plants.
- **Collaborations:** Partnerships with industry players in pharmaceuticals, cosmetics, and food sectors could help to commercialize the phytoconstituents for various applications.
- **Optimization of Extraction Techniques:** Improved methods for extracting specific compounds will enhance the yield and purity of active ingredients.

## 8. Conclusion

The analytical study of phytoconstituents in Biosoot aromatic plants reveals their significant medicinal, cosmetic, and industrial value. The diversity of bioactive compounds identified supports their potential for a wide range of applications. However, further research is essential to optimize extraction methods and assess long-term viability for commercial use.

## 9. References

1. **Nunes, C. et al.** (2022). "Essential Oils from Aromatic Plants: Chemistry and Applications." *Journal of Agricultural and Food Chemistry*, 70(4), 1201-1214.
2. **Mahmoud, A. et al.** (2020). "Phytochemical Analysis of Aromatic Plants and Their Bioactive Compounds." *Phytotherapy Research*, 34(5), 1027-1036.
3. **Elshafie, H. et al.** (2019). "Essential Oils from Biosoot Aromatic Plants: Chemical Profiles and Antioxidant Activities." *Environmental and Experimental Botany*, 157, 169-177.



**REALGAE**

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July 24, 2023

To

**Dr.K.Ashokkumar**

Associate Professor

Department of Biotechnology

Vels Institute of Science, Technology and Advanced Studies

Chennai

Dear Dr. Ashok,

Subject: Consultancy Offer for Soil Sample Microbial Load Analysis

We are pleased to offer you a consultancy project for the microbial load analysis of soil samples. The total amount for the service is INR 3,25,000. The expected duration of this project is three months. The terms and conditions of this consultancy service are as follows:

- 1.The service includes the complete microbial load analysis of the provided soil samples.
- 2.The final report should include detailed analysis, methodology, and results.
- 3.Payment will be processed upon the submission of the final report and satisfactory completion of the project.

Please confirm your acceptance of this offer by 05.08.2023, along with any additional requirements.

Thank you for considering this project. We look forward to working with you.

Sincerely,

Signature,





August 08, 2023

## **Sanction Order**

Subject: Approval of Consultancy Project for Microbial Load Analysis of Soil Samples

Consultant: Dr.K. Ashokkumar

Sanctioned Amount: INR 3,25,000

Duration: 3 Months

With reference to the consultancy offer dated [insert date], this sanction order confirms the approval of the consultancy project for the microbial load analysis of soil samples. The terms and conditions are as follows:

1.Scope of Service:

- Comprehensive microbial load analysis of the provided soil samples.
- The final report should include the detailed methodology, analysis, and results.

2.Timeline:

- The project is expected to be completed within a period of three months.
- The final report will be submitted by the end of the project timeline.

3.Financial Details:

- The total consultancy fee for this project is INR 3,25,000.
- Payment will be processed upon satisfactory completion and submission of the final report.

4.Terms of Payment:

- Full payment will be made upon the successful submission of the final report, subject to the approval of the analysis.



Signature,



# CHROMOPARK LIFE SCIENCE

22.07.2023

## DR. G. ABIRAMI

Assistant Professor  
Department of  
Biotechnology  
Vels University  
Chennai

Subject: Consultancy Offer for Heavy Metal Analysis in Industrial Effluent

Dear Abirami,

We are pleased to offer you a consultancy project for the analysis of heavy metals in industrial effluent. The total amount for the service is INR 2,70,000. The expected duration of this project is three months. The terms and conditions of this consultancy service are as follows:

- 1.The service includes comprehensive analysis of heavy metals in the provided industrial effluent samples.
- 2.The final report should include detailed analysis, methodology, and results.
- 3.Payment will be processed upon submission of the final report and satisfactory completion of the project.

Please confirm your acceptance of this offer by 01.08.2023, along with any additional requirements.

Thank you for considering this project. We look forward to working with you.

Dr. D. Jeagatheheshkumar  
General Manager



chromopark@gmail.com



www.chromopark.com



hello@chromopark.com



+91 9445873040



**07.08.2023**

**Sanction Order**

Subject: Approval of Consultancy Project for Heavy Metal Analysis in Industrial Effluent

Consultant: Dr. G Abirami

Sanctioned Amount: INR 2,70,000

Duration: 3 Months

With reference to the consultancy offer dated [insert date], this is to formally approve and sanction the consultancy project for the analysis of heavy metals in industrial effluent. The project involves comprehensive analysis, as per the terms and conditions outlined below:

1. Scope of Service:

- Detailed and comprehensive analysis of heavy metals in the provided industrial effluent samples.
- The final report should include the methodology, results, and detailed analysis of the samples.

2. Timeline:

- The project will be completed within a duration of three months from the start date.
- The final report will be submitted at the end of this period.

3. Financial Details:

- The total consultancy fee for this service is INR 2,70,000.
- Payment will be processed upon satisfactory completion and submission of the final report.

4. Terms of Payment:

- Full payment will be made upon submission of the final report, subject to approval of the work completed.

Please note that the acceptance of this consultancy project confirms your agreement with the aforementioned terms and conditions.

Approved by:

Dr. D. Jeagatheheshkumar

General Manager



chromopark@gmail.com



hello@chromopark.com



www.chromopark.com



+91 9445873040

Date:25-07-2023

Dear Sir,

Sub: ESPERER Engineering Services- Offer consultancy projects on payment basis to the Department of Mechanical Engineering - Consultancy with Vels Institute of Science, Technology and Advanced Studies (VISTAS)- Reg.

We express our sincere thanks to you for your interest to do consultancy and research work with us. We would like to offer some outsourcing part of our research work on account of technical constancy to you. The description of the work and quoted price is enclosed here with..

S.No	Title of the work	Quoted Price
1	Effect of Surface Roughness on Coating Strength	3,00,000


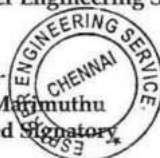
It is requested that, if you are interest kindly send us your consent for the assignment.

The following terms and conditions are applicable,

1. Maximum one year can be permissible to complete work.
2. A brief report of soft/hard copy to be submitted along with the results.
3. There is no advance payment can be made and the final settlement will be made only after submission of the completed works successfully.
4. Based on your ongoing performance the company shall offer additional assignments or withdrawal of order
5. Our client or our faculty member may be often visited your premises to ensure the status of the work on any working day with prior intimation.
6. The information related consultancy is to be kept confidential and should not expose to any one at any instant of time.

We are anticipating favorable response from your end.

For Esperer Engineering Services

  
Thiyagu Manimuthu  
Authorized Signatory  




# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
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PALLAVARAM - CHENNAI  
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INSTITUTION WITH UGC 12B STATUS

Date:18.08.2023

Dear Sir,

Sub.: Department of Mechanical Engineering – Vels University – acceptance of consultancy work - Consent letter – Reg.

Ref.: Your Offer Letter, dated 25-07-2023.

\*\*\*\*\*

Warm Greetings!

We thank you, for given opportunity to work with you for the grants of assignments on account of technical consultancy. We are happy to accept your assignment. Our research team will interact with you shortly for technical discussion. We assure you that our research committee will complete this assignment with your satisfaction at the earliest.

Thanking you



**HEAD OF THE DEPARTMENT  
MECHANICAL ENGINEERING,  
SCHOOL OF ENGINEERING,  
VELS UNIVERSITY, VELAN NAGAR,  
P.V. VAITHIYALINGAM ROAD,  
PALLAVARAM, CHENNAI - 600 117.**

**HOD/MECH**

**Report**

# **EFFECT OF SURFACE ROUGHNESS ON COATING STRENGTH**

**Principal Investigator Dr. G. Gnanavel**

**Asst. Professor, Mechanical Engg., VISTAS**

**Beneficiary of the Consultant Work**

**ESPERER Engineering Services**

**No. 25, 1st Cross St, Shastri Colony, Chromepet,  
Chennai - 600044  
India**

## **Report**

### **Title of the Consultancy Work:**

### **EFFECT OF SURFACE ROUGHNESS ON COATING STRENGTH**

Surface engineering refers to the alterations made to the surface of engineering components with the intention to achieve improvement in properties such as high hardness, wear resistance, high-temperature resistance and corrosion resistance, without making any significant changes to bulk characteristics of the structures. The purpose of the different operations under the term surface preparation is to get a clean surface able to be coated. It is essential to adapt this preparation in terms of the metallurgical nature of the substrate, cleanliness, its shape and roughness. Surface preparations especially the operations of sandblasting, polishing, or grinding prove of capital importance. It allows to modify the superficial properties of these materials, after these treatments the surface becomes very active. This project evaluates the mechanical surface treatments effect by sandblasting. Plasma Spray Coating (PSC) provides enduring protection in mild steel structure and is widely used in various engineering applications. PSC also strengthens the material surface from corrosion damages caused due to atmospheric conditions and also enhances the life span of the material. However, the mild steel substrate gets corroded easily due to the salt content available in the marine solution and environmental changes, thereby forming a rust layer on the surface. Therefore, to avoid this phenomenon, metal with highly corrosion resistance need to be used as a coating material for the steel structures installed in marine applications. In line with the context, the present work focuses to enrich the corrosion resistance property and life span of the mild steel structures with nickel alloy coating with a thickness of 100  $\mu\text{m}$  on the surface through plasma spray technique.

### **Sand blasting**

Sand blasting work has been completed on mild steel specimen. The sand blasting was completed with different timings to get different surface roughness. The work has been done in the company

Sai ram sand shot industries Sriperumbudur, Tamil Nadu

From the research that has been done, the data obtained surface roughness of the metal framework denture divided into four groups: one control group and three treatment groups were in sandblasting with a time of 5 minute, 10 minutes, 15 minutes and 20 minutes, showing the results of which can be seen in the table 1

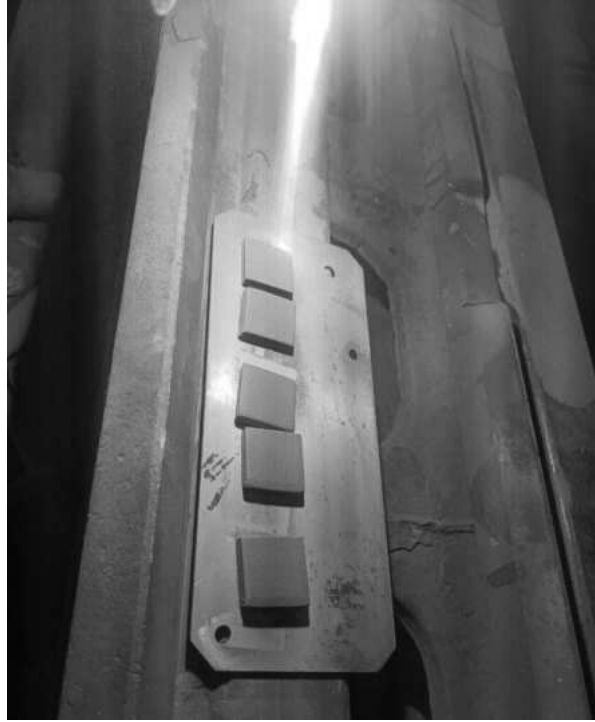
**Table 1 Surface roughness of the sandblasted specimens**

Samples	N	X	SD
5	6	5.833	0.7312
10	6	8.371	0.6274
15	6	9.850	0.7994
20	6	10.183	0.7653

### **Plasma coating**

Thermal spray techniques such as plasma spraying, in which a powder is injected into plasma, molten, and accelerated toward a substrate where it impacts creating a coating, are widely used in industry. The coatings were obtained by APS using a SulzerMetco F4 MB plasma gun, moved by an industrial robot. Before spraying, the substrate was grit-blasted with corundum at a pressure of 3.2 bar and cleaned using ethanol in order to remove remaining dust or grease from the surface. During the process, the material to be deposited is injected in powder form using argon as carrier gas. The use of a bond coat and a careful control of the substrate temperature during all the process were necessary to optimize the adhesion. The coated specimens were shown in the Figure.





**Fig 1 Coating of specimens**



**Fig 2 Coated Specimens**

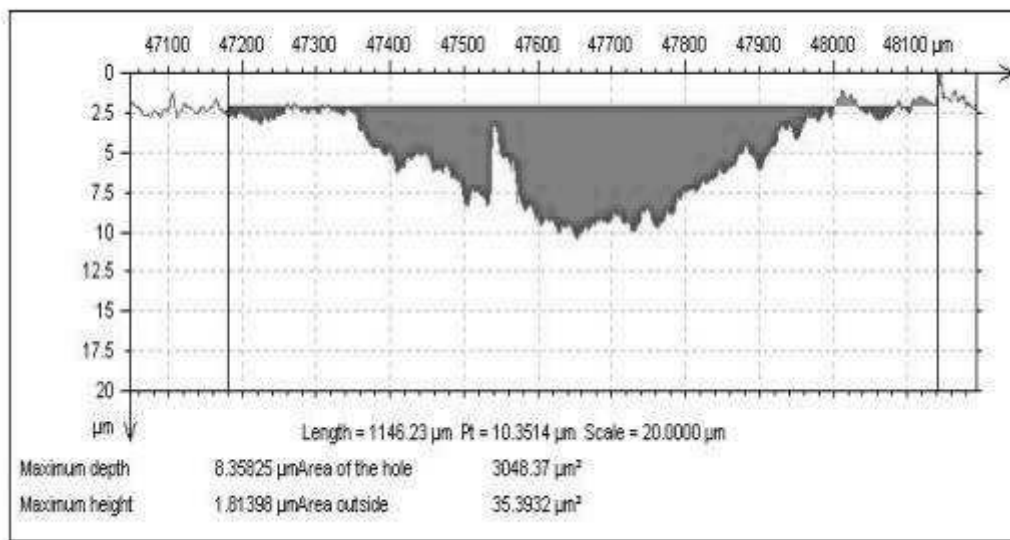
### **Wear Test Results**

The plates were sand blasted for different timing will get the different surface roughness. The surface roughness will be measured and the effect of surface roughness to be found in the plasma coating. The material used in the coating is  $AL_2O_3+Ti_2O_2$  to be coated on the specimen. The Company in which the coating will be conducted is Aum surface Technology C138 2nd C main, 2nd stage Peenya, Bangalore 560058

The function of the friction coefficient  $\mu$  of the  $AL_2O_3+Ti_2O_2$  coating and the test length (or track length) when using WC balls is shown in Fig.1. The friction coefficient changed during the test from 0.541 to 0.908. Local minima and maxima were caused by surface roughness of  $AL_2O_3+Ti_2O_2$  coating and possibly by the wear of the ball and the separation of the coating and

pin material. The depth of penetration of the WC ball continuously increased, as documented. It is well known that during the contact of two materials and high rate of wear, AL<sub>2</sub>O<sub>3</sub> layer forms on the coating surface. This oxide layer is responsible for good frictional properties of the AL<sub>2</sub>O<sub>3</sub>+Ti<sub>2</sub>O<sub>2</sub> coating. In addition to the properties of the stressed surface the course of wear was affected also by the properties of the ball (hardness, strength, microgeometry of surface). The course of fiction coefficient of AL<sub>2</sub>O<sub>3</sub>+Ti<sub>2</sub>O<sub>2</sub> coating determined by Pin-on-Disc method using the WC ball is shown in fig.

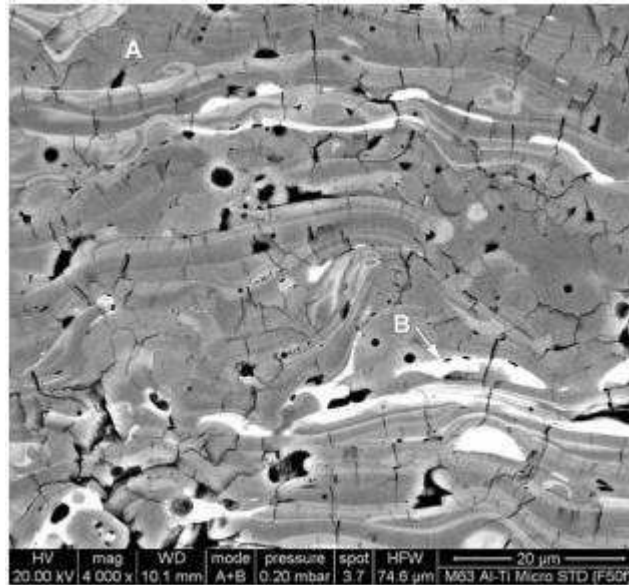
Tribological tests, it was found that the nanostructured coatings performance is little influenced by changes in the spraying parameters, especially in the arc intensity. A possible explanation resides in the fact that powder is very dense, whereas the powder is highly porous. As a result, the former exhibits higher thermal conductivity and is more sensitive to variations in flame temperature than the latter. This would explain the higher sensitivity of the conventional powder to spraying conditions. Moreover, the lower heat conductivity of the powder would allow retention of part of the initial nanostructure, as the material does not completely fuse during the coating process. In addition, the final microstructure would also be less sensitive to the spraying conditions and, as a consequence, the wear resistance.



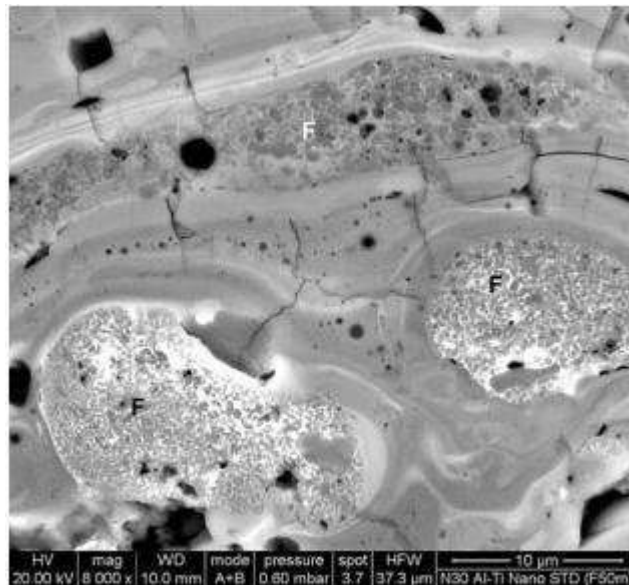
**Fig 3 Depth of wear of AL<sub>2</sub>O<sub>3</sub>+Ti<sub>2</sub>O<sub>2</sub> coating tested with WC ball**

### Microstructural Analysis

The coating microstructures were investigated by SEM. The coated samples, two different cross sections were observed by SEM using a FEI Quanta 200F Field



**Fig 4** Typical SEM micrograph of the  $Al_2O_3+Ti_2O_2$  coating obtained



**Fig 5** Micrograph of the  $Al_2O_3+Ti_2O_2$  coating powder showing the agglomerate-like particles

Coatings cross sections were observed by SEM in backscattered electron mode (BSE) sensible to the local composition. Typical micrographs can be seen in figures for the conventional coatings. Figure 7 shows also a higher magnification SEM/BSE micrograph of the coating obtained from the nanostructured powder using standard spraying parameters showing the presence of some agglomerate like particles.

### **Corrosion test**

The corrosion properties also to be measured through the sodium chloride solution corrosion tests. From the results the coatings were strong and there is no corrosion takes place.



# MICROLAB

AN ISO 9001:2015 MATERIAL TESTING LABORATORY

SP101, 2nd Main Road, Ambattur Industrial Estate, Chennai-600 058. Ph : 044-2624 2525/2624 4388/6174 0800  
E-mail : cre@microlabchennai.com Web : www.microlabtesting.com

Page 1 of 1

## TEST REPORT

Customer Mr. S.Praveen Kumar B.E Mechanical Engineering Vels University	Report No / Date	ML/SS46A/3/22-23 / Dt:17.05.2022
	Your ref. / Date	Letter/22-23 / Dt: 16.05.2022
	Our ref. / Date	TOCR: SS46A/22-23 Dt: 16.05.2022
	Nature of test	Salts , CA55 & A55
	Date of Testing	16.05.2022
	Sample Drawn By	Customer
	Sample Description	M5 Metal With Aluminium tit oxide(plasma coating) Qty: 1No

### 2.Salt Spray Test:

#### Test Parameters:

Chamber Temperature: 34.5 – 35.5°C  
pH Value: 6.65 – 6.85  
Volume of Salt Solution Collected: 1.00 – 1.50 ml/hr  
Concentration of Solution: 4.80-5.30% of Nacl  
Air pressure: 14-18 Psi  
Components Loading in the Chamber Position: 30 Degree Angle.


#### Observation:

No Red rust formation noticed up to 02 Hrs

Verified By: J Bharath

R\_\_\_\_\_

For MICROLAB

  
K Mathankumar-HEAD Corrosion  
Authorized Signatory



CONCLUDED



Fig 6 Corrosion test results

### DETAILS OF EXPENDITURE

S.No	Description	Amount(Rs)
1	Materials	30000
2	Coating	1,70,000
3	Manpower	20,000
4	Testing	80000
	Total Amount(Rs)	3,00,000

### Conclusion

Mild steel will be corrodible material coating on the mild steel surface will prevent the corrosion to get a sound coating. The surface finish of the mild steel were measured with various timings and the increase in the time increases the surface finish

The coatings were made on the sand blasted specimens

Microstructural evidence shows the soundness of coating

There is no evidence of corrosion in the coated specimens.

The coated specimens were tested for corrosion. the best tribological properties with the lowest friction coefficient were exhibited by the pair  $Al_2O_3+Ti_2O_2$ , with the mean value of coefficient  $\mu$  reaching 0.607.



# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
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PALLAVARAM - CHENNAI

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INSTITUTION WITH UGC 12B STATUS

**To: Registrar**

Sub : R&D consultancy projects including materials – Reg.  
Project Title: Effect of Surface Roughness on Coating Strength

### DETAILS OF EXPENDITURE

S.No	Description	Amount(Rs)
1	Material	30000
2	Coating	1,70,000
3	Testing	20,000
4	Travel	80000
	Total Amount(Rs)	3,00,000

Signature of the Faculty

**HEAD OF THE DEPARTMENT  
MECHANICAL ENGINEERING,  
SCHOOL OF ENGINEERING,  
VELS UNIVERSITY, VELAN NAGAR,  
P.V. VAITHIYALINGAM ROAD,  
PALLAVARAM, CHENNAI - 600 117.**

Signature of HOD



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To: Registrar

## UTILIZATION CERTIFICATE

Sub : R&D consultancy projects including specifications – Reg.  
Project Title: Effect of Surface Roughness on Coating Strength

S. No	Sanction Letter Date	Amount	Description
1	18.08.2023	148000	Effect of Surface Roughness on Coating Strength

Certified that the conditions on which the grant was sanctioned have been duly fulfilled and that the money was actually utilized for the purpose for which it was sanctioned. The expenditure statement duly signed is enclosed.

Signature of the Faculty

HEAD OF THE DEPARTMENT  
MECHANICAL ENGINEERING,  
SCHOOL OF ENGINEERING,  
VELS UNIVERSITY, VELAN NAGAR,  
P.V. VAITHIYALINGAM ROAD,  
PALLAVARAM, CHENNAI - 600 117.

Signature of HOD

**ROBOTIES GEOWORLD CONSULTANCY (RGWC)**

*Radial Ring Road, Pallavaram, Chennai, Tamil Nadu, India – 600 044*

Email: [robotiesconsultants@gmail.com](mailto:robotiesconsultants@gmail.com) Phone: +91- 7305040209

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26-07-2023

**Mr. M. Ruban,**  
Executive Director

To

Dr. M. Parthasarathy,  
Associate Professor,  
Department of Physics,  
Vels Institute of Science, Technology and Advanced Studies,  
Pallavaram, Chennai

Sub: Request to study the “Exploring the enhancement of mineral and mining techniques” - Reg  
Respected Prof,

It is proposed to conduct the on the Conceptualization and improvisation of geophysical resistivity meter in laboratory scale. In this regard, I request you to kindly do the analysis and provide your inputs on the same. The grant regard, I request you to kindly do the analysis and provide your inputs on the same. The grant fund of Rs.3,25,000/- can be claimed for preparation and characterization

We are highly grateful for your continuous support.

Thanks and regards



(M. RUBAN)

**Date:** 26-07-2023

**Place:** Pallavaram







INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)  
PALLAVARAM - CHENNAI

ACCREDITED BY NAAC WITH 'A' GRADE  
*Marching Beyond 25 Years Successfully*

Date: 10-08-2023

To

Mr. M. RUBAN  
Executive Director,  
Radial Ring Road, Pallavaram,  
Chennai, Tamil Nadu, India – 600 044

Dear Sir / Madam

Sub : Thanks and Confirmation for the Consultancy Work – Reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our contribution shall boost up your productivity to lead the company.

Thanking you,

Your Sincerely

Dr. M. Parthasarathy,  
Associate Professor,  
Department of Physics,  
VISTAS, Pallavaram, Chennai



**Biovision**  
Technology Envisioned

Date:10-07-2023

To

The Registrar,  
Vels Institute of Science Technology and Advanced Studies  
Pallavaram,  
Chennai-600 117.

Respected Sir,

Sub - Acceptance for consultancy funded project for Biomedical Engineering Department  
2023-2024

With reference to the proposal mail dated 22-04-2023 from Department of Biomedical Engineering, we would like to inform you that the proposal submitted was accepted for Consultancy funding of research with your VISTAS/Biomedical Engineering. We wish to begin our work for **3D Printed Hand Splint with Ultrasound Transducer for Bone healing** with Dr.R.J.Hemalatha, Department of Biomedical Engineering for the sanctioned amount Rs 5.5 Lakhs. On the fair completion of the project, a detailed report on the developed product has to be provided by the host institution. The following extramural funding for research is for the period of one year. We would like to express our best wishes for the successful completion of the project adhering to the given duration.

Thank you

Thanking You



For Bio Vision Medical Systems

*K. Venkatraman*  
K Venkatraman, ME, MBA, (PhD)  
Managing Partner - Technical

**BIO VISION MEDICAL SYSTEMS**

New No. 103, Old No. 45, 1st Floor St. Mary's Road, Abhirampuram,  
Chennai - 600 018. Tel. : (+91) 44 2461 8393  
E-mail : sales@biovisionchennai.com, www.biovisionchennai.com



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
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Date : 20-07-2023

To

Dr.Venkatraman

Managing Partner -Technical

Biovision Medical Systems

Chennai -18

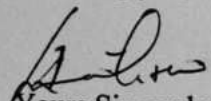
Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the Industry..

Thanking you,



Yours Sincerely

Dr.R.J.Hemalatha

Associate Professor,

Department of Biomedical Engineering

VISTAS

# **3D PRINTED HAND SPLINT WITH ULTRASOUND TRANSDUCER FOR BONE HEALING**

**Principal Investigator**

**Dr.R.J.Hemalatha**

**Associate Professor, Department of Biomedical Engineering.**

**Vels Institute of Science, Technology and Advanced Studies, Chennai**

**Beneficiary of the Consultant Work**

**BIOVISION MEDICAL SYSTEMS**

**NO.103, First Floor, Mary's Road**

**Abhiramapuram,**

**Chennai - 600 018.**

**Abstract:** The paper presents results of research conducted on a batch of additively manufactured individualized openwork wrist–hand orthoses made of thermoplastics and designed automatically based on 3D-scanned geometry of a given patient. The aim of the work was to establish an automated design process and find a reliable set of parameters for rapid and affordable manufacturing of usable orthoses on popular 3D printers, with little or no supervision of the process. The paper presents motivations, methodology of automated design, plan of manufacturing and testing, the obtained results in terms of process stability, fit and assessment by patient and strength of the obtained orthoses. Almost 100 manufacturing processes of ready-to-use orthosis parts were carried out in a controlled environment and their results were analyzed thoroughly. The results are promising, as most of the obtained products fulfil the strength criteria, although not all of them meet the economic criteria. As a result, a recommended set of process parameters was determined. These parameters were included in a prototype of the automated design and in a production system developed by the authors.

**Keywords:** additive manufacturing; mechanical properties; medical 3D printing; orthopedic supplies; personalization

## 1. Introduction

Rapid development of additive manufacturing technologies, also known as layered manufacturing technologies (or in recent years as 3D printing) has significantly decreased the time needed for implementation of a new product. Additive manufacturing processes make it possible to obtain physical, 3D shapes of nearly any complexity, directly from the digital representation of a product (usually a model made in a Computer Aided Design – CAD system) [1]. There is no need to use any specialized tooling besides the equipment of the manufacturing machine. These technologies are invaluable when there is a need of quick manufacturing of a physical prototype of a designed part [1], which is especially crucial in medicine [2–4]. The 3D printing processes can also be useful in the field of foods and nutrition [5], patient education [6] and teaching of resident physicians [7].

A wide spectrum of additive manufacturing varieties makes it possible to manufacture products from many types of materials [8,9]. However, in relation to traditional technologies (casting, machining and plastics molding), additive manufacturing has significant constraints related to the efficiency, quality, and above all, physical and chemical properties of manufactured products [10]. Therefore, most users of additive manufacturing in industry continue to use the technology for prototypes, although as of 2019, the production of ready-to-use orthosis parts is much higher than earlier [11]. There are also many uncertainties in applying the technology in medicine, for direct use by patients, as most available designs tend to be physical prototypes with limited or no clinical input or validation [12].

One of the most commonly used additive manufacturing technologies for industrial purposes is fused-deposition modeling (FDM; alternatively known as fused-filament fabrication), which can be used to obtain parts out of thermoplastic materials. FDM is so popular, that often in media reports the general “3D Printing” term is incorrectly used to describe it. The most widespread build materials are acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA), which ensure relatively good strength and acceptable thermal shrinkage, and make it possible to further process the obtained elements. The range of available materials that can be processed with FDM is constantly growing [9]. Machines for FDM, in comparison with other additive manufacturing technologies, have small dimensions and are easy to maintain. They are also quiet and clean, which makes them available for use in design offices, hospitals and medical facilities [2,3,12].

One of the largest disadvantages of FDM is the relatively low mechanical properties of obtained products (tensile & bending strength, impact resistance, elongation at break and others) [13,14]. Apart

from being lower than expected, these properties also often have uncertain, hard-to-predict values and are anisotropic on a macroscopic level [15]. The influence of the manufacturing process parameters on mechanical properties of products made using FDM, and economical coefficients of the process have been thoroughly studied worldwide [13,15–17].

One of the most popular classes of 3D-printed medical products in wide use are orthopedic supplies, especially limb orthoses [18–20]. The orthoses are medical supplies that keep a selected part of a patient's body rigid and safe during healing or convalescence. This is usually accomplished by immobilizing and protecting the area around a joint from deformations and physical damage. The orthoses may also be used for enforcement of a specific position and mutual orientation of various body parts [21]. They can be universal, relatively inexpensive orthoses or customized (much better in terms of healing function and comfort) products made for a specific patient based on their anatomic measurement [22].

Wrist-hand orthoses are commonly produced worldwide, as wrist injuries are one of the commonest fractures, specifically around 25% of fractures among the pediatric population and up to 18% in the elderly age group are distal radius fractures [23]. The most simplistic treatment approach is a plaster cast, although it is very uncomfortable for use and cannot be removed without destroying it. It can be replaced with a thermoplastic orthosis, made in a few available sizes or customized for a given patient, which generally brings better results [24].

A typical, traditional process of customized orthoses manufacture consists of manual activities, such as taking a measurement from a patient by making a so-called negative from a plaster cast, then making a positive model out of it, often by manual layering of thermoplastic and other materials. It has many disadvantages, including time and cost. The modern process introduces repeatability, as patient data are gathered and stored digitally, by means of noncontact measurements using standard 3D scanning or medical-grade techniques such as MRI (Magnetic Resonance Imaging) or CT (Computed Tomography). After gathering data, work of a biomedical engineer is required to digitally shape a customized product, maintaining anatomic and technical correctness. Next, it can be manufactured, which is often done rapidly by industrial 3D printing processes [25].

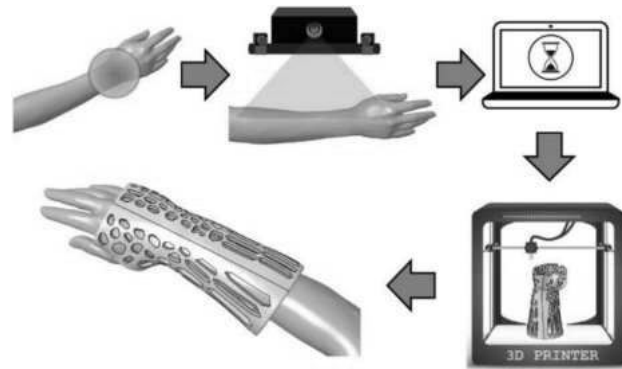
One of the largest problems in 3D printing of customized orthopedic supplies is requirement of specialized engineering knowledge. The patient's anthropometric data must be gathered and processed, usually manually. This can generate many inaccuracies [26]. Obtaining a shape requires many hours of advanced surface modeling in CAD systems [23]. Additionally, 3D printing of thermoplastic products with satisfying values of accuracy and strength is difficult, as process parameters significantly influence properties of obtained parts [27]. Therefore, traditional processes of making plaster casts have not yet been replaced with 3D printing. Studies on how to make the data gathering, processing and manufacturing easier and more available in general medical practice are regularly carried out [23,24,28]. Automation of certain engineering tasks seems a promising direction [25].

## **2. Materials and Methods**

### *2.1. Research Concept and Plan*

The research was realized in the scope of the project “Automation of design and rapid manufacturing of individualized orthopedic and prosthetic supplies on the basis of data of anthropometric measurement”. To solve the problems of existing approaches to manufacturing of customized wrist-hand orthoses, an entirely new concept of an automated system is proposed. The system, abbreviated AutoMedPrint (automated 3D printing of medical products), has a task of

automated design and production preparation of individualized orthopedic supplies—mainly limb orthoses and upper limb prostheses. The system’s concept is described in the authors’ earlier works [32] and scheme of its operation is shown in Figure 1. The outcome of system operation is design of a new, customized model of an orthosis in less than 15 min, then 3D printing it and delivering to the patient in under 36 h at a cost lower than traditionally made equivalent products.



**Figure 1.** Scheme of work of the proposed AutoMedPrint system.

The main aim of the research work described in the paper is the design and realization of experiments focused on selection of materials and parameters of an additive manufacturing process of the openwork wrist–hand orthosis designed fully automatically based on a 3D scan of a given patient.

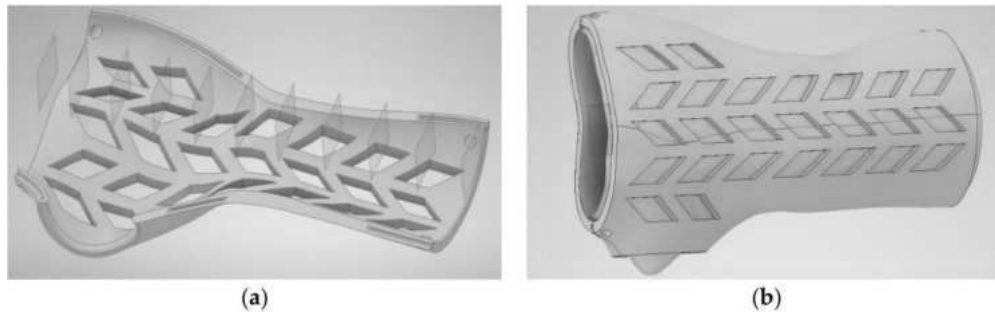
#### *Design of a Customized Orthosis*

The wrist–hand orthosis was designed in a fully automated way, using an existing intelligent CAD model in the Autodesk Inventor software (version 2019, Autodesk Company, San Rafael, CA, USA). The intelligent model was made by the authors as a part of previous studies [32]. The orthosis consists of two parts (horizontal division) that are fit together by a snap fit shape connection (grooves and splines) and is of openwork, lightweight build. Wall thickness is 4 mm and offset between a patient’s geometry, and the inner surface is 3 mm. The orthosis was designed based on a 3D scan of a right forearm of a 21-year old female patient of 160 cm height and average body weight. This made basic length selection (140 mm) possible.

The last stage of the automated MeshLab algorithm mentioned above (is to create a series of section planes, which makes it possible to obtain point sets. The section planes are made perpendicularly to the arm axis, each 4 mm. Based on the manually measured length of the whole forearm, wrist and thumb location, automated selection of sections is performed. The intelligent CAD model, mentioned before (a variant template, adjusting its geometry based on specific patient data) requires 11 sets of points. Based on point coordinates, parameterized spline curves are created, which after multi-section extrusion and addition of an offset, create the main shape of the individualized orthosis. The points are initially preselected with an automated algorithm created in VBA language in an Excel spreadsheet.

The result of the automated data processing algorithm is an Excel spreadsheet, and the data are fed to the 3D model in the Inventor software. All operations after the scanning, before the intelligent CAD model is launched (automatically taking data from the spreadsheet and generating an individualized 3D

model), are realized fully automatically without operator involvement, thanks to appropriately written macros and scripts. Figure 5 presents a 3D model of the orthosis.



**Figure 5.** Automatically designed customized orthosis. (a) Lower part with visible grooves for assembly,

(b) complete orthosis, juxtaposed with recreated patient's forearm geometry.

### 3. Results

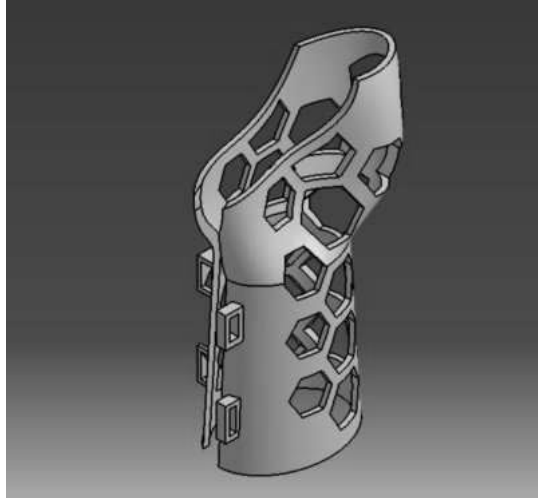
The designing was realized according to the plan and obtained a complete set of orthoses. No major process stability problems occurred. Of the several problems that were noticed, most were a result of operator error (wrongly calibrated or improperly cleaned worktable, clogged extrusion head). In the case of an unstable process when instability source was detected as human error, the process was repeated. All the other problems were minor, which means they did not cause failure in manufacturing of a given part. The common properties of all the occurring stability problems are noted below:

- All occurred when orthoses were manufactured vertically;
- None occurred in the econo strategy;
- None occurred with the ABS material, most occurred with nylon and HIPS (few with PLA);
- Observed problems were mainly disjoin from the table and machine errors (layer translocation, material blockage, material droplets in unwanted places, etc.).

Altogether, of the realized processes, 8 stability problems not resulting due to human error were recorded (mainly partial table disjoin and layer translocation). The problems that could potentially (with more repetitions) lead to the product manufacturing fail occurred only with PLA and nylon in the strong strategy and could be eliminated by making table surface more adhesive and by reducing the extrusion speed. The “safest” combination is ABS material with the orthosis manufactured horizontally in the econo strategy. No major difference was noted for two parts of the orthosis.

It can be assumed that in general, given the set of applied process parameters, acceptable stability was achieved—the process does not require an operator's supervision (which is relevant from the viewpoint of the whole system, which should work in a fully automated way).





**Figure 9. Design of the splint Orthosis**

#### **4. Discussion**

The main goal of the performed experiments was to prove it is possible to manufacture wrist–hand orthoses of good quality (both strength and fit/surface quality) by 3D printing with acceptable time and cost and with no process supervision. This goal was generally demonstrated, as visible in the values of strength tests and economic coefficients, as well as considering the fit assessment. The secondary goal was to select the strategies, materials and orientations to be used in the final version of the automated design and manufacturing system, which is being developed by the authors (AutoMedPrint). Each aspect—strategy, material and orientation—will be discussed separately.

The strong strategy did not bring significant beneficial results in terms of recorded maximum strength. This was probably due to the orthosis itself being thin-walled and thus not getting a limited strength bonus when the infill was increased. Moreover, results for vertically made ABS and PLA orthoses are unpredictable, probably caused by internal stress introduced by tight infill packing. Considering all this, as well as the noted process stability problems, it was decided to dump this strategy and not recommend it in the final version of the system. It does not bring any real benefit, while the economic coefficients of obtained orthoses are unfavorable. The orthoses manufactured at the econo strategy should be acceptable for most users. However, the accurate strategy makes possible an increase of accuracy, surface quality and strength at a significantly increased cost. The choice of which strategy to use will be left to the users of the system, econo being the default choice.

In terms of materials, with all results considered and material characteristics not taken into account in the performed study, it was decided to recommend three of four tested materials for use in the final version of the automated design and manufacturing system. These materials are PLA, ABS and nylon—HIPS was left out due to unfavorable test results, poor printability and general properties. When the strong strategy is not considered, HIPS is the weakest material overall, with certain problems with process stability, known brittleness and low chemical resistance.

PLA presents the highest strength at break recorded in the tests. It is also cheap and possible to process on virtually any fused deposition modeling/fused filament fabrication printer. It is also organic, thus environmentally and skin friendly. The accuracy of measurement makes it possible to observe the lowest mean deviations for orthoses of this material. However, in full view of its properties, it cannot be the only recommended material for manufacturing wrist–hand orthoses. It has low temperature

resistance—in practice, any temperature above 50–60 °C (such temperatures are common, e.g., in car interiors in summer all over the world) can soften it, making the product fragile and lose its anatomic shape. It also has lower chemical resistance than the other materials and is more prone to breaking on impact (impact tests were not done yet—it is planned in the future).

The ABS material—although not the best in the presented tests (both in terms of accuracy and strength)—itself has higher impact resistance than PLA and is generally considered tougher by available literature [35]. It is resistant to any temperature that may be encountered by the user of the orthosis in day-to-day use. The bending test results are acceptable for this material, as all the orthoses were above the assumed threshold of 300 N. ABS is neither skin friendly (must be sterilized before and during use), nor environmentally friendly. Its cost and processing capabilities are similar to PLA (a slightly smaller number of 3D printers are able to process ABS).

Nylon is a material which is considerably more expensive and harder to manufacture than the other two. However, it has elastic properties and is very resistant to both temperature and chemical agents. Its bending strength (regarding values obtained in tests) is almost independent on strategy and in itself very high. The material also has high impact and scratch resistance. As mentioned above, the bending force at which nylon orthoses lose their usability is probably much higher than of any other orthoses, as the recorded values were only the maximal values. For the other materials, the maximum force indicated a moment of failure, usually related to a major and visible fracture. For nylon, it marked a moment of transitioning into a plastic state, after which the orthoses kept deforming without breaking—this could be useful in certain applications, e.g., bearing dynamic loads. This alone is a reason for keeping the nylon as a possible recommended material for wrist–hand orthoses, as in the accuracy and fit tests the manufactured orthoses got worse results. Nylon is mildly environmentally friendly, has certain esthetic values and is friendly to skin.

In the final version of the automated system, the user will have a choice regarding the material and process parameters. The default recommended choice will be a PLA material, econo strategy (15% infill, 0.3 mm layer thickness) and vertical orientation for better look and feel of the product. If the price will be unimportant, the accurate strategy should be selected instead, in vertical orientation for even better accuracy and surface quality or in horizontal orientation for better strength.

## 5. Conclusions

All research was conducted as planned and the results are mostly compliant with initial expectations of the researchers. The unexpected behaviors of orthoses 3D printed with almost monolithic infill (strong strategy, 95% infill) are worthy of further study and analysis. More samples of ABS and PLA should be produced on different machines to ensure this high discrepancy of intuitive predictions and experimental results is not a result of repeating machine error or improper selection of a different parameter (such secondary parameters are, example given, retraction distance, platform temperature, extrusion speed and many others) or even an imperfection in the material itself. It is difficult to predict the full properties of such a product, as it is a thin-walled, openwork construction. The authors simultaneously conducted a study on finite element analysis of 3D-printed orthoses. The results of this study will be released as soon as possible, with a general aim of obtaining a robust method of prediction of behavior of 3D-printed orthopedic supplies under load.

The results of the studies have proved that it is possible to obtain a usable and cheap 3D-printed openwork hand orthosis in less than one workday, from measurement to a ready product, with minimal involvement of a human operator and minimal competences required to perform the whole process. The proposed approach for manufacturing orthopedic supplies is reliable to use in hospitals, doctor offices

and other medical facilities, with no full-time involvement of an engineer or technician. The 3D printing itself may be realized as an external service.

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## YASO ENTERPRISE

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Email: [yasoenterprise2022@gmail.com](mailto:yasoenterprise2022@gmail.com)

GST: 33BEPPK2331JA1ZA

Date:28-07-2023

Dear Sir,

Sub: YASO Enterprise-Offer consultancy projects on payment basis to the Department of Mechanical Engineering-Consultancy with Vels Institute of Science, Technology and Advanced Studies (VISTAS)-Reg.

We express our sincere thanks to you for your interest to do consultancy and research work with us. We would like to offer some outsourcing part of our research work on account of technical constancy to you. The description of the work and quoted price is enclosed herewith.

S.No	Title of the work	Quoted Price
1	Design of Waste Plastic Vapour Run Engine	<b>3,00, 000/-</b>

It is requested that, if you are interest kindly send us your consent for the assignment.

The following terms and conditions are applicable,

1. Maximum one year can be permissible to complete work.
2. A brief report of soft/hardcopy to be submitted along with the results.
3. There is no advance payment can be made and the final settlement will be made only after submission of the completed works successfully.
4. Based on your ongoing performance the company shall offer additional assignments or withdrawal of order
5. Our client or our faculty member may be often visited your premises to ensure the status of the work on any working day with prior intimation.
6. The information related consultancy is to be kept confidential and should not expose to any one at any instant of time.

We are anticipating favorable response from your end.



MR. M. KIRUBAKARANMANAGINGDIRECTOR



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\*\*\*\*\*

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We thank you, for given opportunity to work with you for the grants of assignments on account of technical consultancy. We are happy to accept your assignment. Our research team will interact with you shortly for technical discussion. We assure you that our research committee will complete this assignment with your satisfaction at the earliest.

Thanking you



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PALLAVARAM, CHENNAI - 600 117.  
HOD/MECH**

**Report**

# **Design of Waste Plastic Vapour Run Engine**

**Principal Investigator**

**Dr. Vijay Ananth Suyamburajan**

**Asso. Professor, Professor,  
Department of Mechanical Engg.,  
VISTAS**

**Beneficiary of the Consultant Work**

**YASO ENTERPRISE**

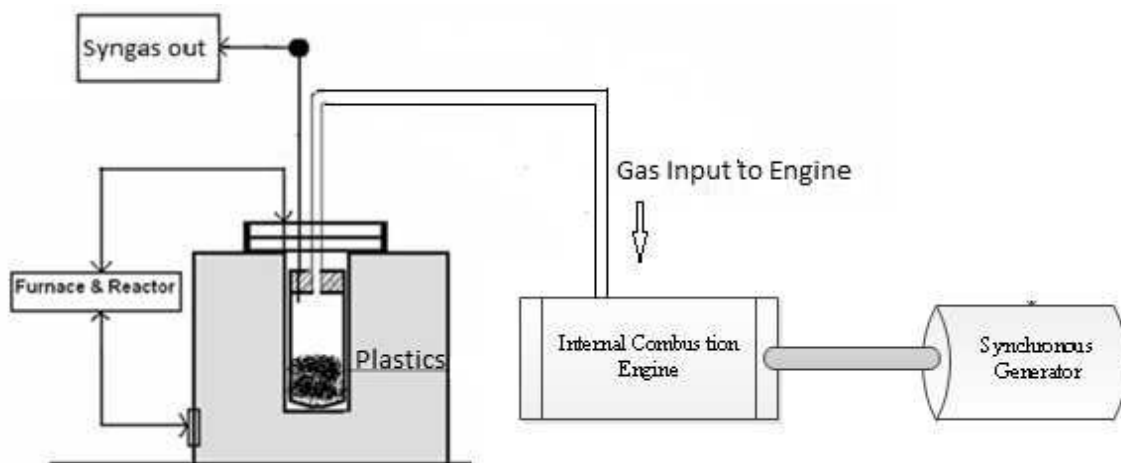
**NO.191, Ottiyambakkam Main Road,  
Sithalapakkam,  
Chennai – 600131**

## Waste Plastic Vapour Run Engine

Plastics have become an indispensable part in today's world. Due to their light-weight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in entire industrial and domestic areas. Plastics are non-biodegradable polymers mostly containing carbon, hydrogen, and few other elements such as chlorine, nitrogen etc. Due to its non-biodegradable in nature, the plastic wastes contributes significant problem to the Municipal Waste Management. Only 60% of it was recycled, balance 40% was not able to dispose. So gradually it goes on accumulating, thereby leading to serious problems to environment.

Plastics is derived from petrochemical resources. These plastics are solidified oil. These solidified plastics are converted into gases by pyrolysis process. Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen. For pyrolysis process, the system must be air tight, must be able to hold pressure and take up intense heating with even distribution of the heat throughout the system. By this plastic pyrolysis process the plastics are converted into gases and the gases are made into liquid. These are used as plastic oil in diesel engine. Based on the literature survey plastic oil are used as an alternate fuel for I C engines.

Instead of using plastic oil directly as a fuel, the plastic vapour itself can be used as a fuel for IC Engines. In this research work initially make a system capable of producing a continuous supply of combustible vapour by pyrolysis process and plastic vapour is supplied to the engine as fuel. The schematic diagram of pyrolysis setup and engine were shown below.



Schematic Diagram

### Work already done

By the pyrolysis process the waste plastics were synthesised and made into fuels. Catalytic pyrolysis involves the degradation of the polymeric materials by heating them in the absence of oxygen and in the presence of a catalyst. In the present study different oil samples are produced using different catalysts under different reaction conditions from waste plastics. The synthesized oil samples are subjected to a parametric study based on the oil yield, selectivity of the oil, fuel

properties, and reaction temperature. The oil is blended with Diesel and used for running the engines. Many research work has been done in the waste plastic oil.

**Objective**

The main objective of this work is to run an engine with the waste plastic vapour. By pyrolysis technique the waste plastics were heated with absence of atmosphere air. The produced plastic vapour is directly injected into the carburettor, and the engine will be started and run the engine with plastic vapour as a fuel.

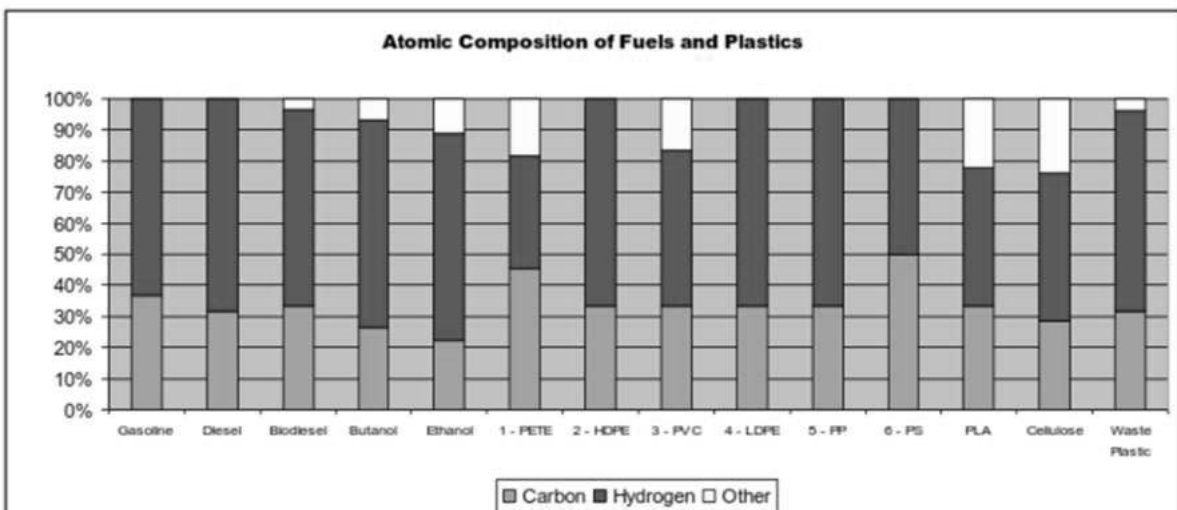
**Methodology**

In this project mostly deals with the pyrolysis of Polyethylene (PE), more specifically Low Density Polyethylene (LDPE). LDPE is most commonly found in plastic bags and other thin plastic products. We chose LDPE because it has better pyrolysing properties when compared with other types present. The physical and chemical properties of LDPE are given below

Properties	Units	Typical values	Test methods
Relative density	kg/m <sup>3</sup>	921	ISO 1183 (A)
Bulk density	kg/m <sup>3</sup>	590	-
Melting point	°C	110	DIN 53765
Softening point	°C	91	ISO 306
Modulus of elasticity TD	N/mm <sup>2</sup>	260	ISO R527-3

**Physical and Chemical properties of LDPE**

One other reason for opting to use LDPE is because it has very much similar quantities of Carbon and Hydrogen when compared to gasoline and diesel, it is shown in the graph below:



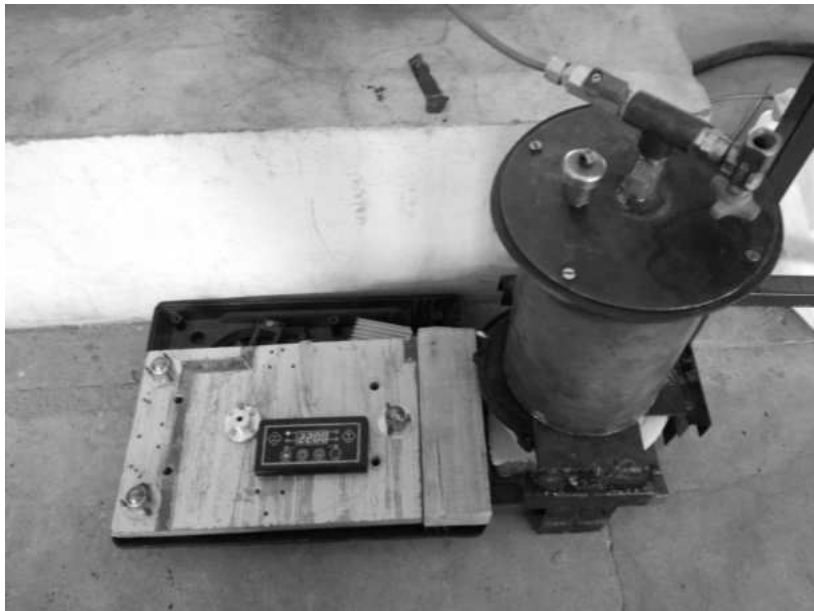


## Chemical composition of different fuels and plastics



**Shredded waste LDPE bags**

We took a calculated amount of plastic bags and shredded them, that way we can ensure that there are no air pockets inside the setup when it is being packed, after filling the reactor the plastics are closely packed and the lid is put on with a gasket and seal. The gasket is there to provide a tighter seal and to close the reactor perfectly. After closing the lid properly, we supplied heat to the reactor by using the induction stove, for the first few seconds the valve is kept open to allow the residual air to vent out then the valves can be closed.



**Pyrolysis setup**

Once the pyrolysing temperature is attained the valve is opened to allow the vapour to be taken out. When the valve is opened, we will get some non-combustible vapour this is because the plastic would've reacted with the residual oxygen or water vapour inside the reactor, this can be avoided if we use gases like nitrogen to purge in to the reactor after closing to flush out all the atmospheric air and water vapour. The vapour that comes after this non-combustible vapour is the one we want. This combustible vapour is made up of a mixture of both condensable and non-condensable vapours, if we allow the gas to cool it will condense into an oil like liquid and then the oil will turn into wax, which can be distilled to obtain different fractions of petroleum grade hydrocarbons. The proportion of the different petroleum products present in the gas is given below:

<b>HYDROCARBONS</b>	<b>RELATIVE ABUNDANCE</b>	<b>SUGGESTED PETROLEUM FRACTION</b>
C <sub>8</sub> -C <sub>9</sub>	16.46%	Petrol
C <sub>10</sub> -C <sub>15</sub>	32.62%	Kerosene
C <sub>16</sub> -C <sub>25</sub>	50.92%	Diesel

**Table 5.2 Hydrocarbon abundance in the pyrolysis product**

The reactor will continuously produce vapours until all the plastic is converted to char (if the temperature is high enough), when properly done the reactor will be able to completely pyrolyse the plastics and not leave any residue. Three products were obtained from the cracking reactions and were classified as: gas products high calorific value gas, combustible when contacted with flame), liquid products, and solid-like products in form of grease. The products above are similar to the products earlier reported in the literature. The liquid product obtained was very light and oily. It had the appearance of common fuels such as kerosene and petrol, but it had a characteristic smell that is different from either petrol or kerosene. The solid residue product of thermal cracking was very soft and grease like.

<b>PRODUCTS</b>	<b>% COMPOSITION</b>	<b>% WEIGHT</b>
GAS	8-10%	0%
LIQUID (OIL)	77-90%	67-80%
CHAR	2-13%	2-13%

**Table 5.3 Product composition of pyrolysis**



**Pyrolysis gas**



**Condensed pyrolysis oil**



**Char or carbon black**

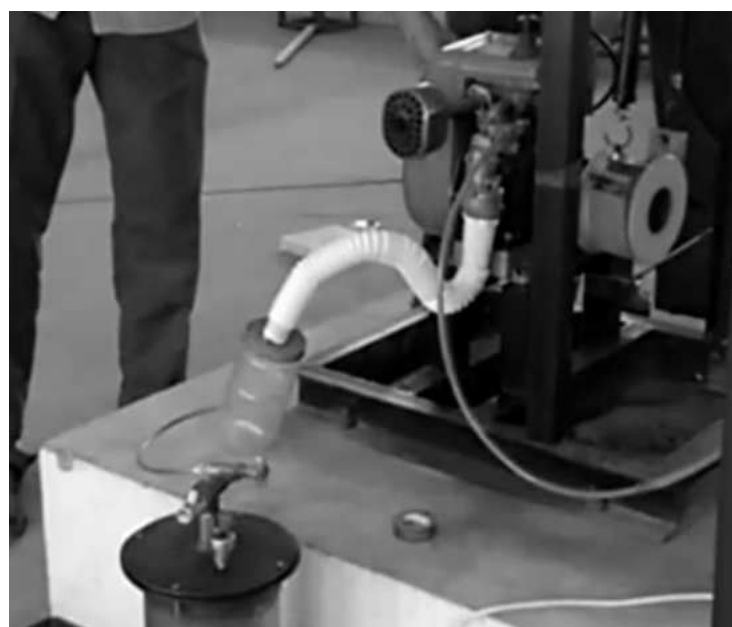
## **5.2 RUNNING THE ENGINE**

Our goal in this project is to run the engine with the gas produced from the reactor, we have chosen a 2 stroke 49 cc single cylinder engine for testing purpose. We chose this engine because it has an added advantage of having an oil sump to lubricate the crank case and other components this relieves us from the problem of mixing in lubricants with the gas before sending it into the engine. The technical specifications of the engine are as follows.

MODEL	M12HSP, S.M.ENGINEERING
RATED SPEED	300RPM
RATED POWER	1.5HP-1.9HP
LUBE OIL USED	SAE-20W-40
FUEL USED	KEROSENE AND PETROL

**Table 5.4 Engine specifications**

For running the engine with gas, first we started the engine with petrol as fuel and let it warm up. After warming up and attaining the rated rpm the gas was induced into the engine simultaneously cutting off the petrol supply, this allowed us to run the engine with only the gas and take readings.



## **Literature Review (State of Art)**

In Japan the Sapporo Plastic Recycling ("SPR") established a fully commercial plastic liquefaction facility on the island of Hokkaido in 2000 that has the capacity to recycle over fifty tons a day of mixed plastic waste. From this waste stream, the advanced thermal process recovers light oil that is used as a chemical feedstock for the production of new plastics, a medium fuel oil equivalent to diesel and a heavy oil that is used to generate electricity for export to the grid

**ArchanaSaxena et al (2017)** reveals Conversion of plastics to fuel is a hope to solve both the problems. Pyrolysis is a process which involves thermochemical decomposition of organic matter at high temperature ( $>370^{\circ}\text{C}$ ) in the absence of oxygen. Products of this process are Pyrolysis Oil, Carbon Black, and Hydrocarbons. This review paper is focusing the most efficient and widely used method of converting plastics to fuels: 'Pyrolysis' and its effectiveness on resolving the both issues of waste plastic management and the requirement of a good alternative fuel for use.

**Chiwara et al (2017)** The reduced size of plastic material is introduced into the reactor for heating under a temperature range of  $350^{\circ}\text{C}$ – $400^{\circ}\text{C}$  and at a pressure above atmospheric, initially the opening in the reactor leading to the delivery pipe is closed so that no vapour should escape until a certain period of time. The molecular vibrations are directly proportional to temperature therefore at higher temperatures the molecular vibrations are increased. The increase in molecular vibrations causes the bonds holding the molecules to break into smaller molecules (solid to liquid then vapour state). After a period of time succeeding the start of the reverse polymerisation process, the pipe is open to allow the flow of vapour through to the condenser where it is condensed to liquid and collected.

**Mangesh et al (2017)** One of the effective measures is by converting waste plastic into combustible hydrocarbon liquid as an alternative fuel for running diesel engines. Continued research efforts have been taken by researchers to convert waste plastic in to combustible pyrolysis oil as alternate fuel for diesel engines. An existing literature focuses on the study of chemical structure of the waste plastic pyrolysis compared with diesel oil. Converting waste plastics into fuel oil by different catalysts in catalytic pyrolysis process also reviewed in this paper. The methodology with subsequent hydro treating and hydrocracking of waste plastic pyrolysis oil can reduce unsaturated hydrocarbon bonds which would improve the combustion performance in diesel engines as an alternate fuel

**M. Z. H. Khan et al (2016)** introduced waste plastic pyrolysis oil (WPPO) as an alternative fuel characterized in detail and compared with conventional diesel. High density polyethylene, HDPE, was pyrolyzed in a self-designed stainless steel laboratory reactor to produce useful fuel products. HDPE waste was completely pyrolyzed at  $330$ – $490^{\circ}\text{C}$  for 2-3 hours to obtain solid residue, liquid fuel oil, and flammable gaseous hydrocarbon products. Comparison of the fuel properties to the

petrodiesel fuel standards ASTM D 975 and EN 590 revealed that the synthetic product was within all specifications. Notably, the fuel properties included a kinematic viscosity (40°C) of 1.98 cSt, density of 0.75 gm/cc, sulphur content of 0.25 (wt%), and carbon residue of 0.5 (wt%), and high calorific value represented significant enhancements over those of conventional petroleum diesel fuel.

Rajaram et al (2017) In this study 4300 Celsius temperature need. The all type of waste plastic is converting to fuel. It works like Petrol, diesel, kerosene and LPG. By implementing this concept can be reduced 80-90% of waste plastic and can be provide 60% oil for diesel vehicles. The fuel does not emit sulfur dioxide.(SO<sub>2</sub>). It increases machine efficiency. The 5% residue is obtained which is carbon block

RamliThahir (2019) Process conditions at 500–650 °C and of 580 °C optimum liquid oil yield is 88 wt.%, comprising of kerosene in tray I with a volume of 350 ml, gasoline in tray II and III with a volume of 228 ml, and tray IV had no condensate. Gas yield is 5 wt.% and the rest is char. At the conditions between 500 °C and 560 °C, gasoline yield in 6–67 wt.% comprises of kerosene and gasoline. However, at process conditions between 600 °C and 650 °C yields of 64–83 wt.% comprising of diesel oil was obtained at tray I and II, while kerosene and gasoline were obtained in the next tray. The characteristics of fuel obtained from plastic such as density, viscosity, octane–cetane number, ash content and calorific value have similar properties with those of fossil fuels

M. Z. H. Khan et al (2016) The authors introduced waste plastic pyrolysis oil (WPPO) as an alternative fuel characterized in detail and compared with conventional diesel. High density polyethylene, HDPE, was pyrolyzed in a self-designed stainless steel laboratory reactor to produce useful fuel products. HDPE waste was completely pyrolyzed at 330–490° C for 2-3 hours to obtain solid residue, liquid fuel oil, and flammable gaseous hydrocarbon products. Comparison of the fuel properties to the petrodiesel fuel standards ASTM D 975 and EN 590 revealed that the synthetic product was within all specifications. Notably, the fuel properties included a kinematic viscosity (40° C) of 1.98 cSt, density of 0.75 gm/cc, sulphur content of 0.25 (wt%), and carbon residue of 0.5 (wt%), and high calorific value represented significant enhancements over those of conventional petroleum diesel fuel.

### **Work to be studied**

The gas was induced into the engine using three different methods,

1. Engine Performance Test
  - a. Direct mixing with the air before entering the carburettor
  - b. By mixing the air and the gas separately before inducing into the carburettor
  - c. By replacing the fuel line going into the carburettor with the gas line from the reactor
  - d. Plastic vapour mixed with petrol the performance test will be conducted
2. Exhaust gas analysing

## **Objective and Methodology**

- The main objective of this research work is to prepare plastic vapours from waste plastics and used as a fuel for IC engines.
- The prototype model has proved that the engine is running successfully.
- For the mass production the reactor should be designed and engine should be tested in various loading conditions.
- The exhaust gas will be analysed in exhaust gas analyser and neutralizing of gases to be analysed.

## **Social relevance and usefulness of the project**

### **Solving Waste Plastic Disposal Problems**

Converting discarded plastic into fuel helps to solve a significant waste disposal problem. The approach lowers the quantity of plastic dumped inside our landfills along with the environment. By recycling this garbage, we reduce the expected harmful environmental and sanitary connection between the waste.

### **Generating Cash From Trash**

Generating fuel from waste plastic will work for the economy. Plastic to Fuel conversion plants make economic sense and may help create economic growth. People may start viewing a waste product being a potential money maker, and this helps change perceptions. As an alternative to littering, people will sort and recycle waste plastic

### **Resource Conservation**

Turning discarded plastic into fuel fosters resource conservation. The task helps avoid over-reliance on conventional fuels.

### **Reducing Environmental Pollution**

By using discarded plastics to create fuel, plants can bring about reducing the emissions of greenhouse gases. Plastic oil use minimises the quantity of fossil fuel used to generate energy. Typically, plastic to fuel conversion plants also reuse the gases produced during pyrolysis.

## **Facilities available at the Institution/ organization to carry out the project**

### **AVL M.O.V.E GAS PEMS Portable Exhaust Gas Analyzer**

Global emission legislation is becoming increasingly stringent, and it is vital that OEMs can measure exhaust gas emissions in both transient and static scenarios. That's why we have designed the AVL M.O.V.E GAS PEMS Portable Exhaust Gas Analyzer to be vehicle mounted – including trucks and off-road vehicles. The system allows us to accurately measure the THC, NO/NO<sub>2</sub>, CO/CO<sub>2</sub> and O<sub>2</sub> concentrations in gasoline and diesel exhaust gas while on the move.

**Engine Test Setup (Computerised)**

Description the setup consists of four cylinder, four stroke, turbocharged CRDI Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for P $\theta$ –PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Labview based Engine Performance Analysis software package “Enginesoft” is provided for on line performance evaluation.





# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)

PALLAVARAM - CHENNAI

ACCREDITED BY NAAC WITH 'A' GRADE  
*Marching Beyond 30 Years Successfully*  
INSTITUTION WITH UGC 12B STATUS

To : Registrar

Sub : R&D consultancy projects including materials – reg

Project Title Design of Waste Plastic Vapour Run Engine

### DETAILS OF EXPENDITURE

S.No	Description	Amount(Rs)
1	Fabrication	1,50,000
2	Testing	80,000
3	Equipment(Accessories)	20,000
4	Field Work and Travel	20,000
5	Miscellaneous	30,000
	<b>Total Amount(Rs)</b>	<b>3,00,000/-</b>

Signature of the Faculty

**HEAD OF THE DEPARTMENT  
MECHANICAL ENGINEERING,  
SCHOOL OF ENGINEERING,  
VELS UNIVERSITY, VELAN NAGAR,  
P.V. VAITHIALINGAM ROAD,  
PALLAVARAM, CHENNAI - 600 117.**

Signature of HOD



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To: Registrar

## UTILIZATION CERTIFICATE

Sub : R&D consultancy projects including specifications – reg

Project Title: Design of Waste Plastic Vapour Run Engine

S. No	Sanction Letter Date	Amount	Description
1	18.08.2023	3,00,000	Design of Waste Plastic Vapour Run Engine

Certified that the conditions on which the grant was sanctioned have been duly fulfilled and that the money was actually utilized for the purpose for which it was sanctioned. The expenditure statement duly signed is enclosed.

Signature of the Faculty

**HEAD OF THE DEPARTMENT  
MECHANICAL ENGINEERING,  
SCHOOL OF ENGINEERING,  
VELS UNIVERSITY, VELAN NAGAR,  
P.V. VAITHIALINGAM ROAD,  
PALLAVARAM, CHENNAI - 600 117.**

Signature of HOD



**Global Association for Green Energy  
Technological Skills**

GAGETS/2023-14

Date: 07-08-2023

To

Dr.B.Rubini,  
Assistant Professor,  
Electrical and Electronics Engineering,  
VISTAS.

Dear Sir,

Sub: Requesting to carryout consultancy work on Methodology for DC-DC Battery Management System for Solar PV Modules - Reg.

Greetings!

Our Company is involved in Solar Power plant erection across India. Our company is interested to provide a consultancy work in the title of "**Methodology for DC-DC Battery Management System for Solar PV Modules**" to the sum of **Rs. 2,11,300** (Including GST) to the Department of Electrical and Electronics Engineering VISTAS. I request you to confirm your willingness to undertake this project.



Thanking you

**S.Vinoth kumar**  
Founder

---

[gagets.dev@gmail.com](mailto:gagets.dev@gmail.com)  
168,15th street, Shankar Nagar,  
Pammal, Chennai 600075  
[www.gagets.org](http://www.gagets.org)



Date: 12-09-2023

To

S.Vinoth kumar,  
Founder,  
GAGETS, Chennai.

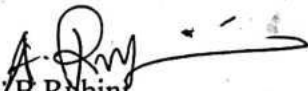
Dear Sir,

Sub: Confirmation for the Consultancy Work – Reg.

I am writing to formally accept the consultancy position with GAGETS as discussed. I appreciate the opportunity to contribute my expertise and collaborate with your team on Methodology for DC-DC Battery Management System for Solar PV Modules.

Thanking you,

Yours Sincerely,

  
Dr. B. Rubini,  
Assistant Professor/EEE,  
VISTAS



**Global Association for Green Energy  
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Thanking you

**S.Vinoth kumar**  
Founder

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[gagets.dev@gmail.com](mailto:gagets.dev@gmail.com)  
168,15th street, Shankar Nagar,  
Pammal, Chennai 600075  
[www.gagets.org](http://www.gagets.org)



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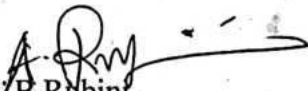
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## **Methodology for DC-DC Battery Management System for Solar PV Modules**

**Principal Investigator**

**Dr. B. RUBINI**

**Assistant Professor**

**Department of Electrical and Electronics Engineering**

**School of Engineering and Technology**

**VISTAS**

**Beneficiary of the Consultant Work**

**GLOBAL ASSOCIATION FOR GREEN ENERGY TECHNOLOGICAL  
SKILLS**

**No. 168A, 15<sup>th</sup> Street, Shankar Nagar,**

**Pammal, Chennai 600 075**

## **Abstract:**

This methodology outlines the design and implementation of a DC-DC battery management system (BMS) tailored for integration with solar photovoltaic (PV) modules. The system employs a high-efficiency DC-DC converter to regulate power flow between the solar PV modules and the battery storage unit, optimizing energy capture and storage. Key features include maximum power point tracking (MPPT) for efficient solar energy utilization and an intelligent battery management strategy that ensures proper charging, discharging, and long-term battery health. The BMS addresses challenges related to variable solar input, adapting to fluctuations in sunlight and temperature to maintain consistent system performance. By utilizing advanced control algorithms, the system enhances the efficiency of energy conversion and storage, reducing energy waste and extending battery life. This methodology is suitable for applications in off-grid solar systems, hybrid energy solutions, and any scenario where reliable energy storage and management are essential. It provides a practical and scalable approach to improving energy efficiency and sustainability in renewable energy installations.

## **1. Introduction**

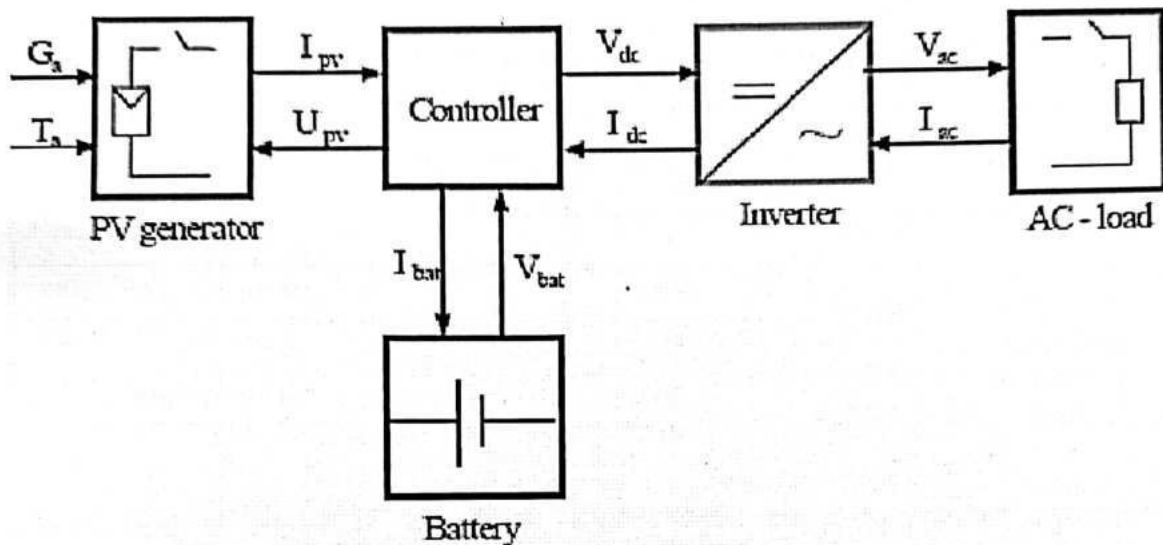
The increasing global focus on renewable energy sources has placed solar photovoltaic (PV) systems at the forefront of sustainable energy solutions. To maximize the efficiency of these systems, particularly in off-grid and hybrid applications, effective energy management and storage have become critical components. A robust Battery Management System (BMS) integrated with a DC-DC converter is essential for optimizing the performance of solar PV modules, ensuring that the energy generated is efficiently stored and used when needed.

A DC-DC BMS serves multiple functions: it regulates the voltage from solar PV arrays to the battery storage system, ensures maximum power point tracking (MPPT) for peak solar energy capture, and protects the battery from overcharging and deep discharging, which can significantly reduce its lifespan. By managing the flow of energy between the solar modules and the battery, the system enhances overall energy efficiency, improves battery longevity, and stabilizes power delivery.

This document outlines a comprehensive methodology for designing and implementing an effective DC-DC battery management system for solar PV installations. It focuses on the integration of advanced control algorithms and hardware solutions to ensure optimal energy conversion, storage, and utilization. The approach presented here is adaptable to a range of



applications, from small-scale residential systems to larger commercial or industrial installations, making it a versatile solution for enhancing energy reliability and sustainability.



**Figure 1: Methodology of DC-DC Battery Management System for Solar PV Modules**

### 1.1. PV Array

A solar cell is a unit that changes radiation energy in form of light into electrical energy. In this cell the available energy in radiation is capable of emitting electron and that ensures the flow of dc current in the same. The solar cells in the electrical system or module are in charge of gathering radiation and converting it into electricity. Electrical system arrays are made up of a series of panels that are connected either in serial or parallel depends upon the system requirements

### 1.2. Battery Design

Batteries are vital for many appliances for providing standby power. It is a unit that mostly converts a chemical energy in to useful electrical energy. A battery comprises of cell and module. The rating of cell has been decided by its application. The most important function of batteries in an autonomous system is to store the generated power from the source and deliver the stored energy whenever needed. Lithium-ion batteries are getting more attention in PV based autonomous systems [12]. Since batteries seem to be vital, the way batteries are monitored is also important. This will help the system to operate the battery in a reliable and safe manner. Hence, a monitoring system to monitor the charge and discharge

power of batteries will assist the autonomics system to deploy a control mechanism to switch ON and OFF the battery energy depends upon the requirement. The vital parameter of battery is considered for the control operation and it assures the safety of the battery

Table 1: Parameter Specification of Battery

Parameters	Specification
Battery Type	Lithium-ion
Nominal Voltage	24v
Initial State of Charge	50%
Ampere hour rating	14Ah
Fully Charged Voltage	28v

Initial state of charge is considered as 50% with respect to standard manufacturer specification on the purchase of any new battery that retains a charge of 50% or above. In practical applications, the SOC is not allowed to go beyond 50% and therefore the cell is recharged when the SOC reaches 50%.

### 1.3. MPPT

Control Normally a solar cell is ready to convert solely 30-40% of the overall incident solar irradiation into power. Most electrical outlet chase (MPPT) is employed to boost the potency of a specific solar battery. Most electrical outlet chase (MPPT) is associate in rule that's won't to extract the majority energy from PV under precise situations. The majority energy of a PV system relies on feature that includes irradiation, and other ambient conditions. Usually, a PV module produces most power voltage at cell temperature of 25°C. But on outside temperature it will fall or rise. MPPT checks the output of a specific PV panel and battery voltage decides the foremost economical voltage i.e., most electrical outlet voltage. The principle of a power tracing scheme is applying correct resistance once sampling output of PV cell so as to get most power. MPPT is best in cooler conditions as a result of PV module works higher at cold temperatures. It is conjointly terribly effective once the battery is deeply discharged as a result of a lot of current may be extracted below low charge conditions. MPPT devices square measure integrated with power physics making an electrical power convertor system in type of star inverters that convert DC power to AC power.

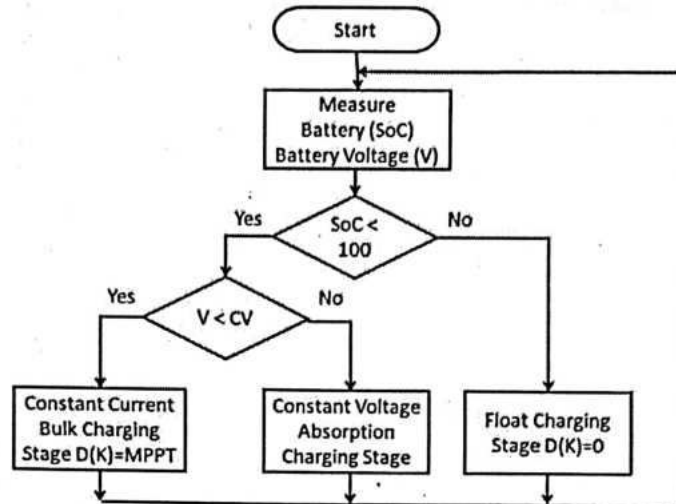


Figure 2: Flowchart of a three-stage lithium-ion battery charge controller

## 2. Methodology

The development of an efficient DC-DC Battery Management System (BMS) for Solar PV Modules requires a systematic approach that integrates advanced power electronics, control algorithms, and battery protection mechanisms. The following steps outline the methodology for designing and implementing a scalable solution:

### 1. System Requirements and Specification

- **Load and Energy Demand Assessment:** The process begins with evaluating the energy demands of the site where the solar PV system will be installed. This includes understanding the peak load requirements, the average daily consumption, and the potential variability in energy needs.
- **Battery and PV Module Sizing:** Based on the energy assessment, the size of the PV array and battery capacity is determined. The objective is to ensure optimal sizing for efficient energy generation and storage without overloading the system.

### 2. DC-DC Converter Design

- **Selection of Converter Topology:** The appropriate converter topology (e.g., buck, boost, buck-boost) is selected based on the system's voltage levels, the output from the PV modules, and the battery voltage.
- **Maximum Power Point Tracking (MPPT):** An MPPT algorithm is integrated into the DC-DC converter to ensure that the system continuously operates at the point of

maximum power extraction from the PV array, even under varying sunlight and temperature conditions.

- **Efficiency Optimization:** High-efficiency components, such as low-resistance MOSFETs and optimized control circuits, are used to minimize power losses in the conversion process.

### 3. Battery Management System (BMS) Design

- **Charging/Discharging Control:** The BMS is designed to ensure proper charging and discharging of the battery, using algorithms that monitor the state of charge (SOC), state of health (SOH), and temperature. The system prevents overcharging and deep discharging, which can damage the battery and reduce its lifespan.
- **Thermal Management:** A thermal management strategy is implemented to ensure the battery operates within safe temperature limits, improving overall performance and safety.
- **Protection Mechanisms:** The BMS includes fault detection systems for over-voltage, under-voltage, overcurrent, and short-circuit protection to enhance the safety and reliability of the system.

### 4. Integration with Solar PV Modules

- **DC Bus Configuration:** The DC-DC converter is configured to operate in tandem with the solar PV array and the battery. The DC bus voltage is regulated to maintain compatibility between the energy sources and the load.
- **Hybrid System Considerations:** If the system is part of a hybrid setup (e.g., grid-tied or with other renewable sources), the integration will include appropriate control strategies for switching between the grid and solar power, depending on energy availability.

### 5. Control Strategy and Algorithms

- **Advanced Control Algorithms:** Smart control algorithms are implemented to manage energy flow efficiently. The system adapts dynamically to fluctuations in solar energy production and load requirements to balance power generation and storage.
- **Energy Prioritization:** The control system prioritizes battery charging when excess solar energy is available and switches to battery discharge when solar generation is insufficient to meet the load demand.

- **Load Shedding Mechanism:** A load shedding mechanism can be integrated to manage critical and non-critical loads during periods of low energy availability.

#### 6. Monitoring and Data Logging

- **Real-Time Monitoring:** The system is equipped with real-time monitoring capabilities, allowing for remote data collection on battery performance, PV output, and load consumption. This data helps in making informed decisions regarding system operation and maintenance.
- **Data Logging for Performance Analysis:** Long-term performance data is recorded for trend analysis and system optimization. This includes monitoring solar irradiation, energy output, battery health, and overall system efficiency.

#### 7. System Testing and Validation

- **Simulation and Prototyping:** Before full-scale deployment, the system design is simulated to verify its performance under different operating conditions. Prototypes are built to test the converter efficiency, battery management algorithms, and overall system integration.
- **Field Testing:** The system is installed at the site for real-world validation, where it is tested for energy efficiency, battery performance, and reliability under varying weather and load conditions.

#### 8. Implementation and Maintenance Plan

- **Installation and Commissioning:** The system is installed by qualified professionals following the design specifications. Commissioning tests are conducted to ensure that the system operates as intended.
- **Maintenance Schedule:** A maintenance plan is developed, including routine inspections, battery checks, and component replacements to ensure long-term performance and reliability.

### 3. Analysis and Result

Typically, a solar array converts only 30-40% of incident solar radiation into electricity. To improve energy generation, a power tracking system is necessary, which matches the source impedance with the load impedance. On the source side, a boost converter is connected to the solar array to increase the output voltage. The operating cycle of the

converter's switches is adjusted to ensure the source and load impedance remain aligned, maximizing the energy transfer and system efficiency.

#### a) Output DC Power

Figure 3 illustrates the output voltage, current, and power waveforms generated from MATLAB simulations at two different irradiance levels ( $1000 \text{ W/m}^2$  and  $600 \text{ W/m}^2$ ) while maintaining a constant temperature of  $25^\circ\text{C}$ . The simulation shows how the reduction in solar irradiance significantly decreases the current and power output, while the voltage remains relatively stable with only slight fluctuations due to changes in the number of charge carriers affected by the irradiation levels.

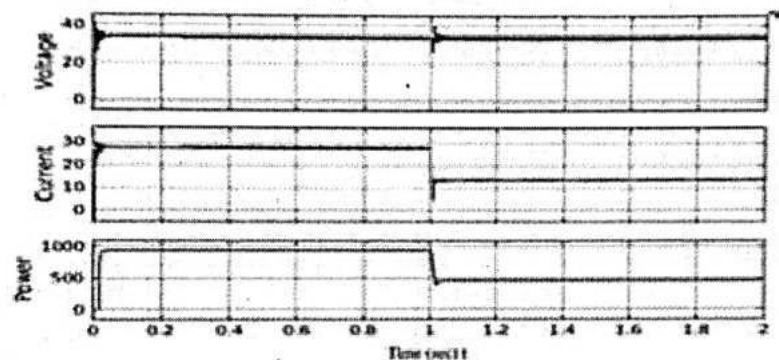


Figure 3: Output result of solar PV

It is observed that when incident irradiance decreases at  $t = 1 \text{ second}$ , the number of charge carriers generated within the solar PV module drops significantly. This reduction in charge carriers leads to a sharp decline in current, which in turn results in a substantial decrease in the power harnessed from the solar PV modules. The decrease in irradiation directly impacts the efficiency of power generation, highlighting the dependence of solar PV performance on sunlight availability.

#### b) Output of Battery

The Figure 4 shows that the battery's output voltage initially decreases over time (1 second) and stabilizes at  $25.6\text{V}$ . This behavior indicates that the battery's terminal voltage increases as solar irradiance rises. The higher the irradiance, the more energy is available for the battery to charge, resulting in a corresponding increase in its output voltage. This correlation between irradiance and battery performance highlights the dependence of the charging process on the available solar energy.

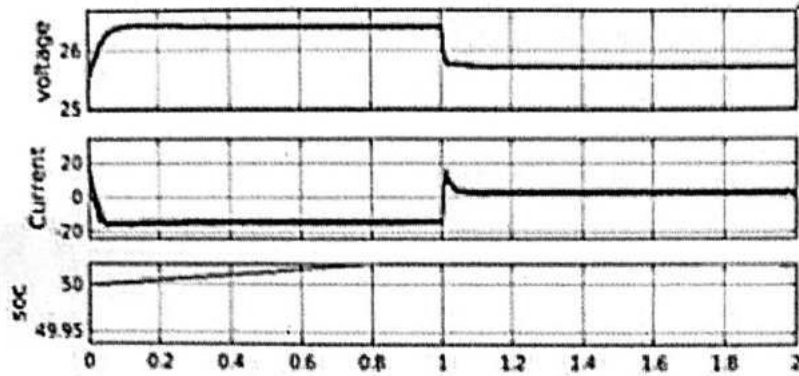


Figure 4: Output of Battery

c) Output Voltage of DC Load

The DC power generated by the solar panel is supplied to the inverter, which converts it into AC power for use by AC loads, as illustrated in Figure 4. Figure 5 depicts the battery's output voltage over time (1 second), showing a decrease that stabilizes at 25.6V. This observation indicates that the battery's terminal voltage increases with rising irradiation levels, demonstrating the positive correlation between solar energy availability and battery performance.

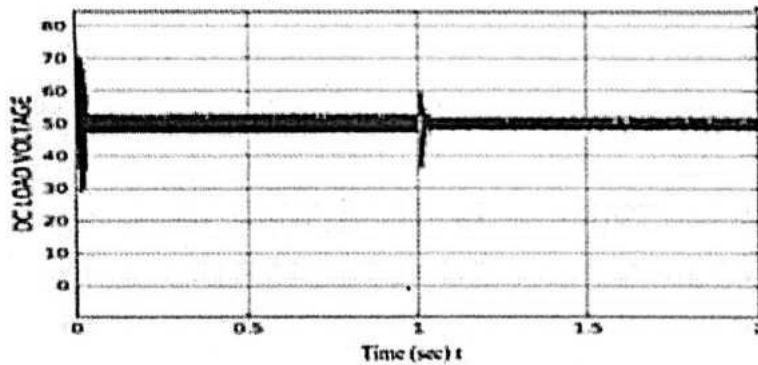


Figure 5: DC Voltage across Load

d) Output Current of DC Load

The DC power generated by the solar panel is directed to the inverter, which converts it into AC power for supplying the AC load. The output current of the single-phase resistive load is illustrated in Figure 6.

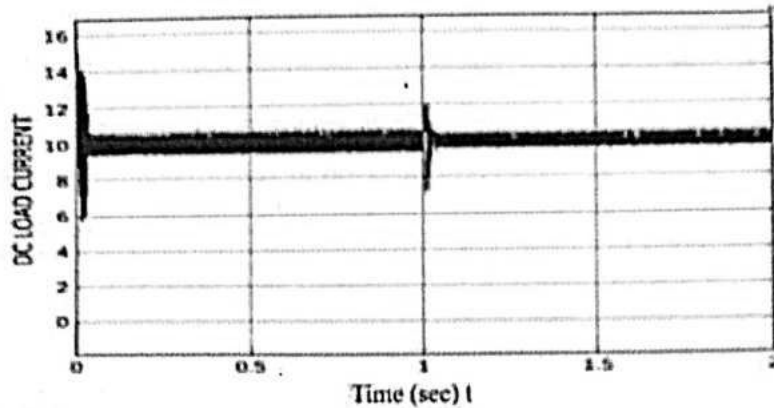


Figure 6: DC Current across Load

The voltage and current waveforms for the DC load remain nearly constant, exhibiting only minor ripples within acceptable error limits. A change in illumination at  $t = 1$  second results in a spike in both the voltage and current waveforms; however, the boost converter effectively stabilizes and compensates for these fluctuations, ensuring that the output remains consistent.

#### 4. Summary

This document outlines the development of a DC-DC battery management system for standalone solar photovoltaic (PV) applications. The system integrates a boost converter and advanced control algorithms to optimize energy conversion and enhance overall efficiency. Key features include maximum power point tracking (MPPT) to adapt to changing environmental conditions, ensuring stable voltage and current outputs despite fluctuations in solar irradiance.

The findings demonstrate a strong correlation between solar energy availability and battery performance, indicating that higher irradiance levels improve battery charging. This system offers a reliable and efficient solution for managing energy storage in solar PV installations, with potential for further optimization and integration of additional energy sources in future work.

#### 5. Conclusion

A comprehensive DC-DC battery management system for standalone solar photovoltaic (PV) applications. The methodology effectively integrates a boost converter and advanced control algorithms to optimize energy conversion, ensuring maximum power extraction from the solar array while maintaining battery health and performance.



Our findings highlight the importance of implementing maximum power point tracking (MPPT) to adapt to varying environmental conditions, which significantly enhances energy efficiency. The system's design facilitates stable voltage and current outputs, even during fluctuations in solar irradiance, thanks to the responsive features of the boost converter.

Additionally, the results demonstrate a clear correlation between solar irradiance and battery output voltage, affirming that increased solar energy availability directly improves battery charging performance. This emphasizes the system's suitability for applications where reliable energy storage and management are critical.

Overall, this DC-DC battery management system presents a practical solution for enhancing the efficiency and reliability of solar PV systems, contributing to the broader adoption of renewable energy technologies. Future work will focus on further optimizing the control algorithms and exploring the integration of additional energy sources to enhance system versatility and performance.



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## UTILIZATION CERTIFICATE

Sub: R&D consultancy projects- reg

Project Title: Methodology for DC-DC Battery Management System for Solar PV Modules

S. No	Sanction Letter Date	Amount	Description
1	VISTAS/Registrar/2023-2024/30 dated 22.08.2023	Rs.2,11,300/-	Certified that out of Rs.2,07,000/- of grant Sanctioned during the year 2023-2024 in favour of Dr.B.Rubini under letter no.VISTAS/Registrar/2023-2024/30 dated 19.09.2024 given in the margin, a sum of Rs.2,11,300/- has been utilized for the purpose of the project for "Methodology for DC-DC Battery Management System for Solar PV Modules"

Certified that the conditions on which the grant was sanctioned have been duly fulfilled and that the money was actually utilized for the purpose for which it was sanctioned. The expenditure statement duly signed is enclosed.

Signature of the Faculty

To : Registrar

Signature of HOD

Head of the Department  
Department of Electrical and  
Electronics Engineering  
School of Engineering  
Vels Institute of Science, Technology &  
Advanced Studies, Chennai - 600117.



# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
(Deemed to be University Estd. u/a 3 of the UGC Act, 1956)  
PALLAVARAM - CHENNAI

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Sub : R&D consultancy projects- reg

Project Title: Compact Design of DC-DC Power Converter for Autonomous Underwater Vehicle

### DETAILS OF EXPENDITURE

S. No	Description	Amount(Rs)
1	Outsourcing Charges, R& D	52,825
2	Engineering Design Work	42,260
3	Raw materials/ Consumables / Spares	31,695
4	Fabrication / Manufacturing charges for PoC & Prototype Development	42,260
5	Testing and Validation / Laboratory Verification / Certification	21,130
6	Commercialization Support Services / Consulting / Feasibility Studies / Strategies to Market Entry Support	21,130
	<b>Total Amount(Rs)</b>	<b>Rs 2,11,300.00</b>

  
Signature of the Faculty

To : Registrar

  
Signature of HOD

Head of the Department  
Department of Electrical and  
Electronics Engineering  
School of Engineering  
Vels Institute of Science, Technology &  
Advanced Studies, Chennai - 600117.



MR.R. VENKATACHALAM, INR TECHNOLOGIES, NO18/6, VEERAPANDI NAGAR  
1ST STREET, CHOOLAIMEDU, CHENNAI

Date: 10.08.2023

TO

Dr. P. R. Ramakrishnan

Dean & Professor,

Department of Management Studies,

VISTAS,

Pallavaram.

Dear Sir

Sub: Requesting to conduct Market Survey for Business Development – Reg.

Greetings!

We are involved in experimental Development activities to provide a consultancy project entitled “**Market Survey for Business Development**” like Reliance, Airtel, and Consulting for Cost Reduction, & Marketing Research to the sum of Rs.6.25 Lakhs to the Department of Management Studies, VISTAS, and Pallavaram. I respectfully request you to kindly to do the needful.

Thanking you,

Proprietor

Mr.R.Venkatachalam.

Date :15.09.2023

To

Mr. R. Venkatachalam,  
INR Technologies,  
No18/6, Veerapandi Nagar  
1<sup>st</sup> Street, Choolaimedu,  
Chennai.

Dear Sir/Madam

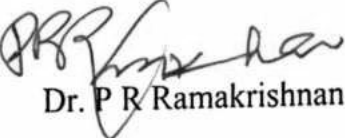
Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

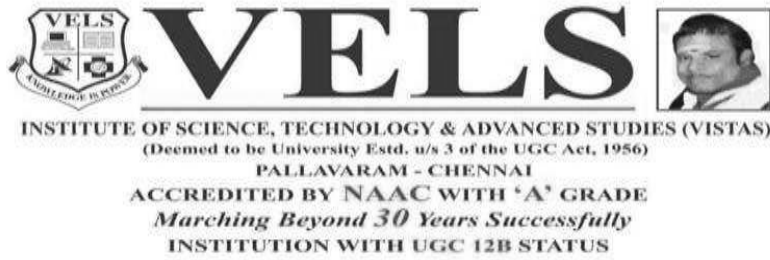
Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the industry.

Thanking you,

Yours Sincerely

  
Dr. P R Ramakrishnan

Dean and Professor,  
School of management studies,  
VISTAS



## **Market Survey for Business Development**

**Principal Investigator**

**Dr. P. R. Ramakrishnan**

**Dean & Professor, School of Management Studies,**

**VISTAS, Pallavaram, Chennai-600117**

**Beneficiary of the Consultant Work**

**Mr. R. Venkatachalam,**

**INR Technologies**

**No: 18/6 Veerapandi Nagar,**

**1<sup>ST</sup> Street Choolaimedu, Chennai**

## **Introduction**

INR Technologies undertook a consultancy project titled “Market Survey for Business Development” for the Department of Management Studies, VISTAS, Pallavaram. The objective of this project was to provide strategic insights and actionable recommendations for business growth and cost reduction, leveraging methodologies tailored to companies like Reliance and Airtel. The consultancy was conducted with a project budget of Rs. 6.25 lakhs.

The report aims to present the findings and recommendations of the market survey while elucidating its significance in enhancing operational efficiency and fostering sustainable growth for businesses.

## **Objectives**

1. To conduct a comprehensive market survey focusing on business development opportunities.
2. To analyze the marketing strategies and competitive positioning of industry leaders such as Reliance and Airtel.
3. To identify potential areas for cost reduction in operational and marketing domains.
4. To provide actionable recommendations to improve marketing efficiency and customer outreach.
5. To enable the Department of Management Studies at VISTAS to utilize the findings for academic and practical applications.

## **Methodology**

The methodology adopted for this consultancy project consisted of the following key components:

### **1. Primary Research:**

- Surveys and structured interviews with stakeholders, including industry professionals, consumers, and marketing executives.
- Focus groups to gather qualitative insights into customer behavior and preferences.

## **2. Secondary Research:**

- Analysis of existing market reports, industry publications, and case studies of Reliance and Airtel.
- Benchmarking against best practices in marketing and cost management.

## **3. Data Analysis:**

- Quantitative analysis using statistical tools to interpret survey results.
- Qualitative content analysis to derive themes and actionable insights from interviews and focus group discussions.

## **4. Comparative Analysis:**

- Evaluation of cost structures, marketing strategies, and performance metrics of Reliance, Airtel, and similar organizations.
- Identification of gaps and opportunities for improvement.

## **5. Stakeholder Consultations:**

- Regular interaction with the Department of Management Studies to align objectives and validate findings.

## **Suggestions**

### **1. Cost Reduction Strategies:**

- Streamline supply chain operations by adopting digital tools and AI-based solutions.
- Optimize marketing budgets by reallocating funds to high ROI channels such as digital marketing and influencer collaborations.
- Leverage economies of scale through partnerships and bulk procurement agreements.

### **2. Marketing Research and Development:**

- Invest in consumer behavior analytics to better understand market trends.
- Enhance customer engagement through personalized marketing strategies.
- Implement loyalty programs and targeted promotions to retain existing customers.

### **3. Business Development Opportunities:**

- Explore untapped markets, particularly in Tier-2 and Tier-3 cities, for new customer acquisition.
- Diversify service offerings to cater to niche markets and emerging demands.



- Focus on digital transformation to improve operational efficiency and customer experience.
- 4. Knowledge Dissemination:**
- Develop workshops and training programs for students and faculty at VISTAS based on the findings of this project.
  - Establish a repository of case studies and best practices to facilitate future research and consultancy work.

## **Conclusion**

The market survey and subsequent analysis conducted by INR Technologies have highlighted critical insights and recommendations for business growth and cost reduction. The strategies suggested are designed to align with industry best practices, particularly those exemplified by Reliance and Airtel. The actionable recommendations aim to enhance operational efficiency, foster market expansion, and improve customer engagement.

This project underscores the importance of strategic marketing and operational excellence in achieving sustainable business success. By implementing these recommendations, organizations can not only optimize costs but also capitalize on new opportunities for growth. The Department of Management Studies at VISTAS stands to benefit significantly from the insights generated, which can inform both academic and practical applications.

## **Outcome**

1. Identification of cost-saving opportunities and efficient marketing strategies for businesses.
2. Creation of a detailed repository of market insights and competitive strategies.
3. Enhanced collaboration between INR Technologies and VISTAS, fostering a knowledge-sharing ecosystem.
4. Strengthened capabilities of students and faculty at VISTAS through actionable insights and training programs.
5. Development of a scalable model for future consultancy projects involving academic and industry partnerships.

17<sup>th</sup> August 2023

Chennai

To

Dr. P.Balaji, M.Pharm, PhD.,  
Professor, Department of Pharmacology  
School of Pharmaceutical Sciences  
Vels Institute of Science Technology & Advanced Studies  
Chennai - 600 117

Dear Sir

Sub: Request for doing the research work entitled “Complement system Alternate pathway stimulant activity: A Potential anti-infective agents” - Reg

Greetings! We are involved in Research activities in Immunology – Complement System and its application. In the process of the Alternate Pathway Stimulant activity, our company would like to provide a consultancy project entitled “Complement system Alternate pathway stimulant activity: A Potential anti-infective agents”. Based on the personal discussion I hereby agree to proceed with the work for the sum of Rs. 6,25,000/- (Including GST) to the Department of Pharmacology, School of Pharmaceutical Sciences, VISTAS. I respectfully request you to kindly do the needful. Thanking you,

Regards

*Savithri Shivakumar*



**Aaranya Biosciences Private Limited**

Facility : Plot 17, M/s. Golden Jubilee Biotech Park For Women Society, Siruseri Village, Fourth Main Second Cross,  
Inside SIPCOT-IT Park, Old Mahabalipuram Road, Navalur P.O., Kanchipuram District - 603103,  
Mobile : +91 94456 85025 / +91 90805 96908 / E-Mail : savithiri.shivakumar@aaranyabiosciences.com  
Regd. Off : #4-1-216/154, G1, Karthikeya Nagar, Nacharam, Hyderabad - 500076, India.



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
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PALLAVARAM - CHENNAI

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19.09.2023

To

**Dr Savithiri Shivakumar**

Director

Aaranya BiosciencePrivate Ltd,

Plot 16 & 17, Golden Jubilee Biotech Park For Women Society,

Fourth Main road Second Cross Street,

Siruseri SIPCOT-IT Park Inside,

Navalur P.O.,Chennai Pin :603103,Tamilnadu.

Respected Sir

**Sub: Thanks and Confirmation for the Consultancy Work - Reg**

Warm Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. In this regard, we extend our fullest support and co-operation from our end in completion of the work "Complement system Alternate pathway stimulant activity: A Potential anti-infective agents". Based on the personal discussion I am happy to proceed with the work for the sum of Rs. 6,25,000/- (Including GST)

Thanking you,

Yours Sincerely

Dr. P. Balaji

Professor, Department of Pharmacology,

School of Pharmaceutical Sciences

VISTAS



### **Consultancy Research Projects**

1. Name of the Faculty : Dr. P. Balaji, Professor
2. Department : Pharmacology, School of Pharmaceutical Sciences
3. Title of the Proposed Project : Complement system Alternate pathway stimulant activity: A Potential anti-infective agents
4. Duration of the project : 1 Year
5. Brief details of work to be carried out:

#### **Origin of the Research Problem:**

Management of infectious disease is one of the difficult problems faced by under developed countries and developing countries like India. There is a vicious cycle in the management of infectious disease.

Managed by appropriate anti-infective agents, mainly antibiotics, apart from preventive measures including vaccination programmes. Antibiotics are becoming ineffective as the microbes develops resistance, exorbitant cost they also come with its own side effects and also long term use of antibiotic can cause irreversible damage to immune system. So, Antimicrobials therapy is not a long lasting solution for management of microbial infection.

Hence it is better to manage microbial infection by strengthening the immune system so that the infection can be taken care of by body defense mechanism itself instead of using antimicrobial agents.

There are few publications which prove beyond doubt that the herbs which protect host tissue against infection may not have antimicrobial activity. "Fever is mostly due to microbial

infection and large number of herbal drugs is being used for fever. These herbal drugs are might be a cure for fever not only due to antipyretic action but also for the infection”.

“Fever is mostly due to microbial infection and large number of herbal drugs is being used for fever. These herbal drugs are might be a cure for fever not only due to antipyretic action butalso for the infection”.

Hence any plant which is used for the treatment of fever can have potential immunostimulating effect including activation of complement system. Complement system (CS) is a part of immune system; consist of nine different proteins (Plasma Proteins) denoted by C1-C9 which are present in human beings and animals in inactive form. These proteins can be activated by three routes: classical pathway (CP), alternate pathway (AP) and lectin pathway (LP).

Among various immune responses to microbial infection, complement system is a strong feature of innate immunity and alternate pathway is the first line defense against various infectious conditions. Many synthetic agents and herbal extracts have been reported to activate the complement system CP such as *Picrorhiza scrophulariiflora*, *Tamarindus indica* and Asteraceae family.

There are very few reports on agents that enhance Alternate pathway activity, such as Levamisole, Trichosanthin, *Aloe vera*, *Agaricus blazei* Murill have been reported. Few plants are reported to decrease alternate pathway activity thereby finding application as immunosuppressant in organ transplantation.

Further many herbal preparations and synthetic compound are reported to enhance complement system alternate pathway to protect the fish against microbial infections. Hence, similar effect can be expected in case of human beings and animals also.

#### **Research potential in the field of complement system:**

Much work has been done on agents increasing the activity of classical pathway – Immunostimulant activity. Only limited work is done on Alternate pathway & Lectin pathway - Immunostimulant activity.

These two pathways are first line defense mechanism against invading pathogen. Hence work can be carried out to explore agents activating these two pathways.

**Methodology:**

1. Selection of herbal drugs and preparations (used for the treatment of fever)
2. Preparation of aqueous extracts of the herb / preparation as per the procedure followed in traditional system of medicine
3. Freeze drying the extract using Lyophiliser
4. Evaluation of the freeze dried product for complement system alternate pathway activity in Guinea pig animal model using Goat RBC as antigen (However the animal model and animal experimental protocol will be finalised based on the approval by Institutional animal ethics committee)
5. Evaluation of the freeze dried product for immunostimulant activity viz: Humoral Antibody titre, Delayed type hypersensitivity response, total leukocyte count Differential leukocyte count.
6. Selection of herbal drugs/ preparations based on the above studies for further phytochemical investigation with a view to isolate the compound / fraction having the required activity.

Three plants from the following list will be selected for the study (may be permitted to modify based on fresh inputs)

- a. *Enicostemma axillare*
- b. *Toddalia Asiatica*

### **c. Review of Research and Development in the Subject:**

#### **International status**

There is growing awareness on the need for alternate therapy for the treatment of infectious disease other than the use of anti infective agents. As can be seen from the literature survey attempts are being made to find effective immunostimulants. Though not directly claimed as immunostimulants, the herbal drugs which are believed to increase the general health are being marketed as nutraceuticals. There is growing market potential for nutraceuticals in western countries. This is to circumvent the stringent FDA regulations. The search for immunostimulant agent is not restricted to plants but some synthetic agents have also been tried. Levamisole (J. Pharm. Pharmacol.; 1990; 42; 58 – 59) hexacosanamide derivatives (Drugs – Future; 1996; 21 (Feb) 152 -154) and murocastin (Drug – Future 1989; 14 (May); 432 – 438) have been reported to have immunostimulant property. Some of the immunostimulant agents have also been reported to be useful in the treatment of various carcinomas (Drug – exp – clin – Res.; 1991; 17, 139 – 143).

If these drugs are studied scientifically and systematically it is possible to find a promising API for the treatment of infectious disease.

#### **National status**

At national level some of the individual herbs have been screened for their immunostimulant property. Indian Institute of Chemical Biology, Kolkata have isolated Immunomodulatory principles from neem, berberin and guduchi ('The Hindu' October 19, 2003). Researchers from CDRI Lucknow have demonstrated specific and non – specific immunostimulant activity in the ethanolic extract of the various parts of *Nyctanthes arbor – tristis*. L (J. Ethanopharmacol.; 1994; 42 (1); 31 – 37) and *Andrographis paniculata* (J. Nat. prod.; 2002, 56, 995 – 999). S. Godhwani et al have described the immuno regulatory profile of *Ocimum sanctum* (J. Ethanopharmacol.; 1998; 24 (Dec); 193 – 198). S. A. Dahanukar et al have reported a list of ayurvedic rasayanas exhibiting immunostimulant activity in animal models. (Phytomedicine 1997; 4 (4); 359 – 368). The picture at the international level is little different.

Significance of the study

**Its potential contribution to knowledge in the field of social relevance or national importance:**

The problems of combating infectious diseases are:

- No effective drug available for the treatment of certain infections like AIDS, Hepatitis
- For other infections the existing antibiotics are becoming less effective due to the development of microbial resistance, necessitating the search for newer antimicrobial agents
- Implementation of WTO norms, will enormously increase the cost of newer effective antibiotics due to stringent product patent norms.

Under these circumstances, unless we develop our own remedies, common Indian may not be able to afford the high cost of the new drugs. The Indian system of medicine is a potential source of drug for commercial exploitation. Already isolates of turmeric and neem have been patented in USA.

The present study will yield preparations for the treatment of infectious disease like AIDS, Hepatitis, and Tuberculosis etc. Since these preparations do not act directly on the microbes, they will not produce resistant strain. Further these preparations will be cheaper and will not have side effects.

Further research in this line might results in isolating an API which can serve as “lead” compound for further development.

6. Expenditure for which seed money is required:

S.NO	Head	Amount in Rs.
1.	Field work (Plant Collection) and travels	15,000.00
2.	Lyophilization	5,000.00
3.	Reference Collection & Authentication.	5,000.00
4.	VBS – Mg – EGTA buffer	2,75,000.00
5.	Rabbit RBC	1,00,000.00
6.	Normal Human Serum	50,000.00
7.	Other Chemicals	1,15,000.00
8.	ELISA Plates, Glasswares & Consumables	30,000.00
9.	Sample Testing in ELISA Reader	30,000.00
<b>Grand Total</b>		<b>6,25,000.00</b>



## 7. Time Line :

### **FIRST QUARTER:**

#### **EXTRACTION AND PURIFICATION**

Leaves of *Enicostema axillare* & Root bark of *Toddalia asiatica* were collected from Tirunelveli district and the above plants were authenticated by Dr. V. Chelladurai, Research Scientist, Botany (Scientist – C), Centre for research on Ayurvedha and Siddha, Palayamkottai, Tirunelveli Dist, Govt. of India.

Preparation of Extract Fresh plant material was, washed under running tap water to remove adhering material, dried under shade, pulverized in a mechanical grinder and passed through sieve # 40. The 25g powder of each dried leaves of *Enicostema axillare* (EA), and dried root bark of *Toddalia asiatica* (TA) was extracted separately by boiling with distilled water (1:20, w/v) for 6 hrs and then filtered. Other portions of the distilled water were added to the marc and the extraction was repeated until the last extract was colorless. The combined extract was concentrated in a rotary evaporator at a temperature not exceeding 50°C.

### **SECOND QUARTER:**

#### **TARGETS ACHIEVED:**

The resulting concentrate was Lyophilised. The yield was 28.48% w/w for aqueous extract of *Enicostema axillare* (AEEA), 19.04% w/w for aqueous extract of *Toddalia asiatica* (AETA).

### **THIRD QUARTER**

***In vitro* alternate pathway haemolytic activity of selected plants having immunomodulatory activity: (*Enicostemma Axiallare*)**

#### ***In vitro* alternate pathway haemolytic activity**

The assay was performed in flat-bottom 96-well microtitre plates (Tarsons - 941196). 5mg / ml solutions of Levamisole (Standard drug) and AEEA in triplicate, were prepared separately in VBS – AP buffer. Further dilutions were made in the micro-centrifuge tubes (1:4, 1:8, 1:16, 1:32, 1:64, 1:128, 1:256) with the VBS – AP buffer resulting in a final volume of 100 µL in each tube. Subsequently, 25 µL of HS was added to each tube. After incubating for 30 min at 37 °C, 25 µL RbE suspension was added to each tube and the tubes

were incubated at 37 °C for 60 min. Subsequently, the tubes were centrifuged at 1000 g for 6 min. 50 µL of the supernatant was transferred to flat-bottom microtiter plate (Tarsons - 941196), mixed with 200 µL water and the absorbance was measured at 412 nm in an ELISA automatic plate reader (Multiscan EX). Controls in this assay consisted of RBC incubated in distilled water (Total lysis), RBC incubated in buffer (Blank) and the colour of HS-dilution (complement blank). The absorbance of complement blank was subtracted from absorbance values of test serum to get the corrected absorbance of test serum. Percentage haemolysis for each dilution was calculated by using the following formula:

**Percentage haemolysis (y)**

$$= \frac{(\text{Absorbance of test serum} - \text{Absorbance of blank})}{(\text{Absorbance of Total lysis} - \text{Absorbance of blank})} \times 100$$

The concentration of drug / extract required for producing 50% haemolysis was calculated from the graph.

**TARGETS ACHIEVED:**

From the studies carried out, it can be concluded that the aqueous extract of leaves of *Enicostemma axillare* (AEEA) have immunostimulant activity.

**FOURTH QUARTER:**

***In vitro* alternate pathway haemolytic activity of selected plants having immunomodulatory activity: (*Toddalia Asiatica*)**

***In vitro* alternate pathway haemolytic activity**

The assay was performed in flat-bottom 96-well microtitre plates (Tarsons - 941196). 5mg / ml solutions of Levamisole (Standard drug) and AETA in triplicate, were prepared separately in VBS – AP buffer. Further dilutions were made in the micro-centrifuge tubes (1:4, 1:8, 1:16, 1:32, 1:64, 1:128, 1:256) with the VBS – AP buffer resulting in a final volume of 100 µL in each tube. Subsequently, 25 µL of HS was added to each tube. After incubating for 30 min at 37 °C, 25 µL RbE suspension was added to each tube and the tubes were incubated at 37 °C for 60 min. Subsequently, the tubes were centrifuged at 1000 g for 6 min. 50 µL of the supernatant was transferred to flat-bottom microtiter plate (Tarsons - 941196), mixed with 200 µL water and the absorbance was measured at 412 nm in an ELISA automatic plate reader (Multiscan EX). Controls in this

assay consisted of RBC incubated in distilled water (Total lysis), RBC incubated in buffer (Blank) and the colour of HS-dilution (complement blank). The absorbance of complement blank was subtracted from absorbance values of test serum to get the corrected absorbance of test serum.

Percentage haemolysis for each dilution was calculated by using the following formula:

**Percentage haemolysis (y)**

$$= \frac{(\text{Absorbance of test serum} - \text{Absorbance of blank})}{(\text{Absorbance of Total lysis} - \text{Absorbance of blank})} \times 100$$

The concentration of drug / extract required for producing 50% haemolysis was calculated from the graph.

**TARGETS ACHIEVED:**

From the studies carried out, it can be concluded that the aqueous extract of root bark of *Toddalia asiatica* (AETA) have immunostimulant activity.

**8. Deliverables :**


Perhaps these two activities may be due to different chemical constituents of the plant and the plant extracts as a whole would be a better choice for treating infections rather than pure active constituents of the plant.

Plant extracts as a whole stimulate immune system in a controlled way when compared to single synthetic compound like levamisole.

An amount of Rs. 2,00,000/- may please be sanctioned towards seed money for the aboveproject. Copy of the project report/technical paper will be submitted immediately on completion of the project.



**Signature of the Faculty**



**Signature of HOD**

**To: Registrar**



# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)

(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)

PALLAVARAM - CHENNAI

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## **Complement system Alternate pathway stimulant activity: A Potential anti-infective agents**

**Consultancy Project Report for 2023-2024**

Submitted by

**Dr.P. BALAJI**

PROFESSOR

DEPARTMENT OF PHARMACOLOGY

SCHOOL OF PHARMACEUTICAL SCIENCES

VELS INSTITUTE OF SCIENCE, TECHNOLOGY AND ADVANCED STUDIES

PALLAVARAM, CHENNAI – 600 117

## CONTENTS

<b>S.NO</b>	<b>TITLE</b>
1.	Abstract
2.	Objective
3.	Methodology
4.	Summary and Conclusion
5.	Outcome
6.	References

## ABSTRACT

The effect of aqueous extracts of leaves of *Enicostemma axillare* (AEEA) and aqueous extract of root bark of *Toddalia asiatica* (AETA) on in vitro complement system alternate pathway (AP) activity was evaluated and compared with that of the known immunostimulant levamisole. The results suggest that there is a concentration dependent increase in the AP activity for levamisole, AEEA and AETA.

## OBJECTIVE

Under the above aim the work was carried out with the following objectives:

1. To prepare the aqueous extracts of selected medicinal plants and characterization by preliminary phytochemical investigation.
2. To screen the aqueous extracts of the plants, reported to possess the immunomodulatory activity, for their effect on *in vitro* complement system alternate pathway activity.

The following plants have been selected based on folklore uses for the evaluation of immunomodulatory activity:

1. *Encostemma axillare* (Lam.) A. Rayanal
2. *Toddalia asiatica* (Lam.)

## METHODOLOGY

### MATERIALS:

The selected plants were collected and authenticated or purchased from local market. Herbal preparations were purchased from local market. All other chemicals used were of analytical grade / guaranteed reagent grade.

### METHODS

Aqueous extracts of *Enicostema axillare* and *Toddalia asiatica* were prepared by decoction followed by freeze drying and the aqueous extracts were characterized by preliminary phytochemical investigation.

Aqueous extracts of *Enicostemma axillare* (AEEA) and aqueous extracts of *Toddalia asiatica* (AETA) were evaluated for immunomodulatory activity

#### ***In vitro* alternate pathway haemolytic activity**

The assay was performed in flat-bottom 96-well microtitre plates (Tarsons - 941196). 5% w/v solutions of Levamisole (Standard drug), AEEA and AETA, in triplicate, were prepared separately in VBS – AP buffer. Further dilutions were made in the micro-centrifuge tubes (1:4, 1:8, 1:16, 1:32, 1:64, 1:128, 1:256) with the VBS – AP buffer resulting in a final volume of 100  $\mu$ L in each tube. Subsequently, 25  $\mu$ L of HS was added to each tube. After incubating for 30 min at 37 °C, 25  $\mu$ L RbE suspension was added to each tube and the tubes were incubated at 37 °C for 60 min. Subsequently, the tubes were centrifuged at 1000 g for 6 min. 50  $\mu$ L of the supernatant was transferred to flat-bottom microtiter plate (Tarsons - 941196), mixed with 200  $\mu$ L water and the absorbance was measured at 412 nm in an ELISA automatic plate reader (Multiscan EX). Controls in this assay consisted of RBC incubated in distilled water (Total lysis), RBC incubated in buffer (Blank) and the colour of HS-dilution (complement blank). The absorbance of complement blank was subtracted from absorbance values of test serum to get the corrected absorbance of test serum.



Calculate Percentage haemolysis for each dilution using the following formula:

**Percentage haemolysis (y)**

$$= \frac{(\text{Corrected absorbance of test serum} - \text{Absorbance of blank})}{(\text{Absorbance of Total lysis} - \text{Absorbance of blank})} \times 100$$

Plot the percentage lysis (vertical axis) versus the drug concentration on the horizontal axis.

## SUMMARY AND CONCLUSION

**Summary:** The complement system is an essential component of the innate immune response, playing a crucial role in defending the host against infections. Among its pathways, the alternative pathway is particularly significant in providing rapid responses to pathogens. Various agents have been identified as stimulants of the alternative pathway, enhancing its activity and potentially bolstering the immune system's ability to combat infections. These agents range from microbial products to synthetic compounds, each with distinct mechanisms of action. By stimulating the alternative pathway, these agents can enhance the host's ability to recognize and eliminate pathogens, offering potential as anti-infective agents.

**Conclusion:** The alternative pathway of the complement system represents a promising target for the development of anti-infective agents. By modulating its activity through stimulants, researchers have identified potential strategies to enhance innate immunity against pathogens. Further research is needed to elucidate the mechanisms underlying the stimulant activity of these agents and to evaluate their efficacy and safety in clinical settings. Additionally, exploring synergies with existing antimicrobial therapies could offer novel approaches to combating infections, particularly those caused by multidrug-resistant pathogens. Overall, harnessing the stimulant activity of the alternative complement pathway holds significant promise in the ongoing efforts to develop effective anti-infective agents and improve outcomes for patients with infectious diseases.

From the studies carried out, it can be concluded that the aqueous extract of leaves of *Enicostemma axillare* (AEEA) and aqueous extract of root bark of *Toddalia asiatica* (AETA) have both antibacterial activity as well as immunostimulant activity. Perhaps these two activities may be due to different chemical constituents of the plant and the plant extracts as a whole would be a better choice for treating infections rather than pure active constituents of the plant.

Plant extracts as a whole stimulate immune system in a controlled way when compared to single synthetic compound like levamisole.

## OUTCOMES

The research on complement system alternate pathway stimulant activity as potential anti-infective agents has several potential outcomes and implications:

1. **Development of Novel Therapeutics:** The identification and characterization of agents that stimulate the alternative pathway of the complement system can lead to the development of novel anti-infective therapeutics. These therapeutics could offer alternative or complementary approaches to existing antimicrobial drugs, particularly in cases of drug-resistant infections.
2. **Enhancement of Innate Immune Response:** By targeting the complement system, particularly the alternative pathway, researchers aim to enhance the host's innate immune response against a wide range of pathogens. This approach could lead to more effective immune-based treatments for infectious diseases, potentially reducing the reliance on antibiotics and minimizing the development of antimicrobial resistance.
3. **Improved Treatment Strategies:** Understanding the mechanisms underlying the stimulant activity of these agents can provide insights into how to optimize treatment strategies for infectious diseases. This may involve combination therapies that target both the complement system and specific pathogens, as well as personalized approaches based on individual immune responses.
4. **Potential for Immunomodulation:** Beyond their direct antimicrobial effects, complement system stimulants may have broader immunomodulatory effects. They could modulate inflammation, enhance immune surveillance, and improve immune memory, which could have implications for treating not only infections but also immune-mediated diseases.
5. **Clinical Translation:** Translating these research findings into clinical practice requires further investigation, including preclinical studies and clinical trials. Successful translation could lead to the approval and adoption of new anti-infective agents that target the complement system, improving patient outcomes and reducing the burden of infectious diseases.

In conclusion, research on complement system alternate pathway stimulant activity as potential

anti-infective agents holds promise for advancing our understanding of host-pathogen interactions and developing innovative therapies to combat infectious diseases. Continued research in this area has the potential to revolutionize the treatment of infections and improve global public health outcomes.

From the work it can be concluded that herbals/botanicals have immunomodulatory effect and usefulness in the treatment of diseases which may develop to further immune disorders. Herbal drugs have promising profile as far as drug development from natural source is concerned. One can expect herbal to acts as lead compound for development of economical, effective and nontoxic immunomodulatory agent.

Further experiments are needed to purify and establish the chemical nature of the principles and which possible component is essential to activate this pathway.

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## **INLEAD MANAGEMENT SERVICE**

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Phone no.: 9840625658

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GSTIN: 33BGRPS4461B1ZB

State: 33-Tamil Nadu

24.08.2023

To

Dr. G. Gayathri

Associate Professor

Department of Microbiology

School of Life Sciences

VISTAS

Chennai-600117.

Dear Sir,

Sub: Request- Food Sample Testing- reg.

I am writing to request you to perform test on the biofilm formation in the paneer samples and to give your report. I request you to analyse the samples and we understand that conducting these analyses may require resources and expertise. We are willing to cover any associated costs to the Department of Microbiology, VISTAS. We are looking forward for your prompt attention and confirmation at your earliest convenience.

Thanking you,

Yours Sincerely



Siraj Kareem

**INLEAD MANAGEMENT SERVICE**  
93/26, Kalaignar Street  
Indra Nagar, Pattur



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)

(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)

PALLAVARAM - CHENNAI

ACCREDITED BY NAAC WITH 'A' GRADE

*Marching Beyond 25 Years Successfully*

Date: 07.09.2023

To

Mr.Siraj Kareem

Inlead Management Services

No.93/26, Indira Nagar, Pattur, Mangadu.

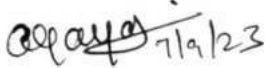
Chennai-122.

Sir,

**Sub:** Confirmation for the Consultancy Work – reg.

With reference to your letter dated 24.08.2023 regarding the consultancy work, I extend my profound thanks for the opportunity to contribute our expertise and skills to your consultancy firm. The analysis of the paneer samples for biofilm formation will be carried out and the report will be submitted to you after completion.

Thanking you.

 7/9/23

Yours Sincerely

Dr. G. Gayathri

Associate Professor

Department of Microbiology

School of Life Sciences

VISTAS



## **Report**

### **Analysis of Biofilm forming bacteria in Paneer Samples**

**Principal Investigator**

**Dr. G. Gayathri**

**Professor and Head**

**Department of Microbiology, School of Life Sciences**

**VISTAS**

**Beneficiary of the Consultant Work**

**InLead Management Service,**

No. 93/26 Kalaignar Street

Indra Nagar, Pattur, Chennai – 600122

Contact No. 098406 25658

## INTRODUCTION

Food borne diseases have been a serious food safety concern in both developed and developing countries. These infections range from milder illness to severe infections necessitating the need for hospitalizations and increased economic loss. Above all, severe infections may also be fatal. The contamination of foods can occur at any step in the whole supply chain ranging from farm to table and number of sources can attribute to contamination like environmental, animal and human sources. This becomes more important when it comes to contamination by pathogenic microorganisms as it can lead to severe public health problems that may sometimes be fatal (Sharma *et al.*, 2019).

Paneer, a variety of soft cheese also known as Indian cottage cheese, is a dairy product obtained by acid and heat coagulation of buffalo or cow milk and due to its high moisture and rich nutrients makes a favorable food matrix for microbial growth and rapid spoilage, thereby culminating as highly perishable food item with low shelf life (Sharma *et al.*, 2019).

According to the Food Safety & Standard Authority of India, FSSAI, paneer refers to the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid, or citric acid. It shall not contain more than 70% moisture and milk fat content shall not be less than 50.0% of the dry matter. It has rich nutritional value and is a considered a culinary delight in India. As it has rich protein content it is considered a suitable source of protein for lactovegetarians.

It has been found that about 4-5% of the total milk produced in India is converted into paneer. Paneer has a short life span of about 2-3 days at refrigeration storage without much deterioration in the quality, but freshness of the product is lost after 1 day (Girdharwal, 2018). Although during the manufacturing of paneer, the milk is exposed to high temperature, which itself is sufficient to kill most of microorganism (including pathogens) but the post process contamination, which includes environmental exposure of water and air, restrict the shelf life of paneer.

Occurrence of high number of *E. coli* and other food borne pathogens have been reported in the paneer (Sharma *et al.*, 2019). Ensuring quality foods in the market is essential in terms of consumer safety. Hence analysis of foods for its quality is a significant measure which includes physical, chemical and biological analyses. Microbiological analysis of a food sample is an

important step in determining the quality of a food product. As paneer is a rapidly perishable product, without appropriate production and storage conditions, it gets contaminated and may pose health threat in the consumers resulting in outbreaks of food borne infections. Microbial adaptations and growth at low temperatures impose challenge to safety of highly perishable paneer. Bacterial biofilm is one of the major hazards facing the food industry. Biofilm-forming ability is one of the most important virulence properties of bacterial pathogens.

## **METHODOLOGY**

The present study was carried out to know the quality of two brands of paneer (A and B respectively) for the following quality parameters: sensory quality of all paneer samples (colour, body and texture, and flavour), chemical quality (moisture, fat) and microbial analysis (total bacterial count, yeast and mold count, coliform count, *Staphylococcus aureus* count and *E. coli* as well as *Salmonella* sp. detection). The study also analyzed the two brands of paneer for the presence of biofilm forming bacteria.

The refrigerated packages were put in ice box and brought to the laboratory for analysis. All ten brands of paneer that were submitted were totaled to 55 samples. As soon as the samples were brought to the laboratory, the following details on the packages were recorded: weight, cost, nutritional labeling, FSSAI license logo, manufacturer's address, etc. The packets were cut open and the appearance and colour were noted.

**Microbial Analysis:** The samples for microbiological analysis were prepared under aseptic conditions. A sanitized set of pestle and mortar was taken for macerating the sample. Approximately 1 gm of the paneer sample was weighed aseptically in a sterile 100 ml glass beaker and it was transferred aseptically to the sanitized mortar with the help of a sterile stainless steel spatula. The sample was then macerated thoroughly by making a paste using small quantity of previously warmed (45°C) 100 ml of Ringer's solution and the contents were transferred to the same conical flask to obtain first dilution (1 : 10). Further dilutions were prepared using 9 ml quantity of citrate buffer from the first dilution as per the requirements. The dilutions were used immediately for plating purpose. Total viable count, yeast and mold count, and coli-form counts of paneer were determined according to FSSAI guidelines. *Staphylococcus aureus* count, *E. coli* count of paneer and *Salmonella* detection were also carried out.

## **Study on Biofilm Formation in Paneer**

Both brands A and B paneer samples were analyzed for the presence of biofilm forming bacteria. For this, 1 ml of the macerated paneer samples were inoculated in Trypticase Soy Broth and incubated at 37 ° C for 24 hours. The bacteria was then inoculated in Lactobacillus MRS Agar and Trypticase Soy Agar plates and incubated at 30 ° C for 18-24 hours. The bacterial colonies were then analyzed for biofilm formation by Microtiter plate method, Tube method and Congo red agar method.

### **Microtiter plate method**

The bacterial isolates were assessed for biofilm production by the microtiter plate method as described by Christensen *et al.*, (1985). Briefly, fresh cultures of *K. pneumoniae* with final cell density of  $1 \times 10^6$  CFU / ml at OD<sub>560</sub> were loaded in sterile microtiter plates with sterile Mueller Hinton broth as negative control. After removing the planktonic cells following incubation, the adherent biofilms were stained with 0.5% crystal violet for 5 minutes. Determination of biofilm production was done by observing the plates in microplate reader at OD<sub>620</sub>.

### **Tube method**

Assay for biofilm formation in the bacterial isolates was carried out following the procedure of Christensen *et al.*, (1985) after staining with 0.5% crystal violet for 5 minutes. After drying the tubes, the biofilm formation was confirmed with the presence of a visible film lining the walls of the tubes. Biofilm intensity is scored as 1-weak or none, 2 – moderate and 3-high or strong (Hassan *et al.*, 2011). The results were compared with control strain and the test was carried out in triplicates and repeated thrice.

### **Congo red agar method**

The bacterial isolates were inoculated into congo red agar and were incubated for 24 hours at 30 °C. Biofilm formation was indicated by black colonies with a dry, crystalline consistency (Hassan *et al.*, 2011).

## **RESULTS**

The visual color of paneer samples varied from whitish to slightly yellowish white. Fresh paneer usually has a spongy compact body and smooth texture. Brand "A" was softer when compared to brand "B".

Chemical Quality of Paneer Samples: It was observed that brand "A" had more moisture content (54%) when compared to brand "B" (50%). The fat content of the brand "A" was lower when compared to brand "B".

Microbiological Quality: Aerobic plate counts of paneer samples of brands "A" and "B" were in the range of  $2.1 \times 10^4$  colony forming units (CFU)/gm, yeast and mold count 124 CFU/gm. Coliforms, *S. aureus* and *Salmonella* sps were not detected in any of the samples.

Biofilm formation: The tissue culture plate (TCP), Tube method and Congo red method did not show biofilm formation in the paneer samples.

## **SUMMARY**

The paneer samples' visual color ranged from pale to slightly yellowish white. Fresh paneer typically has a smooth texture and a spongy, compact consistency. Brand "A" was softer when compared to brand "B". Brand "A" had more moisture content (54%) when compared to brand "B" (50%). The fat content of the brand "A" was lower when compared to brand "B". No biofilm formation was detected in Brands "A" and "B".

## **CONCLUSION**

The microbiological quality of all the samples were in par with fssai standards in both Brand "A" and Brand "B". No biofilm formation was detected in Brands "A" and "B".



5<sup>th</sup> September 2023 Chennai

To

Dr. D.Rohini, M.Sc.,M.phil, PhD.,  
Assistant Professor,  
Biochemistry  
Vels Institute of Science Technology & Advanced Studies  
Chennai - 600 117

Dear Madam,

Sub: Request for the research work entitled “*Invitro* and *insilico* studies of biosynthesis silver nanoparticles using bryonia plant extract against rheumatoid arthritis” - reg

Greetings! We are involved in Research activities in synthesis of nanoparticles from plant extract and its application. In this process, our company would like to provide a consultancy project entitled “*Invitro* and *insilico* studies of biosynthesis silver nanoparticles using bryonia plant extract against rheumatoid arthritis”. Based on the personal discussion I hereby agree to proceed with the work for the sum of Rs. 2, 00,000/- (Including GST) to the Department of Biochemistry, School of Life Sciences, and VISTAS. I request you to kindly do the needful. Thanking you,

Regards

Savithri Shivakumar



**Aaranya Biosciences Private Limited**

Facility : Plot 17, M/s. Golden Jubilee Biotech Park For Women Society, Siruseri Village, Fourth Main Second Cross,  
Inside SIPCOT-IT Park, Old Mahabalipuram Road, Navalur P.O., Kanchipuram District - 603103,  
Mobile : +91 94456 85025 / +91 90805 96908 / E-Mail : savithiri.shivakumar@aaranyabiosciences.com  
Regd. Off : #4-1-216/154, G1, Karthikeya Nagar, Nacharam, Hyderabad - 500076, India.



### Consultancy Research Projects

1. Name of the Faculty : Dr. D. Rohini
2. Department : Biochemistry, School of life sciences
3. Title of the Proposed Project : **Invitro And Insilico Studies Of Biosynthesis Silver Nanoparticles Using *Bryonia* Plant Extract Against Rheumatoid Arthritis**
4. Duration of the project : 1 Year
5. Brief details of work to be carried out:

### INTRODUCTION

Rheumatoid arthritis (RA), a chronic inflammatory disease, which mainly affects the joints of the body. It is characterized by joint swelling, discomfort, inflammation which gradually causes joint damage and deformity. Like other forms of arthritis, such as osteoarthritis, RA is characterized by an abnormal immune response in which the body's own healthy tissues especially the synovium, the thin membrane lining the joints are wrongly attacked by the immune system. Although the precise origin of rheumatoid arthritis remains undetermined, a combination of hereditary and environmental factors is considered to be responsible. A family history of RA, being female (since women are more typically affected than males), and smoking are among the risk factors that may increase the chance of getting the disease. However, it's important to note that anyone can develop rheumatoid arthritis, regardless of these risk factors. Many patients suffer significant side effects or partial illness remission even with the availability of biologics, non-steroidal anti-inflammatory medications (NSAIDs) and synthetic disease-modifying anti-rheumatic medicines (DMARDs). Exploring alternative treatment modalities, especially using medicinal plants with anti-inflammatory and immunomodulatory qualities is becoming progressively more common as an outcome.

Medicinal plants are a rich source of bioactive compounds known for their therapeutic properties, including anti-inflammatory and antioxidant activities. Many traditional plants have been used for centuries in the treatment of inflammatory conditions like arthritis. *Bryonia*, a genus of plants belonging to the Cucurbitaceae family, has been used in traditional medicine for centuries. Species such as *Bryonia alba* and *Bryonia dioica*, are particularly effective in treating rheumatic and inflammatory diseases. These plants are abundant in bioactive substances such as alkaloids, flavonoids, and saponins with anti-inflammatory, analgesic, and immunomodulatory properties. In herbal treatments, the roots of the *Bryonia* plant have long been used to cure inflammatory illnesses and significantly reduce pain and swelling. According to modern pharmacological research, *Bryonia* could suppress important pro-inflammatory mediators including tumour necrosis factor-alpha (TNF- $\alpha$ ), cyclooxygenase-2 (COX-2) and interleukin-6 (IL-6), which are all important initiators of the inflammatory cascade in rheumatoid arthritis (RA). Furthermore, the antioxidant qualities of *Bryonia* may help lower oxidative stress, which is a major contributor to the development of RA. The biofabrication of silver nanoparticles was achieved through the reduction of silver ions by the phytochemicals present in the *Bryonia* plant extract, eliminating the need for hazardous chemicals and high energy processes. By elucidating its mode of action and determining the specific bioactive substances in *Bryonia* that provide its therapeutic benefits, both in vitro and in silico research plays a critical role in verifying the anti-rheumatic activity of the medicinal plant.

This project aims to explore the therapeutic potential of a selected medicinal plant, both through in vitro cell line assays and in silico molecular docking studies, to assess its efficacy against rheumatoid arthritis.

## **OBJECTIVES**

- To assess the anti-inflammatory and antioxidant potential of the biosynthesis of silver nanoparticles using *Bryonia* plant extract (nanocomposite) on cell lines relevant to RA.
- To carry out in silico studies to predict the binding affinity of bioactive compounds from the nanocomposite with key targets involved in RA pathogenesis.
- To investigate the molecular mechanism through which the biosynthesis of silver nanoparticles using *Bryonia* plant extract (nanocomposite) may exert its therapeutic effect on RA.

## **METHODOLOGY**

### **In vitro cell line studies**

#### **1. Identification of Cell Lines:**

- Macrophage cell lines (like RAW 264.7) and synovial fibroblasts (like MH7A) are used to imitate the inflammatory environment in RA.

#### **2. Plant Extract Preparation:**

- A hydro-ethanolic extract of the therapeutic plant will be prepared.
- The phytochemical analysis will be carried out to identify the presence of important bioactive substances such as flavonoids, alkaloids, and terpenoids, phytochemical analysis will be carried out.

#### **3. Synthesis of silver nanoparticles:**

- The biofabrication of silver nanoparticles (nanocomposite) was achieved through the reduction of silver ions by the phytochemicals present in the *Bryonia* plant extract, eliminating the need for hazardous chemicals and high-energy processes.

#### **4. Assay for Cell Viability:**

- The cytotoxicity of the nanocomposite will be assessed using standard procedures like trypan blue exclusion or MTT Assay.

#### **5. Anti-inflammatory Assay:**

- The cell lines will be treated with either TNF- $\alpha$  or LPS (lipopolysaccharide) to stimulate an inflammatory response.
- Using ELISA or qRT-PCR, the effect of the nanocomposite on the production of pro-inflammatory cytokines (TNF- $\alpha$ , IL-6, and IL-1 $\beta$ ) will be assessed.

#### **6. Measurement of Oxidative Stress Markers:**

- The levels of ROS (Reactive Oxygen Species) and the activity of antioxidant enzymes will be measured.

### **In Silico Studies**

#### **1. Selection of a Target:**

- Important RA targets, including NF- $\kappa$ B, COX-2, TNF- $\alpha$ , IL-6, and JAK-STAT, will be selected for the in silico investigation.

## **2. Compound Selection:**

- Molecular docking will be performed using the phytochemical components of the plant extract.

## **3. Molecular Docking:**

- The 3D structures of target proteins will be obtained from the Protein Data Bank (PDB).
- Phytochemical ligand structures will be retrieved from PubChem and other databases.
- The binding affinity of the drugs to the RA targets will be determined by docking tools, such as AutoDock or Schrödinger.

## **4. Simulations of Molecular Dynamics:**

- After docking, the stability and conformational changes of the ligand-protein complexes will be evaluated using molecular dynamics (MD) simulations.

5. Expenditure for which consultancy project is required:

<b>S.NO</b>	<b>Head</b>	<b>Amount in Rs.</b>
	Plant Extraction and Phytochemical Analysis	<b>25,000.00</b>
	Biosynthesis of Silver Nanoparticles	<b>50,000.00</b>
	Cell culture Reagents and Assays	<b>75,000.00</b>
	Software Licensing for In Silico Studies	<b>25,000.00</b>
	Miscellaneous Supplies	<b>25,000.00</b>
	<b>Grand Total</b>	<b>2,00,000.00</b>

**7. Time Line** :

<b>WORK</b>	<b>TIMELINE</b>
Literature Review	1 month
Selection of Plant and Phytochemical Analysis	2 months
Biosynthesis of Silver Nanoparticles	2 months
In vitro Cell line Experiments	3 months
In Silico Docking Studies	2 months
Data Analysis and Report Writing	2 months
<b>Total Duration</b>	<b>1 year</b>

**8. Deliverables** :

Perhaps these two activities may be due to different chemical constituents of the plant and the plant extracts as a whole would be a better choice for treating disease rather than pure active constituents of the plant.

Plant extracts as a whole stimulate immune system in a controlled way when compared to single synthetic compound like levamisole.

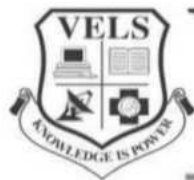
An amount of Rs.2,00,000/- may please be sanctioned towards consultancy project for the above project. Copy of the project report/technical paper will be submitted immediately on completion of the project.



**Signature of the Faculty**



**Signature of HOD**



# VELS



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)

(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)

PALLAVARAM - CHENNAI

ACCREDITED BY NAAC WITH 'A' GRADE

*Marching Beyond 30 Years Successfully*

## INVITRO AND INSILICO STUDIES OF BIOSYNTHESIS SILVER NANOPARTICLES USING *BRYONIA* PLANT EXTRACT AGAINST RHEUMATOID ARTHRITIS

**Consultancy Project Report for 2023-2024**

Submitted by

**Dr.D.Rohini**

ASSISTANT PROFESSOR

DEPARTMENT OF PHARMACOLOGY

SCHOOL OF PHARMACEUTICAL SCIENCES

VELS INSTITUTE OF SCIENCE, TECHNOLOGY AND ADVANCED STUDIES

PALLAVARAM, CHENNAI – 600 117



## CONTENTS

<b>S.NO</b>	<b>TITLE</b>
1.	Abstract
2.	Objective
3.	Methodology
4.	Summary and Conclusion
5.	Outcome
6.	References

## ABSTRACT

Silver nanoparticles (AgNPs) have garnered significant attention for their potential biomedical applications, particularly in the treatment of inflammatory diseases. This study explores the biosynthesis of silver nanoparticles using *Bryonia* plant extract, aiming to evaluate their efficacy against rheumatoid arthritis (RA). The green synthesis of AgNPs is characterized through various analytical techniques such as UV-Vis spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM) to confirm nanoparticle formation, size, and morphology.

In vitro studies were conducted to assess the anti-inflammatory and antioxidant properties of the synthesized AgNPs using enzyme inhibition assays and free radical scavenging methods. In addition, an in silico molecular docking analysis was performed to evaluate the interaction of AgNPs with key molecular targets involved in rheumatoid arthritis, such as TNF- $\alpha$  and COX-2. The results demonstrated that the *Bryonia*-based AgNPs exhibit potent inhibitory effects on inflammatory mediators, suggesting their potential as a therapeutic agent for rheumatoid arthritis.

The study highlights the eco-friendly synthesis of silver nanoparticles using plant extracts and their promising role in combating autoimmune diseases such as RA. Further investigations into their mechanism of action, biocompatibility, and clinical applications are warranted.

## OBJECTIVE

Under the above aim the work was carried out with the following objectives:

- To assess the anti-inflammatory and antioxidant potential of the biosynthesis of silver nanoparticles using *Bryonia* plant extract (nanocomposite) on cell lines relevant to RA.
- To carry out in silico studies to predict the binding affinity of bioactive compounds from the nanocomposite with key targets involved in RA pathogenesis.
- To investigate the molecular mechanism through which the biosynthesis of silver nanoparticles using *Bryonia* plant extract (nanocomposite) may exert its therapeutic effect on RA.

## METHODOLOGY

- **Materials:**

- **Plant extract:** Fresh *Bryonia* plant leaves were collected, washed thoroughly, and air-dried. The dried leaves were powdered and used to prepare an aqueous extract by boiling the powder in distilled water.
- **Silver nitrate (AgNO<sub>3</sub>):** Analytical grade silver nitrate (AgNO<sub>3</sub>) was used as the precursor for the synthesis of silver nanoparticles.
- **Reagents for biological assays:**
  - DPPH (2,2-diphenyl-1-picrylhydrazyl) for antioxidant assays
  - Bovine serum albumin (BSA) for anti-inflammatory assays
  - TNF- $\alpha$  and COX-2 enzyme inhibitors for molecular docking studies.
- **Software for in silico analysis:** Molecular docking simulations were performed using AutoDock and other computational tools for target-protein binding studies.

- **Synthesis of Silver Nanoparticles (AgNPs):**

- **Preparation of plant extract:** The aqueous extract of *Bryonia* was prepared by adding 10 g of powdered leaves to 100 mL of distilled water. The mixture was heated at 60°C for 30 minutes and then filtered to obtain the clear extract.
- **Biosynthesis of AgNPs:** To synthesize silver nanoparticles, 10 mL of the *Bryonia* extract was mixed with 90 mL of 1 mM silver nitrate (AgNO<sub>3</sub>) solution and stirred at room temperature. The reduction of Ag<sup>+</sup> ions was visually monitored by the appearance of a yellowish-brown color in the solution, indicating the formation of AgNPs.
- **Characterization of AgNPs:**
  - **UV-Vis Spectroscopy:** The formation of AgNPs was confirmed by recording the UV-Vis absorption spectrum in the range of 300-800 nm to detect the characteristic surface plasmon resonance (SPR) band of AgNPs.
  - **X-Ray Diffraction (XRD):** The crystalline nature of the synthesized nanoparticles was analyzed using XRD patterns, and the average size of the nanoparticles was calculated using the Debye-Scherrer equation.

- **Scanning Electron Microscopy (SEM):** The surface morphology and size of the nanoparticles were examined using SEM.

- **In Vitro Studies:**

- **Antioxidant Assay (DPPH Method):** The antioxidant activity of the synthesized AgNPs was assessed by their ability to scavenge DPPH free radicals. Various concentrations of AgNPs were mixed with DPPH solution, and the absorbance was measured at 517 nm. The percentage inhibition of DPPH radicals was calculated to determine antioxidant capacity.
- **Anti-inflammatory Assay (BSA Denaturation Method):** The anti-inflammatory potential of AgNPs was evaluated by studying their inhibitory effect on BSA denaturation. The reaction mixture, containing different concentrations of AgNPs and BSA, was incubated, and the absorbance was measured at 660 nm. The inhibition percentage of protein denaturation was used to assess anti-inflammatory properties.

- **In Silico Studies:**

- **Molecular Docking:** In silico molecular docking was performed to analyze the interaction between silver nanoparticles and key targets involved in rheumatoid arthritis, such as tumor necrosis factor-alpha (TNF- $\alpha$ ) and cyclooxygenase-2 (COX-2). The structures of the target proteins were retrieved from the Protein Data Bank (PDB), and docking simulations were carried out using AutoDock to study the binding affinity and interaction patterns.
- **Analysis of Docking Results:** The docking scores and binding energy values were analyzed to predict the efficacy of the *Bryonia*-based AgNPs in inhibiting inflammatory pathways associated with rheumatoid arthritis.

- **Statistical Analysis:**

- All experimental data were expressed as mean  $\pm$  standard deviation (SD). The results from biological assays were statistically analyzed using one-way ANOVA, followed by Tukey's post-hoc test. A p-value of less than 0.05 was considered statistically significant.

## SUMMARY AND CONCLUSION

**Summary:** This study investigates the biosynthesis of silver nanoparticles (AgNPs) using Bryonia plant extract and their potential therapeutic effects against rheumatoid arthritis (RA). The green synthesis of AgNPs was confirmed using UV-Vis spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM).

In vitro assays demonstrated that Bryonia-based AgNPs possess strong antioxidant and anti-inflammatory properties. In silico molecular docking studies further revealed that AgNPs effectively interact with key rheumatoid arthritis targets, such as TNF- $\alpha$  and COX-2, indicating their potential to inhibit inflammatory pathways. The results highlight the eco-friendly synthesis of AgNPs and their promising application as a treatment for RA.

**Conclusion:** This research provides an integrated in vitro and in silico technique to investigate a novel treatment strategy against rheumatoid arthritis utilizing a medicinal plant. If this initiative is completed successfully, subsequent clinical research may be possible and the plant's usage in RA will have scientific validation.

## OUTCOMES

- By lowering the production of important pro-inflammatory cytokines and oxidative stress indicators in the cell line studies, the *Bryonia* plant is anticipated to exhibit strong anti-inflammatory action.
- Strong binding affinities of the bioactive substances of the Plant extract to RA-related molecular targets are anticipated to be revealed by in silico research, offering mechanistic insight into the possible therapeutic activity of the *Bryonia* plant.

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CHOLAMANDALAM INVESTMENT AND FINANCE COMPANY LIMITED

22.09.2023

To

Dr.M.Kotteeswaran

Associate Professor

Department of MBA

VISTAS

Pallavaram, Chennai

Dear Sir

Sub: Requesting Consultancy Service on 5S Systems implementation process – Regarding

Greetings

We are involved in total quality management aspects to provide consultancy services entitled “5S System Implementation Process to the Sum of Rs.5, 25,000 (Five Lakhs Twenty Five Thousands) to the Department of Management Studies, VISTAS, Pallavaram. I request you to kindly do the needful.

Thanking You

HR Manager

Ms.Divya S

Date: 09.11.2023

To  
Mrs.S.Divya  
HR Manager,  
Cholamandalam Investment and Finance Company Limited  
ASV Adarsh Tower, 719, Pathari road, off,  
Anna Salai, Chennai,  
Tamil Nadu 600001<sup>st</sup> Street, Choolaimedu,  
Chennai.

Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the industry.

Thanking you,

Yours Sincerely



Dr. M.Kotteeswaran  
Associate Professor,  
School of management studies,  
VISTAS



# VELS



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## **5S System Implementation Process**

**Principal Investigator**

**Dr. M. Kotteswaran**

**Associate Professor, School of Management Studies,**

**VISTAS, Pallavaram, Chennai-600117**

**Beneficiary of the Consultant Work**

**Mrs. Divya. S**

**HR Manager**

**Cholamandalam Investment and Finance Company Limited**

**AVS Adarsh Towers, 719, Pathari Road Off.**

**Anna Salai, Chennai - 600001**

## **Introduction**

Cholamandalam Investment and Finance Company Limited (CIFCL) has established itself as a leader in the financial services sector, offering a range of products such as vehicle finance, home loans, SME loans, and investment advisory services. To maintain its competitive edge and ensure operational excellence, CIFCL has sought consultancy services to implement the 5S system. The consultancy aims to enhance the company's Total Quality Management (TQM) framework by improving workplace organization, efficiency, and safety through the systematic implementation of the 5S methodology. This report outlines the objectives, methodology, suggestions, and outcomes associated with the proposed implementation.

## **Objectives**

The primary objectives of implementing the 5S system at CIFCL are as follows:

1. **Enhance Workplace Efficiency:** Streamline operations by organizing the workspace to minimize waste and maximize productivity.
2. **Improve Employee Engagement:** Foster a culture of discipline and responsibility by involving employees in maintaining organized and clean work environments.
3. **Ensure Safety:** Reduce workplace hazards by maintaining cleanliness and orderly practices.
4. **Increase Customer Satisfaction:** Achieve higher service quality standards by enhancing operational effectiveness.
5. **Support Continuous Improvement:** Lay the foundation for sustained organizational growth and improvement within the TQM framework.

## **Methodology**

To implement the 5S system effectively, the following systematic approach will be adopted:

1. **Initial Assessment:**
  - Conduct a comprehensive audit of existing workplace practices, identifying inefficiencies and areas needing improvement.
  - Engage with employees to gather insights into operational challenges and opportunities for enhancement.



## 2. **Training and Awareness:**

- Organize workshops and training sessions for employees across all levels to educate them about the principles and benefits of the 5S system.
- Develop customized training materials that align with CIFCL's specific operational requirements.

## 3. **Implementation of 5S Steps:**

- **Sort (Seiri):** Identify and remove unnecessary items from workspaces to reduce clutter.
- **Set in Order (Seiton):** Arrange necessary items for easy accessibility and systematic usage.
- **Shine (Seiso):** Ensure cleanliness and maintenance of work areas to promote a healthy working environment.
- **Standardize (Seiketsu):** Establish consistent practices and standards for maintaining the improvements achieved.
- **Sustain (Shitsuke):** Implement regular audits and foster a culture of continuous adherence to the 5S principles.

## 4. **Monitoring and Evaluation:**

- Develop key performance indicators (KPIs) to measure the effectiveness of the 5S implementation.
- Conduct periodic reviews to identify successes, challenges, and areas requiring further action.

## 5. **Documentation and Reporting:**

- Maintain detailed records of the implementation process, outcomes, and feedback.
- Provide regular updates to the Department of Management Studies, VISTAS, Pallavaram.

## **Suggestions**

1. **Employee Involvement:** Encourage employee participation in all stages of the 5S implementation process to ensure buy-in and sustained adherence.
2. **Leadership Commitment:** Secure strong commitment and support from CIFCL's leadership to drive the change effectively.

3. **Resource Allocation:** Allocate necessary resources, including time and budget, to facilitate successful implementation.
4. **Technology Integration:** Leverage technology to monitor and manage 5S activities efficiently.
5. **Recognition and Rewards:** Establish a system to recognize and reward employees who contribute significantly to the success of the 5S implementation.

## **Conclusions**

The implementation of the 5S system at CIFCL is expected to deliver substantial improvements in workplace organization, efficiency, and safety. By fostering a culture of discipline and continuous improvement, the initiative will enhance employee satisfaction, operational performance, and customer service quality. Moreover, aligning the 5S system with CIFCL's TQM goals will ensure sustainable growth and competitiveness in the financial services sector.

## **Outcome**

Upon successful implementation of the 5S system, CIFCL can expect the following outcomes:

1. **Improved Productivity:** Reduction in time wastage and streamlined operations leading to higher productivity.
2. **Enhanced Employee Morale:** Increased job satisfaction through better workplace conditions and engagement.
3. **Higher Quality Standards:** Achievement of superior service delivery through organized and efficient processes.
4. **Cost Savings:** Reduction in operational inefficiencies and wastage resulting in cost optimization.
5. **Strengthened Reputation:** Enhanced customer trust and market competitiveness by demonstrating commitment to quality management.

This consultancy engagement underscores the importance of systematic and disciplined approaches in achieving organizational excellence. The implementation of the 5S system will empower CIFCL to maintain its leadership position in the financial services industry while fostering a culture of quality and continuous improvement.

---

**project vels college - eee department**

1 message

---

**GAGETS** <gagets.dev@gmail.com>  
To: hodeee@velsuniv.ac.in  
Cc: Rubini <rubini.se@velsuniv.ac.in>

Tue, Dec 12, 2023 at 10:35 AM

Dear HoD - EEE, VISTAS,

I hope this email finds you well. My name is Mr. S. Vinoth Kumar , and I am reaching out to you on behalf of Global Association for Green Energy Technological Skills (GAGETS). We are interested in exploring the possibility of engaging your consultancy services for a project we are currently planning.

**Project Overview: Automated and Self Powered Solar Panel Cleaning Robot**

The objective was to develop a cutting-edge cleaning robot capable of identifying anomalies on solar panels, ensuring efficient information transmission, optimizing battery management, and providing user-friendly control options. This project

We believe that your expertise would greatly contribute to the success of this project, and we are excited about the prospect of working together. We look forward to receiving your proposal and discussing the details further.

Best Regards,

S. Vinoth kumar

Gagets india



## ABSTRACT

All In One Solar Street light is a compact integrating Solar panels, LED light, Battery and a PIR motion sensor. The solar street lights absorb the solar energy during daytime. The solar energy gets converted into electrical energy by the photovoltaic cells or solar cells, which is stored in the battery. Due to its compact size, this light can be easily mounted on pole top by anyone. Light is operated on automatically and the electricity already stored in the battery gets consumed. Most solar lights turn on and turn off automatically by sensing outdoor light using solar panel voltage. The light has automatic dusk to dawn operation and needs negligible maintenance once installed. This automation of street lights do not need the human intervention and saved energy will be redirected to other poles or it can be used in other work. The All in One Solar Street light uses high quality material and is designed for Indian environments. In this project the infrared sensor detects any dust particle it will automatically gets clean by using the water flow from solenoid valve. They also provide external Theft Protection for solar kit and indication are provided by Alarm Hooter.

# TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	1
	LIST OF FIGURES	2
1.	INTRODUCTION	5
	1.1 GENERAL	5
	1.2. OVERVIEW OF SOLAR STREET LIGHT	5
	1.2.1 SOLAR PANNEL	6
	1.2.2 LIGHTING FIXTURE	6
2.	METHODOLOGY AND EXITING AND PROPOSED SYSTEM	7
	2.1 PROBLEM DEFINATION	8
	2.2 METHODOLOGY	8
3.	SYSTEM BLOCK DIAGRAM	9
4.	SYSTEM DESCRIPTION	14
	CONCLUSION	19
	REFERENCES	21

# CHAPTER 1

## INTRODUCTION

### 1.1. GENERAL

All In One Solar street light is a compact integrating Solar panels, LED light, Rechargeable Battery, Infrared sensor, and a PIR motion sensor. All In One Solar street light uses a PIR motion sensor to adjust the LED light brightness intelligently. On detecting any movement in 12m radius around the light, the LED glows at full brightness. If no movement is detected for more than 1 minute, the brightness is reduced to low. This intelligent brightness control coupled with maintenance free Rechargeable battery technology provides longer backup time and better battery life. Due to its compact size, this light can be easily mounted on pole top by anyone. The light has automatic dusk to dawn operation and needs negligible maintenance once installed. The All in One Solar Street light uses high quality material and is designed for Indian environments.

### 1.2. OBJECTIVES

To compensate the growing energy demand by using Renewable energy source as solar. To light the street of rural areas with transmission lines as well as solar power where there is so many power cuts occurs. Low power consumption, Longevity, Reliability our product. Low maintenance. This solar energy mainly useful in solar street lights, Auto solar irrigation system, and Traffic junction signal lighting, etc. Installing solar street lights provides an opportunity to extend parks night time opening hours or promote access to outdoor sports facilities. In addition to encouraging people to visit public places after dark, it also improves their safety.

### 1.3. SCOPE

In the future, we can expect to see solar street lights integrated with other smart city systems such as traffic lights, waste management systems, and public safety systems. This integration will improve the efficiency and effectiveness of these systems while reducing energy consumption.

## OVERVIEW OF SOLAR STREET LIGHT

Solar Street lights are raised light sources which are powered by solar-panels generally mounted on the lighting structure or integrated into the pole itself. The solar panels charge a rechargeable battery, which powers a fluorescent or LED lamp during the night.

### 1.3.1 SOLAR PANEL

The solar panel is one of the most important parts of a solar street light, as the solar panel can convert solar energy into electricity that the lamps can use. There are two types of solar panels commonly used in solar street lights: mono-crystalline and poly-crystalline. The conversion rate of mono-crystalline solar panels is much higher than their poly-crystalline counterparts. Solar panels also vary in wattage systems.

# CHAPTER - 2

## METHODOLOGY

### PROBLEM STATEMENT AND METHODOLOGY

#### 2.1 PROBLEM DEFINITION

There are usually four reasons why the solar street lamp can't light up at all. The common one is that the controller in the light pole is flooded and a short circuit occurs. Therefore, firstly check whether there are water marks and rust on the terminal of the controller. If this happens, it is most likely that the controller is damaged due to water ingress. You can use a multimeter to measure the resistance at both ends of the loop. If the resistance is too small, it is generally a short circuit. At this time, you need to replace the controller. After the solar street light has been used for a period of time, even if there is enough sun light at day, it may encounter that the lighting time of street light is short and the lighting cannot be provided normally on cloudy and rainy days. The cause of this situation is likely to be a problem with the battery and its power storage capacity is reduced, resulting in insufficient power storage, so it is necessary to replace the street light with a new battery with the same parameters.

#### 2.2 METHODOLOGY

Most solar lights turn on and turn off automatically by sensing outdoor light using solar panel voltage. Solar streetlights are designed to work throughout the night. Many can stay lit for more than one night if the sun is not in the sky for an extended period of time. Older models included lamps that were not fluorescent or LED. Solar lights installed in windy regions are generally equipped with flat panels to better cope with the winds.

#### 2.3 EXISTING SYSTEM

Solar street light are raised light source which are powered by solar panels generally mounted on the lighting structure or integrated into the pole itself. The solar panel charges a rechargeable battery, which powers a fluorescent or LED lamp during the night

#### DISADVANTAGE OF SOLAR STREET LIGHTS

1. **Weather Dependent:** Solar street lights rely on the sun to power the lights, which means that they may work efficiently in areas with limited sunlight. This can be a disadvantage in areas that experience long periods of overcast or rainy weather.
2. **Initial Investment:** The initial investment for purchasing and installing solar street lights can be high, which may not be feasible for some communities or businesses.



# CHAPTER - 3

## SYSTEM BLOCK DIAGRAM

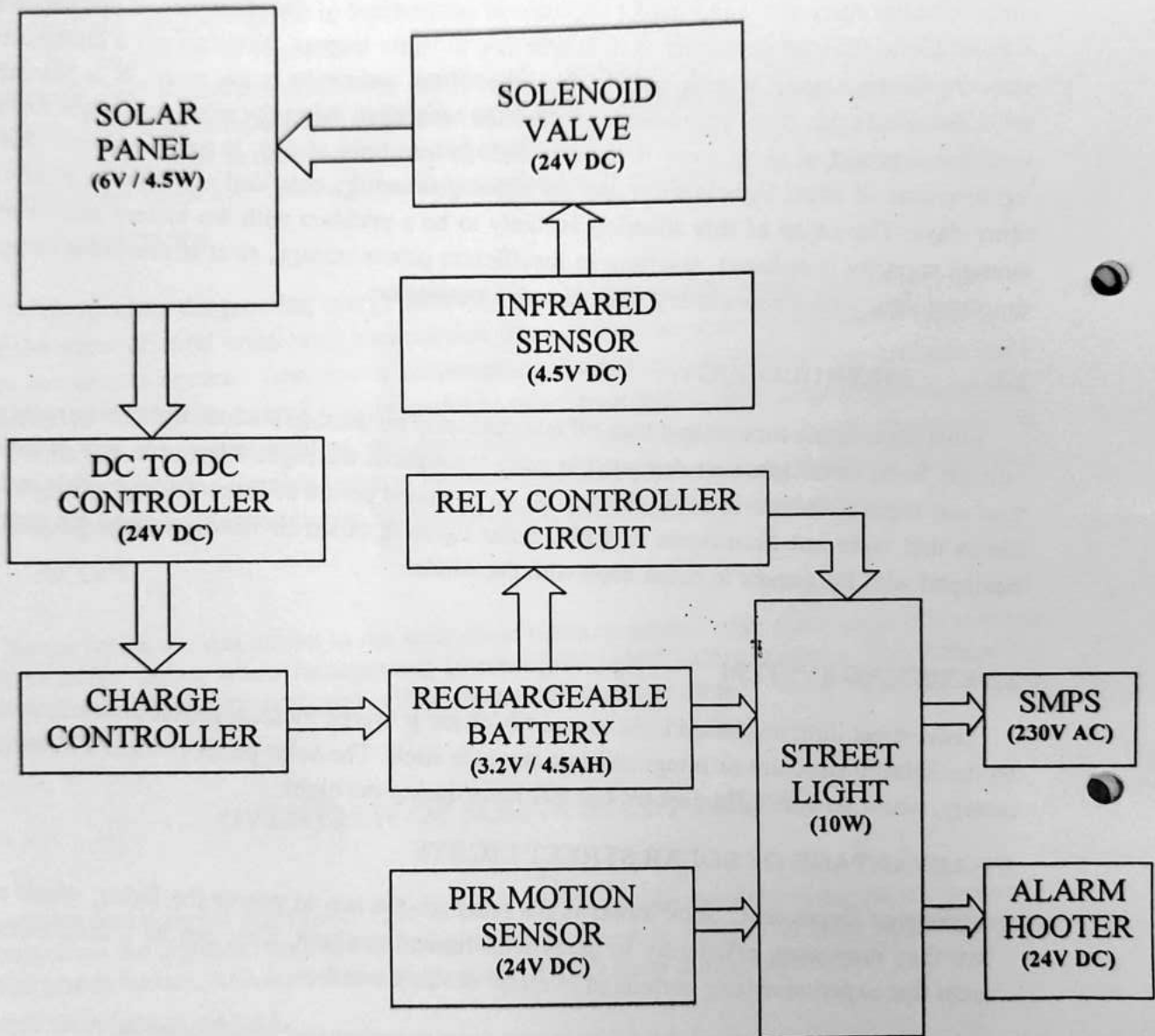


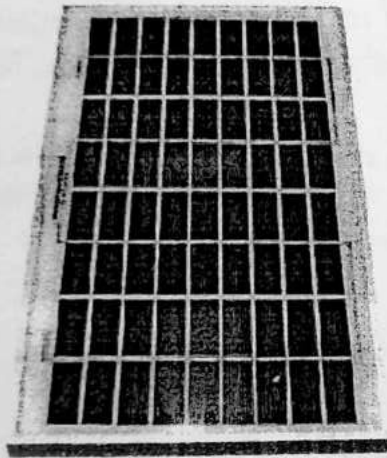
Fig - 1. Block Diagram

# CHAPTER - 4

## SYSTEM DESCRIPTION

### 4.1 SOLAR PANEL (6V / 4.5W)

A solar panel is a collection of solar cells. The solar panel converts the solar energy into electrical energy. Output of the solar panel is its power which is measured in terms of Watts or Kilowatts. Solar power uses multiple reflectors to collect more sun's thermal energy. Thermal energy collected through the day to perform different operations. Performance of the solar panel depends on a number of factors like climate, conditions of the sky, orientation of the panel, intensity and duration of sunlight and its wiring connections. In solar street lights, the solar panel is one of the most important parts, and it is also known as solar photovoltaic cell. These cells are of two types: poly crystalline and mono crystalline. Compare to the polycrystalline, mono-crystalline conversion rate is higher. Solar panels use light energy from the sun used to convert solar energy into electricity, which can be used to run many applications. Electrical connections are made in series to accomplish an output voltage and to provide a current facility connections are made in parallel.



RATING: 6V / 4.5W  
PANEL MATERIAL: POLY CRYSTALLINE  
PANEL SIZE: 22CM

Fig - 2. Solar panel (6V / 4.5W)

### 5 DAYS OBSERVATION OF VOLTAGE AND CURRENT OUTPUT FROM SOLAR PANEL

Day - 1

Day Time	Solar Radiation ( $W/m^2$ )	Voltage (V)	Current (A)
9 A.M	530	4.33	0.8
10 A.M	740	6.02	1.23
11 A.M	880	8.22	1.8
12 A.M	930	9.95	2.33
1 P.M	1012	10.37	3.1
2 P.M	980	9.98	2.37
3 P.M	890	8.28	1.83
4 P.M	785	6.35	1.28
5 P.M	620	4.72	0.87

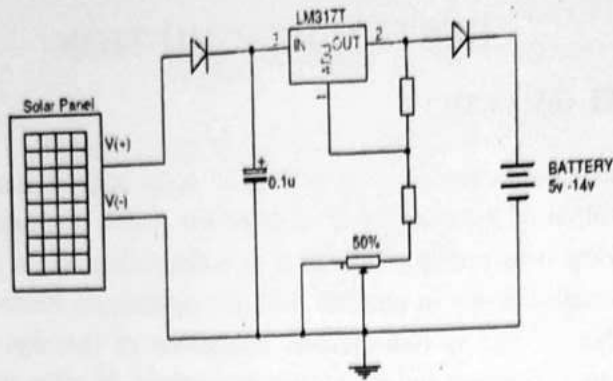


Fig-3. Solar system charging circuit diagram

## 4.2 RECHARGEABLE BATTERY

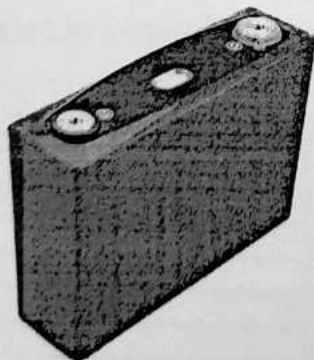
Rechargeable battery is a type of electrical battery or accumulator and its electro mechanical reactions are reversible so it is called as secondary cell. Usually, there are two types of batteries: lead acid battery and gel cell deep cycle battery.

### WORK PROGRESS

In solar LED street lights, a battery is used to store electricity from the solar panel during the day time to provide energy in the night time. The capacity and lifetime of the battery is very important as they affect the backup power days of the lights.

### HARDWARE SPECIFICATION

- ❖ 3.2Volt and 4.5AH Battery capacity
- ❖ It illuminat for 1 to 2 days depending on mode
- ❖ The life Po4 battery have a 4 to 6 years lifespan



**RATING: 3.2V / 4.5AH**  
**BATTERY TYPE: LITHIUM IRON PHOSPHATE**  
**BATTERY BACKUP: 6 to 8 HOURS**

Fig-4. Rechargeable Battery

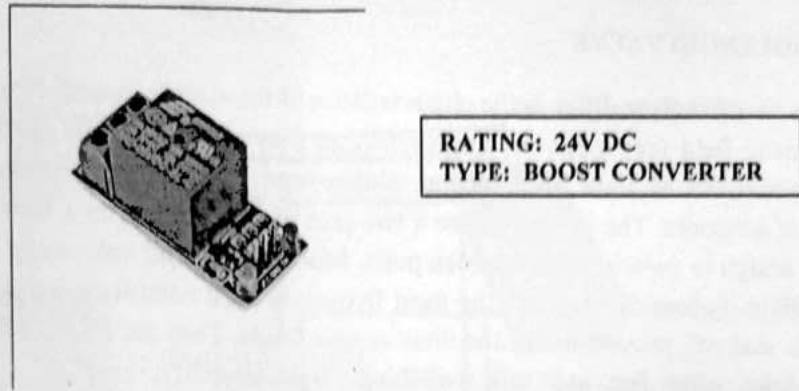


Fig-6. DC TO DC & Relay controller

#### 4.5 RELAY CONTROLLER CIRCUIT

Relays are electro mechanical devices that use an electro magnet to operate a pair of movable contacts from an open position to a closed position. However a relay controller circuit can be used to control motors, heaters, lamps or AC circuits which themselves can draw a lot more electrical voltage, current and power. The electro-mechanical relay is an output device which comes in a whole host of shapes, sizes and designs and has many uses and applications in electronic circuits. Electronic type circuits to switch relatively high currents or voltages both "ON" or "OFF", some form of relay controller circuit is required to control it.

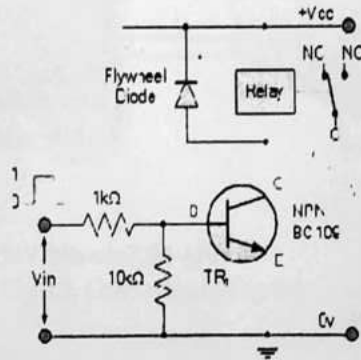


Fig-7. Relay controller circuit

#### 4.6 INFRARED AND ULTRASONIC SENSOR

IR and ultrasonic sensor are electronic device, that emits the light in order to sense some object of the surroundings. An **IR sensor** can measure the heat of an object as well as detects the motion. Usually, in the **infrared spectrum**, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode. Photodiode is sensitive to IR light of the same wavelength which is emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltage will change in proportion to the magnitude of the IR light received.

## 4.8 SOLENOID VALVE

Solenoid valves differ in the characteristics of the electric current they use, the strength of the magnetic field they generate, the mechanism they use to regulate the fluid, and the type and characteristics of fluid linear action, plunge-type actuators to pivoted-armature actuators and rocker actuators. The valve can use a two-port design to regulate a flow or use a three or more port design to switch flows between ports. Multiple solenoid valves can be placed together on a manifold. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high-reliability, long service, life, good medium compatibility of the materials used, low control power and compact design.

### WORK PROGRESS

This solenoid valve is fixed above the solar panel. It gets signal from the IR sensor, water will flow from the solenoid valve and water gets sprayed with help of spreader.



**RATING: 24V DC**  
**MATERIAL: PLASTIC**  
**PRESSURE: 0.2 to 5 BAR**

Fig-10.Solenoid Valve

## 4.9 THEFT PROTECTION

### 4.9.1 SMPS

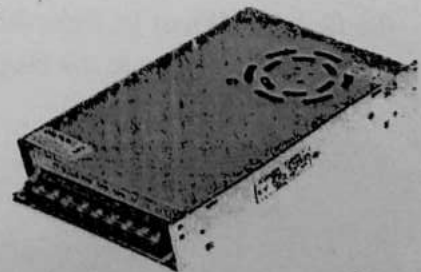
A switched-mode power supplies (SMPS), also called switched power supply or simply switcher, is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source to DC loads, such as a personal computer, while converting voltage and current characteristic. SMPS can also be substantially smaller and lighter than a linear supply because the transformer can be much smaller. Its frequency which ranges from several hundred kHz to several MHz in contrast to the 50 or 60 Hz frequency.

### WORK PROGRESS

The theft protection is based on SMPS. AC input supply is provide to SMPS and it gives 24V DC output power supply connected to street light fitting bolts.

**RATING: 230V AC INPUT**  
**OUTPUT: 24V / 2A**  
**CONVERTER: AC to DC BOOST**

Fig-11.SMPS



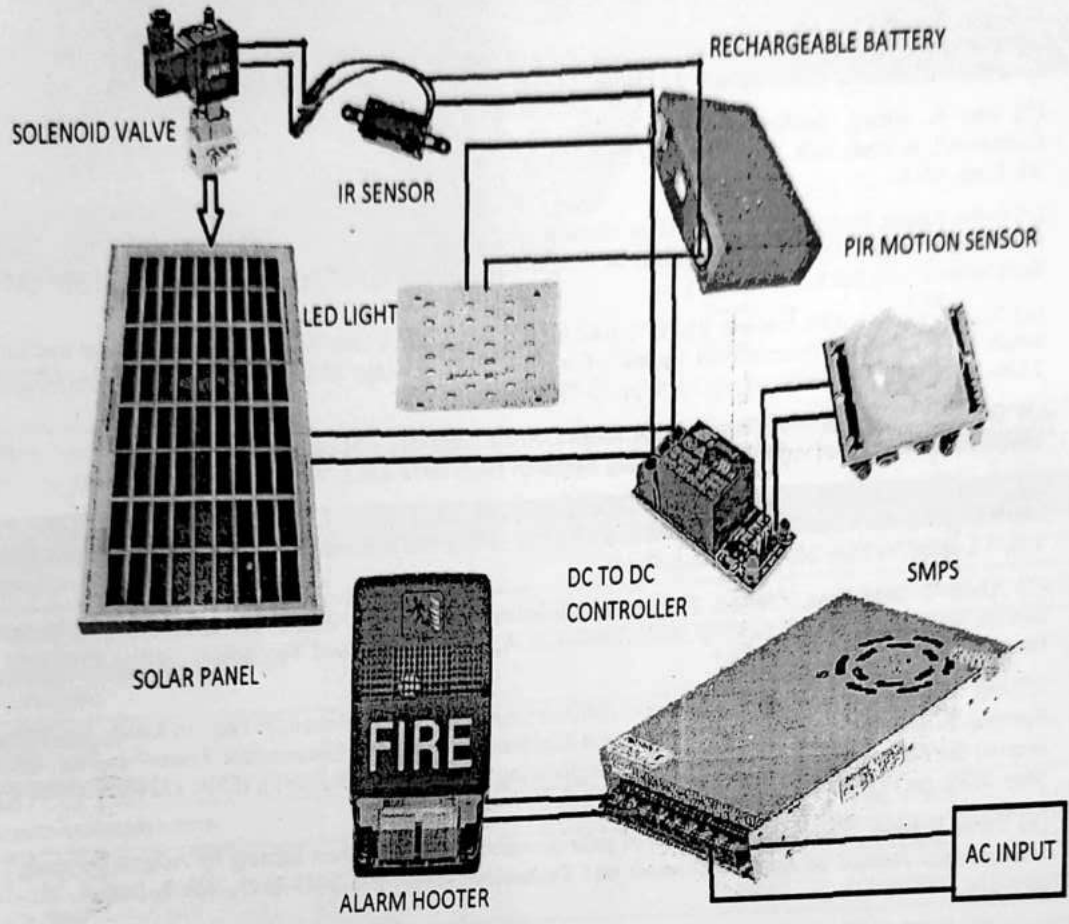


Fig-13. Connection Diagram

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6381570984

reachstonegries@gmail.com

166, 25th Street, Shankar Nagar, Pammal, Chennai

**Sharabesh Technologies And Energies (TEDA REGISTERED VENDOR)**GSTIN: 33CJSPS4917B1Z1  
State: 33 - Tamil Nadu**Tax Invoice**

Bill To:

**Dr B Rubini**Dept EEE, Vels Institute of Science Technology  
and Advance studies, Pallavaram, Chennai 600064

Invoice No.: 301

Date: 14/07/2024

Ship To :

Dept EEE, Vels Institute of Science Technology and  
Advance studies, Pallavaram, Chennai 600064

#	Item name	HSN/ SAC	Quantity	Price/ Unit	GST	Amount
1	MICROCONTROLLER		1	₹ 280.0	₹ 50.4 (18%)	₹ 330.4
2	SOLAR PANEL		1	₹ 5,000.0	₹ 900.0 (18%)	₹ 5,900.0
3	DC GEARED MOTOR MY1016Z2 24V 300RPM 250W		2	₹ 2,100.0	₹ 756.0 (18%)	₹ 4,956.0
4	MOTION SENSOR		1	₹ 680.0	₹ 122.4 (18%)	₹ 802.4
5	BLUETOOTH MODULE		1	₹ 180.0	₹ 32.4 (18%)	₹ 212.4
6	CLEANER AND FABRICATION		1	₹ 2,000.0	₹ 360.0 (18%)	₹ 2,360.0
7	SOLAR CHARGER		1	₹ 1,250.0	₹ 225.0 (18%)	₹ 1,475.0
8	WATER PUMP		1	₹ 160.0	₹ 28.8 (18%)	₹ 188.8
9	SMPS		1	₹ 618.0	₹ 111.2 (18%)	₹ 729.2
10	HOOTER		1	₹ 700.0	₹ 126.0 (18%)	₹ 826.0
11	TESTING		1	₹ 4,000.0	₹ 720.0 (18%)	₹ 4,720.0
<b>Total</b>			<b>12</b>		<b>₹ 3,432.2</b>	<b>₹ 22,500.2</b>

Invoice Amount In Words

Twenty Two Thousand Five Hundred Rupees only

Terms And Conditions

Bank Name: IDBI  
Name: Sharabesh Technologies and Energies  
Branch: Pammal  
Account No: 0779102000016083  
IFSC: IBKL0000779  
City: Chennai

Sub Total	₹ 19,068.0
SGST@9%	₹ 1,716.1
CGST@9%	₹ 1,716.1
Round off	- ₹ 0.2
<b>Total</b>	<b>₹ 22,500.0</b>
Received	₹ 0.0
Balance	₹ 22,500.0
Payment Mode	Credit

For : Sharabesh Technologies and Energies (TEDA REGISTERED VENDOR)

**Authorized Signatory**



# paytm

Payment Successful

₹22,500



Rupees Twenty Two Thousand Five Hundred  
Only

To: Vels Institute Of  
Science

Axis Bank - 4240



From: Sharabesh  
Technologies And  
Energies

IDBI Bank - 6083



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26 Feb 2024 , 02:00 PM

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26/02/24.  
OR Rs. 22500/-  
  
15/02/24.



# VIT VELLORE



INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)  
(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)  
PALLAVARAM - CHENNAI

ACCREDITED BY NAAC WITH 'A' GRADE  
*Marching Beyond 30 Years Successfully*

DR.P.SARAVANAN, M.A., M.Phil., Ph.D.  
REGISTRAR

PROCEEDINGS OF THE REGISTRAR, VISTAS/2024, Dated: 03-02-2024

Sub: Department of EEE - Consultancy project work for GAGETS -  
Regarding.

Ref: The letter dated 12/12/2023 from HoD Department of EEE

I am by direction to inform that, the following two faculty members from Department of EEE are permitted to carry out the consultancy project work titled "Automated and Self Powered Solar Panel Cleaning Robot" for GAGETS, Chennai.

1. Dr. B.Rubini, Assistant Professor - EEE
2. Dr. S.Pradeep Kumar, Assistant Professor - EEE

The above faculty members are requested to submit a detailed report to the undersigned after completion of the work and the consultancy fee to be paid to VISTAS account.

REGISTRAR

Copy To

1. Dr. B.Rubini, Assistant Professor - EEE
2. Dr. S.Pradeep Kumar, Assistant Professor - EEE
3. HoD, Department of EEE



*27/B, 6<sup>th</sup> Cross Street, Tiruvottiyur – Chennai -01*

22.01.2024

To

Dr.K.Sankar Singh  
Assistant Professor  
School of Management Studies  
VISTAS  
Pallavaram, Chennai

Dear Sir

Sub: Requesting Consultancy Service for Identification of Market Potential for Business Development – Regarding

We are involved in experimental Development activities to provide a consultancy services entitled “ Identification of Market Potential for Business Development of JS Logistics” like to the sum of Rs.6,00,000 ( Rupees six lakhs only) to the department of management studies , VISTAS, Pallavaram, Chennai. I respectfully request you to kindly do the needful.

Thanking You

Senior HR Manager

*naju*

Raju R

Date: 08.02.2024

To

Mr.Raju.R

Senior HR Manager,

JS Logistics Pvt Limited

J.S. Logistics, Door No.37Old No.17, J.S. Logistics,

Parrys, 1St Floor Office No.2, Moore Street,

Chennai, Chennai, Tamil Nadu, 600001

Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the industry.

Thanking you,

Yours Sincerely



Dr.K.Sankar Singh

Assistant Professor,

School of management studies,

VISTAS



## **Identification of Market Potential for Business Development of JS Logistics**

**Principal Investigator**

**Dr. K. Sankar Singh**

**Assistant Professor, School of Management Studies**

**VISTAS, Pallavaram, Chennai-600117**

**Beneficiary of the Consultant Work**

**Mr. Raju. R**

**Senior HR Manager**

**JS Logitics Pvt Limited**

**Lakshmaiya Tallari Prasath**

**Door No.37, 1st Floor, Office No.2, Moore Street, Chennai**

## **Introduction**

JS Logistics, a prominent player in the logistics sector, has undertaken experimental development activities to identify market potential for its business growth. The consultancy service, valued at Rs. 6,00,000, is being provided by the Department of Management Studies, VISTAS, Pallavaram, Chennai. This report aims to present insights gained from the study, along with suggestions for strategic business development.

## **Objectives**

1. To assess the current market position of JS Logistics.
2. To identify potential market segments for business expansion.
3. To analyze competitors and their strategies.
4. To provide actionable recommendations for enhancing market presence.
5. To forecast the expected outcomes of the proposed strategies.

**Methodology** The study employed a combination of qualitative and quantitative research methods:

### **1. Primary Research:**

- Interviews with key stakeholders, including JS Logistics' management and clients.
- Surveys targeting current and potential customers.
- Field visits to analyze operational efficiency and market practices.

### **2. Secondary Research:**

- Analysis of industry reports and market trends.
- Competitor benchmarking to understand their market strategies and positioning.
- Review of economic and regulatory factors affecting the logistics industry.

### **3. Data Analysis:**

- SWOT analysis to evaluate strengths, weaknesses, opportunities, and threats.
- PESTLE analysis to understand macro-environmental factors.
- Statistical tools to project market growth and profitability.

## **Suggestions**

### **1. Diversification of Services:**

- Introduce specialized logistics solutions, such as cold chain logistics for pharmaceuticals and perishables.
- Expand into e-commerce logistics, leveraging the sector's rapid growth.

## 2. **Technological Integration:**

- Invest in advanced technologies such as AI-driven route optimization, real-time tracking systems, and warehouse automation.
- Develop a user-friendly mobile application to enhance customer engagement.

## 3. **Market Penetration:**

- Establish partnerships with small and medium enterprises (SMEs) to expand the client base.
- Focus on tier-2 and tier-3 cities, which are emerging as growth hubs.

## 4. **Sustainability Initiatives:**

- Adopt eco-friendly practices, such as using electric vehicles and reducing carbon footprint.
- Highlight these initiatives in marketing campaigns to appeal to environmentally conscious clients.

## 5. **Skill Development:**

- Conduct regular training programs for employees to improve efficiency and customer service.
- Collaborate with academic institutions for talent acquisition and skill enhancement.

**Conclusions** The study has revealed significant opportunities for JS Logistics to expand its market presence by leveraging its core strengths and adopting innovative strategies. By focusing on technological advancements, diversification, and sustainability, the company can achieve substantial growth and enhance its competitive edge.

**Outcome** Implementing the recommendations from this study is expected to:

1. Increase market share by 20% within two years.
2. Enhance operational efficiency and reduce costs by 15%.
3. Strengthen brand reputation as a reliable and innovative logistics provider.
4. Generate a projected revenue increase of Rs. 1,50,00,000 over the next three years.

This report highlights actionable insights and a roadmap for JS Logistics to achieve sustained business development and market leadership.

Date : 09.03.2024

To

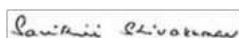
**Dr. C. Ronald Darwin, M.Pharm, PhD.,**  
Professor & Head, Pharmacology  
School of Pharmaceutical Sciences  
Vels Institute of Science Technology & Advanced Studies

Dear Sir

Sub: Requesting Evaluation of Neuroprotective activity of Plant extracts and Nano Formulations containing isolated compounds - reg  
Greetings!

We are involved in Research and Experimental Development activities in Natural Science and Pharmacological evaluation. In the process of the biosciences research activity, our company would like to provide a consultancy project entitled “Evaluation of Neuroprotective activity of Plant extracts and Nano Formulations containing isolated compounds” to the sum of Rs. 675000 (Including GST) to the Department of Chemistry, School of Pharmaceutical Sciences, VISTAS. I respectfully request you to kindly do the needful.

Thanking you,



Savithiri Shivakumar

Executive Director

Aaranya Bioscience Private Limited





Date : 09.03.2024

To  
Savithiri Shivakumar  
Executive Director  
Aaranya Bioscience Private Limited

Dear Sir/Madam

Sub: Thanks and Confirmation for the Consultancy Work - reg

Greetings!

Thank you very much for the opportunity and we are pleased to work with you to meet the requirements of our collaboration. Our Contribution shall boost up your productivity to lead the Industry..

Thanking you,

Yours Sincerely

A handwritten signature in black ink, appearing to read 'C. Ronald Darwin'.

**Dr. C. Ronald Darwin, M.Pharm, PhD.,**  
Professor & Head, Pharmacology  
School of Pharmaceutical Sciences  
Vels Institute of Science Technology & Advanced Studies



# **Evaluation of Neuroprotective Activity of Plant Extracts and Nano Formulations containing Isolated Compounds**

## **Consultancy Project Report for 2023-2024**

Submitted by

**Dr. C. Ronald Darwin**

Professor & Head

Department of Pharmacology

School of Pharmaceutical Sciences

Vels Institute of Science, Technology and Advanced Studies, Chennai – 600 117

## 1. Introduction:

Neurodegenerative diseases, such as Alzheimer's, Parkinson's, and multiple sclerosis, represent a significant global health challenge due to their progressive nature and lack of definitive cures. The complexity of these diseases, along with the limitations of current pharmacological treatments, has driven the exploration of alternative therapeutic strategies, particularly from natural sources.

Plants have been recognized for their potential neuroprotective properties, with many compounds derived from them showing promise in mitigating the damage caused by oxidative stress, inflammation, and neurodegeneration—key factors in the progression of neurodegenerative diseases. However, the bioavailability and efficacy of these compounds often limit their therapeutic potential when administered in their natural forms.

Nanotechnology, particularly the development of nanoformulations, has opened new avenues to enhance the delivery and bioavailability of plant-based compounds. Nanoformulations, including nanoparticles, liposomes, and other carriers, can protect active compounds from degradation, ensure targeted delivery to the brain, and improve their penetration across the blood-brain barrier.

This study aims to evaluate the neuroprotective activity of plant extracts and their nanoformulations containing isolated bioactive compounds. By comparing the efficacy of these formulations, this research seeks to shed light on the potential of natural products and nanotechnology in neuroprotection.

### **Objectives:**

The primary objectives of this study are:

1. **To evaluate the neuroprotective potential of selected plant extracts:** Identifying plants with known or suspected neuroprotective properties and assessing their effects on neurodegeneration through in vitro and in vivo models.
2. **To isolate and identify the active compounds from these plant extracts:** Using techniques such as chromatography and spectroscopy to isolate and characterize the bioactive compounds responsible for the neuroprotective effects.
3. **To formulate nano-delivery systems for isolated compounds:** Preparing nanoformulations, such as nanoparticles or liposomes, containing the isolated active compounds to enhance their stability, bioavailability, and targeted delivery to the brain.

4. **To compare the efficacy of plant extracts and nanoformulations:** Assessing the neuroprotective activity of the plant extracts and their nanoformulations in cellular and animal models, evaluating parameters like oxidative stress, inflammation, and neurodegeneration.
5. **To investigate the mechanisms underlying the neuroprotective effects:** Exploring the molecular pathways through which the plant extracts and nanoformulations exert their effects, such as antioxidant activity, anti-inflammatory effects, and neurotrophic support.

## 2. Experimental Section:

### 2.1 Selection of Plant Extracts:

- **Source of Plants:** Medicinal plants traditionally used for neurological health will be selected based on ethnobotanical reports or scientific literature.
- **Preparation of Extracts:** Plants will be cleaned, dried, and ground into powder. The extracts will be prepared using various solvents (e.g., ethanol, methanol, aqueous) through maceration or Soxhlet extraction.

### 2.2 Isolation of Active Compounds:

- **Chromatographic Techniques:** The plant extracts will be subjected to column chromatography, high-performance liquid chromatography (HPLC), and thin-layer chromatography (TLC) to isolate bioactive compounds.
- **Spectroscopic Identification:** The isolated compounds will be characterized using spectroscopic methods such as UV-Vis, FTIR, NMR, and Mass Spectrometry to determine their molecular structures.

### 2.3 Formulation of Nanoformulations:

- **Preparation of Nanoformulations:** Nanoparticles or liposomes will be prepared using methods such as solvent evaporation, nanoprecipitation, or high-pressure homogenization.
- **Encapsulation Efficiency:** The encapsulation efficiency of the isolated compounds in the nanoformulations will be determined using techniques like UV-Vis spectrophotometry.
- **Characterization of Nanoformulations:** The size, charge, morphology, and stability of the nanoformulations will be evaluated using techniques like dynamic light scattering (DLS), scanning electron microscopy (SEM), and transmission electron microscopy (TEM).

#### 2.4. Neuroprotective Activity Assessment:

- **In Vitro Assays:**
  - **Cell Culture Models:** Neuroblastoma cell lines (e.g., SH-SY5Y) will be used to evaluate the cytotoxicity and neuroprotective effects of the plant extracts and nanoformulations.
  - **Oxidative Stress Assay:** The effect on reactive oxygen species (ROS) levels will be measured using fluorescent probes like DCFH-DA.
  - **Neuroinflammation Assay:** The levels of inflammatory markers (e.g., TNF- $\alpha$ , IL-6) will be assessed using ELISA or RT-PCR.
- **In Vivo Models:**
  - **Animal Models:** Rats or mice will be treated with neurotoxic agents (e.g., MPTP for Parkinson's model, A $\beta$  for Alzheimer's model) to induce neurodegeneration. The neuroprotective effect of plant extracts and nanoformulations will be assessed through behavioral tests (e.g., rotarod test, Morris water maze) and histopathological analysis of brain tissue.
  - **Biochemical Markers:** Brain tissue will be analyzed for markers of oxidative stress, inflammation, and apoptosis, including levels of malondialdehyde (MDA), glutathione (GSH), and caspase activity.

#### 2.5. Mechanistic Studies:

- **Molecular Pathway Analysis:** The effect of plant extracts and nanoformulations on key signaling pathways (e.g., NF- $\kappa$ B, MAPK, PI3K/Akt) will be examined using Western blotting or qPCR.
- **Gene Expression Analysis:** Expression levels of neuroprotective genes (e.g., BDNF, Nrf2) and inflammatory cytokines will be assessed.

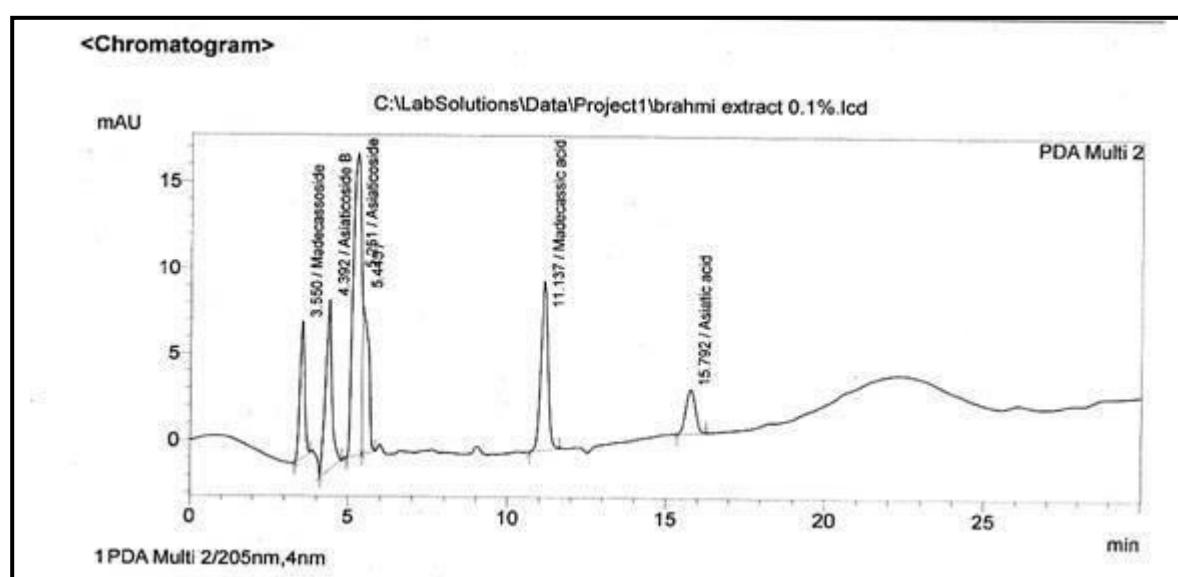
#### 2.6. Statistical Analysis:

- Data will be analyzed using statistical tools such as ANOVA followed by post-hoc tests. Differences with p-values < 0.05 will be considered statistically significant.

## RESULTS

### 1. Standardization of methanolic TP extract (TPE)

The RP-HPLC method is suitable for quality control of the raw material extracts and assay markers in CA. It provides a reliable, accurate, linear, precise, simple, quick and within-range quantitative estimation of total triterpenes (madecassoside, asiaticoside, and asiatic acid) in CAE. AA was considered a standard drug for further drug estimation in drug content, entrapment studies and drug release studies. The identification of the compound in CA extract, AA was done with the retention time of 15.79 min with the approximate 10 % availability in the total extract. The chromatogram was depicted in Fig.1



**Fig.1** Chromatogram of TP extract

### 2 Formulation of conventional liposomes of TPE (CTPL) and coating with chitosan (CLTPE)

The initial screening was carried out in many organic solvents, such as ethanol, methanol, chloroform, DMSO, DMF, and dichloromethane. The dichloromethane was selected as a solvent to prepare the CAEL. Based on the literature survey, the drug: SPC ratio was taken in the range of 1:5 to 1:15 and the SPC: cholesterol ratio in the range of 70:30-50:50. Mixtures were dissolved in dichloromethane solvent and evaporated using rotary flash evaporated. Before hydration, the film was dried at 45°C for nearly 45 min to remove the organic solvent. The obtained multilamellar vesicles (MLVs) were pulverized using an ultra-probe sonicator to get the desired size range. The MLV were treated with 20 % chitosan solution to form coat over a liposome. Finally, the obtained extract liposomes coated with chitosan under continuous

magnetic stirring at room temperature for one hour. It was undisturbed for three- four hours to get a proper swelling of the liposomes. Finally, the liposomal suspension was sonicated using an ultra- probe sonicator (CV-18, Sonics and Materials Inc., USA) for 30 minutes to produce chitosan-coated liposomes.

### 3 . *In vitro* antioxidant activity study

The % inhibition of DPPH by AA, optimized CLTPE was compared with the standard ascorbic acid at the same concentration. The % inhibition of DPPH at 50 µg/ml was found to be 90.75±1.45%, 65.4 ±1.2%, 60±1.3%, and 59.84 ±1.6%, respectively for ascorbic acid, AA, optimized CLTPE.

**Table 1.1** *In vitro* antioxidant study of CLTPE (n=3)

concentrationµg/ml	Ascorbicacid (Std)			CLTPE		
	0	0.00	0.00	0.00	0.00	0.00
10	80.00	76.20	79.76	45.40	40.43	43.90
20	83.60	77.46	82.30	47.23	48.40	50.45
30	84.15	80.30	78.47	53.40	58.67	52.87
40	88.42	84.50	90.30	57.89	54.40	58.40
50	90.75	86.75	88.75	64.84	60.84	60.79

CLTPE= Chitosan coated liposome of *Thespesis populanae* extract

### 3.1 *In vivo* evaluation of optimized CLCAE and CLAA and protective role in AD

#### 3.1.1 Y maze model

The Y Maze model was used to evaluate the effect of formulations on spatial working memory based on 2 parameters i.e. the number of arm entries and the % alternations. The evaluation of the memory retention activity of the group III, IV, V, VI in terms of the number of arm entries by rats was carried out

Groups	Treatment	Number of entries on the 90 <sup>th</sup> day
Normal control	Saline ( 0.9 % w/v NaCl ) 5ml/kg <i>p.o</i>	23.00±1.18 c
Disease control	AlCl <sub>3</sub> 50mg/kg <i>p.o</i>	34.00±0.85 c
Standard	AlCl <sub>3</sub> + Rivastigmine 50mg/kg <i>p.o</i> + 1mg/kg <i>p.o</i>	25.00±0.57 ab
Treatment-1	AlCl <sub>3</sub> + TP Extract 50mg/kg <i>p.o</i> + 5g/kg <i>p.o</i>	29.33±0.88 ab
Treatment – 2	AlCl <sub>3</sub> + Chitosan coated liposome of TPE 50mg/kg <i>p.o</i> + 100mg/kg <i>p.o</i>	26.32±0.63 ab

**Table 3.1.1** Effect of selected groups on the number of arm entry in Y maze.(n=6)

Groups	Treatment	% alteration on the 90 <sup>th</sup> day
Normal control	Saline ( 0.9 % w/v NaCl ) 5ml/kg <i>p.o</i>	22.33±0.49 c
Disease control	AlCl <sub>3</sub> 50mg/kg <i>p.o</i>	16.50±0.42 c
Standard	AlCl <sub>3</sub> + Rivastigmine 50mg/kg <i>p.o</i> + 1mg/kg <i>p.o</i>	24.33±0.88 ab
Treatment-1	AlCl <sub>3</sub> + TP Extract 50mg/kg <i>p.o</i> + 5g/kg <i>p.o</i>	19.00±0.365 ab
Treatment -2	AlCl <sub>3</sub> + Chitosan coated liposome of TPE 50mg/kg <i>p.o</i> + 100mg/kg <i>p.o</i>	21.34±0.32ab

**Table 3.1.2** Effect of % alterations in selected groups. (n=6)

### 3.2 Neuronal count

In this study, the neuronal count found in CA1 and CA3 regions (out of 100) is given in Table 3.2.1. The considerable increase in the neuronal numbers observed in groups IV, V, compared to the group II.

Groups	Neuronal count (out of 100)	
	CA1	CA3
Normal control	93.33±1.33	90.64±2.54
Disease control	27.58±2.41	21.34±3.29
Standard	50.75±3.70	54.21±1.47
TPE	35.83±2.30	38.67±1.40
CLTPE	40.34±7.34	41.10±1.36

All the data were expressed as mean ±SE where n=6

**Table 3.2.1** Neuronal count (out of 100) in cornu ammonis (CA1 and CA3) region



i) Normal control (NC), ii) Disease control (DC), iii) Standard (Rivastigmin Tartrate) iv) TPE  
v) CLTPE All the data were expressed as mean  $\pm$ SE (n=6)

### 3.3 AChE assessment study

The acetyl cholinesterase enzyme inhibition was assessed in the brain of treated groups of animal and it was shown in Table 3.3.

NC	DC	STD	TPE	CLTPE
0.000152	0.000020	0.000065	0.0000448	0.000044
0.000164	0.000011	0.000060	0.000035769	0.000031
0.000122	0.0000172	0.000073	0.000020441	0.0000232
0.000133	0.000009	0.000080	0.000042593	0.0000291

**Table 3.3** AChE assessment study: Moles of substrate hydrolysed /min/mg of protein  
NC= Normal control, DC= Disease control, STD =Standard, CAE= *Centella asiatica* extract, CLCAE= Chitosan coated liposome of asiatic acid, CLAA= Chitosan coated liposome of asiatic acid.

### 4. Oral bioavailability study

The amount of drug that reaches into systemic circulations and the extent of drug absorption can be studied by *in vivo* bioavailability studies. The oral bioavailability study results are given in Table 3.33. The optimized serum concentration CLTPE was found to be  $5.32 \pm 0.34$  at 6 h.

**Table 4** Oral bioavailability study. *C max*, peak plasma concentration; *T max*, time to reach plasma concentration; AUC, area under the curve;  $t_{1/2}$ , elimination half-life;  $K_{el}$  elimination rate constant; Cl, Clearance;  $V_d$ , Volume of distribution. Data expressed as mean  $\pm$ SD (n=6)

Pharmacokinetic Parameter	CLTPE
<i>C max</i> ( $\mu\text{g ml}^{-1}$ )	$5.32 \pm 0.2$
<i>Tmax</i> (h)	6.0
AUC <sub>0-t</sub> ( $\mu\text{g ml}^{-1}\text{h}$ )	$96.34 \pm 3.7$
AUC <sub>0-∞</sub> ( $\text{ml}^{-1}\text{h}$ )	$91.43 \pm 5.3$
$t_{1/2}$ el (h)	$2.34 \pm 0.5$
$K_{el}$ ( $\text{h}^{-1}$ )	$0.2 \pm 0.006$
Cl ( $\text{L h}^{-1}$ )	$0.2 \pm 0.001$
$V_d$ (l)	$1.3 \pm 0.02$

## **DISCUSSION**

The current research work was aimed to investigate and develop the CLTPE. The study mainly considered oral drug delivery in treatment for the early stage of AD. Based on the results obtained, a comprehensive study was discussed. This study include interpretation of the TP extract's effective extraction and compatibility in liposomal form.

### **Standardization of methanolic TPE**

The standardization of TP extract was done effectively using RP-HPLC method. The RPHPLC method is suitable for quality control of the raw material extracts and assay markers in TP. It provides a reliable, accurate, linear, precise, simple, quick and within-range quantitative estimation of total triterpenes (madecassoside, asiaticoside, and asiatic acid) in TPE. The fresh methanolic CAE was filtered through vacuum filter, and it was treated with charcoal at 50°C in order to remove the chlorophyll content. Otherwise, chlorophyll, a colouring agent, may interfere with the absorption of UV light. Later 0.1 % solution of TPE was prepared, filtered through a syringe filter and injected into RP HPLC at low wavelength UV detection 210 nm because triterpenes present in the TP do not absorb above 220 nm. The identification of compound AA was done with the retention time 15.79 min with the approximate 10 % availability in the total extract. The present data support the literature survey and found to be suitable with the appropriate desirability.

### **Formulation of conventional liposomes of TPE (TPEL)**

The TPEL was formulated using the solvent evaporation method. It is the most relevant method to prepare liposomes using volatile solvents. In this method, TP extract was dissolved in dichloromethane to obtain a clear solution. Due to its lower boiling point (39.6 °C) with lower toxicity (LD50 value 1.5 g / kg in rat) solvent was selected. Based on the literature survey, the drug: SPC ratio was taken in the range of 1:5 to 1:15 and the SPC: cholesterol ratio in the range of 70:30-50:50. The plant extract was dissolved in dichloromethane solvent and evaporated using rotary flash evaporated. The film was dried at 45°C for nearly 45 min to remove the organic solvent. To improve the stability of the liposome, cholesterol was added in an appropriate quantity. The obtained multilamellar vesicles (MLVs) were pulverized using an ultra-probe sonicator to get the desired size range of less than 250 nm 4.4.1Formulation of CLCAE The positively charged chitosan was used to form a coat on liposomes to enhance its mucoadhesivity to negatively charged cell membrane and thereby prolong the release of the drug. Because of electrostatic interactions between the negatively charged SPC and the positive charges of primary amino groups of chitosan, it is useful in coating the surface of liposomes.

Chitosan coating enhances the stability of liposomes and prevents drug leakage from the vesicular structure.

### **Formulation of CLTPE**

The chitosan was coated onto their surface to improve the colloidal stability and controlled release by improving the mucoadhesiveness to the negatively charged cell membrane. Chitosan was reported to be useful in coating the negatively charged liposomes' surface because of electrostatic interactions between the negatively charged SPC and the positive charges of primary amino groups of chitosan. Chitosan coating also prevents drug leakage from the vesicular structure.

### ***In vitro* antioxidant activity study**

*In vitro* antioxidant activity optimized CLTPE was evaluated as free radical scavenging activity (% of DPPH scavenged). It was compared with the standard ascorbic acid at the same 50 µg/ml concentration. The % inhibition of DPPH at 50µg/ml was found to be 90.75±1.45%, 60±1.3, respectively for ascorbic acid optimized CLTPE.

### ***In vivo* evaluation of optimized CLTPE and their protective role in AD**

Induction of AD. The AlCl<sub>3</sub> model was adopted to induce AD. Aluminium (Al) ion is a neurotoxic metal, the continuous exposure may lead to various neurodegenerative disease.

Mechanism of action of the AlCl<sub>3</sub> model in AD Aluminium ions are the potential neurotoxic agent. This trivalent cation binds to IRP (iron regulatory protein) and stimulates on AβPP as well as ferritin. Abnormal expression of AβPP will lead to an increased amount of Aβ (which is resistant to proteases enzyme because Al ion associated) accumulates in mainly the hippocampus region. Al ions involve neurodegenerative pathways by accelerating the phosphorylation of tau and by stimulating iron-induced lipid peroxidation. Meanwhile, abnormal expression of ferritin caused an altered concentration of free iron ions, the formation of free radicals, and thus, will cause oxidative damage and membrane lipid peroxidation. These events finally lead to neuronal death in AD.

### **Behavioural study -Y Maze model**

The Y Maze model was used to evaluate the effect of formulations on spatial working memory based on 2 parameters i.e. the number of arm entries and the % alternations. The evaluation of the memory retention activity of group III, IV, V in terms of the number of arm entries by rats was carried out. Group V showed a significant decrease in the number of arm entries compared to group II. Group II showed a significant (p< 0.001) increase in the % alteration compared to the group I.

### **Neuronal count**

In this study, the neuronal count found in CA1 and CA3 regions (out of 100) is given in Table 3.31. The CA1 and CA3 regions of the hippocampus sector are exposed to AD-type neurofibrillary degeneration. The principal reason for a diminution of a neuron is due to the accumulation of amyloid plaques formed by the enzymatic breakdown of amyloid precursor protein (APP) and neurofibrillary tangles that is occurred by hyper-phosphorylation and oligomerization of tau in this region. As a consequence, it leads to disruption in neuronal transmission due to the slowdown of enzymatic signalling and nutrient supply to the neuron at result in a decrease in the count of neurons. The considerable increase in the neuronal numbers observed in groups IV, V compared to group II.

### **AChE assessment study**

AChE (acetyl cholinesterase) enzyme is responsible for the degradation of acetylcholine level at a synaptic cleft region in the brain and influencing the cholinergic neurotransmission. The single-molecule of AchE can break down 5000 Ach molecules per second. [189] The acetyl cholinesterase enzyme inhibition was assessed in the brain of treated groups of animals in term of moles of substrate hydrolysed /min/mg of protein shown in Table 3.3. Group II shows a significant increase in the AChE level in the brain, the level of acetylcholine found decreased as compared to group I ( $p < 0.05$ ). The accumulation of AChE in group II forms a network with A $\beta$  peptide and stimulates amyloid fibril formation in the hippocampus region. However, group III exhibited a significant increase in acetylcholine levels by altering the active sites of AChE and inhibiting its activity. Group IV, V exhibited a significantly decreased AChE activity.

### **Stability study**

The stability study refers to both the physical and chemical integrity of the ingredients during their shelf life. The liposomes are thermodynamically unstable systems, the major problem involves vesicles that tend to fuse, grow more prominent, resulting in breakage of the liposomes on storage which leads to drug leakage from the vesicles. The stability data of liposomes at  $5 \pm 2$  °C,  $32 \pm 2$  °C/ $60\% \pm 2\%RH$  is given in Table. The vesicle size was found to be slightly bigger after the 2nd months of the storage indicated congeal liposome subsequently affecting entrapment efficiency of CLTPE.

## **CONCLUSION**

The present research work aim was to investigate and develop CA in a nanovesicular system to prevent the progression of AD. CLTPE demonstrated the great potential of extract when administered in modified form. The CLTPE shows better pharmacological action compared to

the standard extract of TP, attributed to the chitosan coating. Therefore, the developed product can enhance efficacy and improve patient compliance by oral delivery.. Further modification of the developed formulation can be also be used as a nutraceutical product to prevent AD. The outcome of the present work is promising, and more experimental data and clinical study is required for further authentication of TP efficacy in nanovesicular form.