Karnataka State Council for Science and Technology

Bengaluru-560012

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi - 590018

Synopsis on

"A POWER SUPPLY USING SUPERCAPACITOR STORAGE POWERED BY SOLAR PV CELLS"

This Project is sponsored by KSCST 45th Series of Student Project Programme

[Project Reference Number: 46S_BE_0823]

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING

in

ELECTRONICS & COMMUNICATION ENGINEERING

by

Ms. ADITHI V SHETTY 4MT19EC002

Mr. ADITHYA N KATEEL 4MT19EC003

Mr. AKASH N SALIAN 4MT19EC005

Ms. HARSHITHA B 4MT19EC028

Under the Guidance of

Dr. Vinayambika S Bhat
Professor & HoD – E&CE
Dean Quality Assurance

Dr. Raghavendra Sagar
HoD – Physics

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

(Accredited by NBA)

MANGALORE INSTITUTE OF TECHNOLOGY & ENGINEERING

Accredited by NAAC with A+ Grade, An ISO 9001: 2015 Certified Institution

(A Unit of Rajalaxmi Education Trust®, Mangalore - 575001)

Affiliated to VTU, Belagavi, Approved by AICTE, New Delhi

2022-23

INTRODUCTION

The ever-increasing consumption of fossil fuels and its prices have caused serious concerns about the depletion of fossil fuels that are already existing. At the same time, the global increase in human population has also contributed to growing energy requirements. Therefore, it is important to develop environment-friendly energy storage and generation techniques which includes electrochemical supercapacitors and batteries. The maximum benefit from these energy sources can be achieved only if the energy obtained from these sources can be properly stored.

Supercapacitors can be made from different materials, depending on the type of energy storage required and some capacitance ranges. In electrochemical supercapacitors, two electrodes will be kept apart using a separator. The performance of the supercapacitors mainly depends on the properties of the electrode materials and electrolyte interface. Supercapacitor materials can be synthesised using different methods such as electrochemical deposition, chemical vapour deposition, and chemical bath deposition sol-gel method. Similarly, several methods to fabricate electrodes including spray coating, and inkjet printing.

Activated carbon is used as a cathode due to its high surface area, controllable pore size distribution, and low cost compared to other carbon materials. Activated carbon is prepared from Areca nut fibres, which are rich in good-quality lingo-cellulosic fibres and have potential applications in different fields. Chemical Vapor Deposition (CVD) is used to synthesize carbon materials. Manganese cobalt oxide ($MnCo_2O_4$) an anode due to its wide potential range, high electrochemical activity and environmental friendliness. Lithium hexafluorophosphate ($LiPF_6$), Potassium hydroxide (KOH) and Potassium chloride (KCl) are used as electrolytes while fabricating the cells.

Keywords: Activated Carbon, Capacitor, Manganese Cobalt Oxide ($MnCo_2O_4$), Potassium Chloride (KCl), Supercapacitor.

OBJECTIVES

- To Fabricate supercapacitor devices displaying higher efficiency relative to commercial supercapacitors

- To demonstrate the glowing of a set of LEDs using the fabricated supercapacitor and compare its performance with commercial supercapacitors.

- To show that the fabricated supercapacitor can provide significant cost savings in uninterruptible power supplies when used in place of electrolytic capacitors or conventional batteries

METHODOLOGY

The project involves fabricating a supercapacitor with $MnCo_2O_4$ as the anode and activated carbon as the cathode.

Preparation of cathode:

- Mixing 7.139gm of $MnSO_4$ with 100ml water, 12.289gm of $Co(NO_3)_2$ with 100ml of water and 3.9gm of NaOH with100ml of water respectively with the help of a magnetic stirrer by increasing the temperature.
- $MnSO_4$ solution is mixed with $Co(NO_3)_2$ solution. Adding the mixed solution to the NaOH solution drop by drop using a burette.

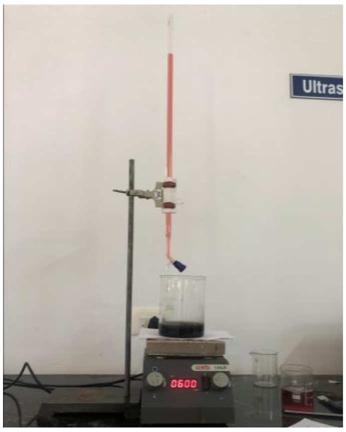

Figure 1: Titration

- Procured solution is stirred for 3 hours continuously using a magnetic stirrer.
- Filtering the procured solution using a funnel. Obtaining the precipitate in a Petri dish and Keeping the Petri dish in a hot air oven for 24 hours at 110° Celsius.

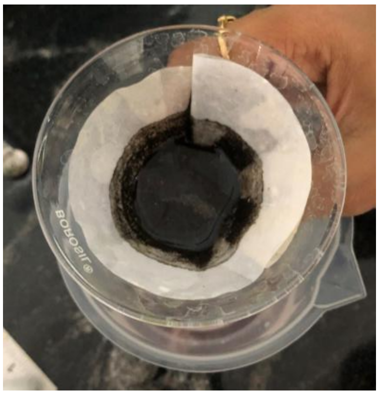

Figure 2: Filtering Figure 3: Procured precipitate Figure 4: Hot air oven

- Crushing the obtained powder using Agate mortar and Pestle. Transferring the obtained hydroxide powder to Alumina Crucible and then Keeping the Crucible in Programmable Furnace for 4 hours at 500° Celsius.

Figure 5: Calcination Figure 6: Programmable furnace Figure 7: Obtained $MnCo_2O_4$

Procedure for preparing the cathode

- Take out the areca nut fibre and wash it using distilled water. In a Teflon container, 9.8 ml of concentrated H_2SO_4 is added to 100 ml of purified water along with cleaned areca nut fibre as shown in Figure 9.

Figure 8: Areca nut fibres

Figure 9: Teflon container

- Keeping the Teflon container inside a high-pressure hydrothermal autoclave reactor. Then Keeping the autoclave reactor inside a hot air oven for 4 hours at 160° Celsius as shown in Figure 10.

Figure 10: Autoclave reactor inside hot air oven

Figure 11: obtained carbon

- Taking out the autoclave reactor and cooling it down for 3 hours.
- 1.7gm of prepared $MnCo_2O_4$ is grinded with 0.3gm of prepared activated carbon with 10 drops of 1-Methyl-2 Pyrrolidone using an agate motor and pestle.
- Similar procedure is done for activated carbon by grinding 2gm of activated carbon with 10 drops of 1-Methyl-2 Pyrrolidone.
- Coating the obtained paste to carbon and aluminium sheets and placing them in a hot air oven for 24 hours at 65°C.
- Copper wires and copper sheets are connected using the Soldering method.
- The coated sheets and the separator are packed using Whatman filter paper as a separator. Further, the coated sheets and the separator are packed.

Figure 12: Coated sheets

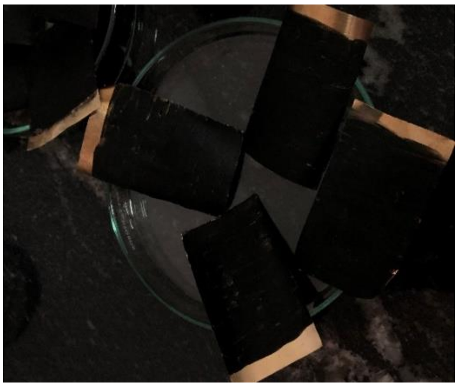

Figure 13: Soldering

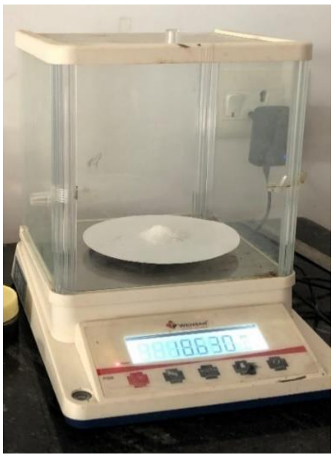

Figure 14: Weighing scale

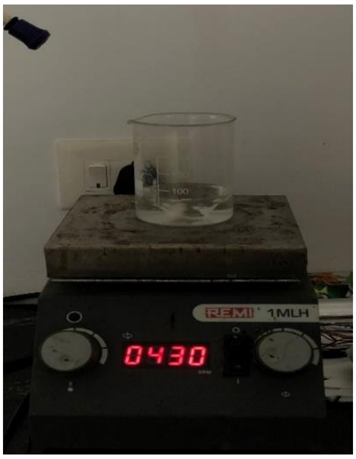

Figure 15: Magnetic stirrer

- Electrode material is prepared using 50 ml distilled and 18.63 gm of KCl for 5M molarity The obtained solution is stirred continuously for 15 minutes at 430 rpm.
- CV characteristics of electrode material are calculated in the electrochemical station. The setup of the electrochemical station is shown in Figure 16.
- There are 3 electrode holders. The green holder holds the working electrode, the red holder holds the Platinum wire counter electrode and the white holder holds Ag/AgCl reference electrode. Measuring vessel filled with 5M electrolyte solution.

- Further the coated sheets are further sealed with electrolyte.

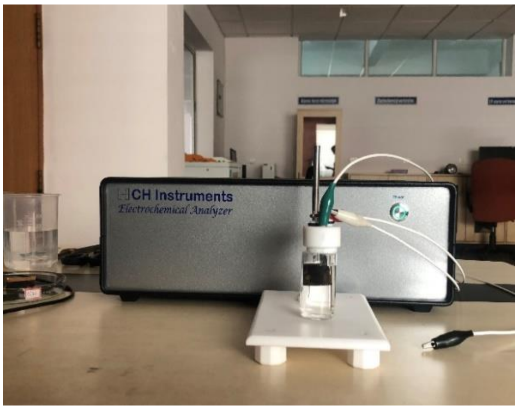

Figure 16: Electrochemical workstation

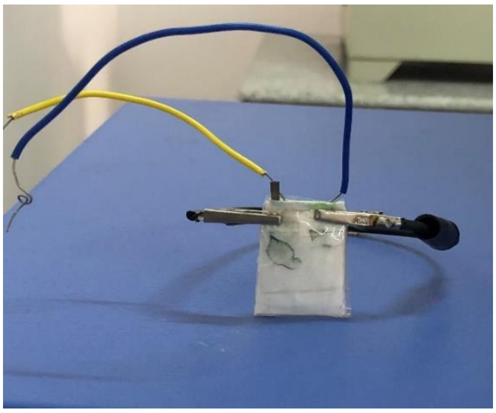

Figure 17: Fabricated supercapacitor

The fabricated supercapacitor will be tested and compared with a commercially available supercapacitor using the circuit as shown in Figure 18 that contains resistors, capacitors, a Schottky diode, and solar panels.

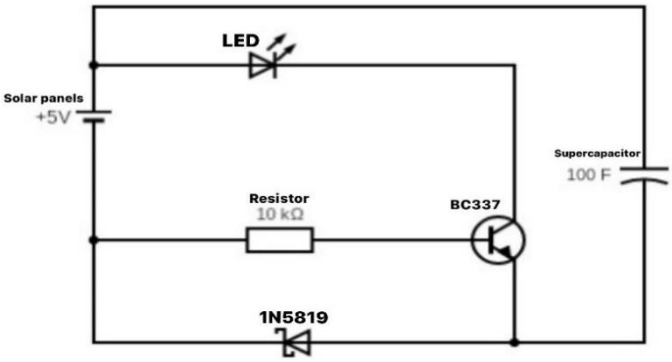

Figure 18: Circuit diagram of the proposed system

RESULT

Figure 19 illustrates the glow of an LED using a supercapacitor. Sunlight strikes the solar panel, and the energy from the sun is absorbed by the PV cells in the panel. This energy generates electrical charges that move in reaction to an internal electric field in the cell, causing electricity to flow. This electricity is stored in a Supercapacitor, which in turn glows the LED.

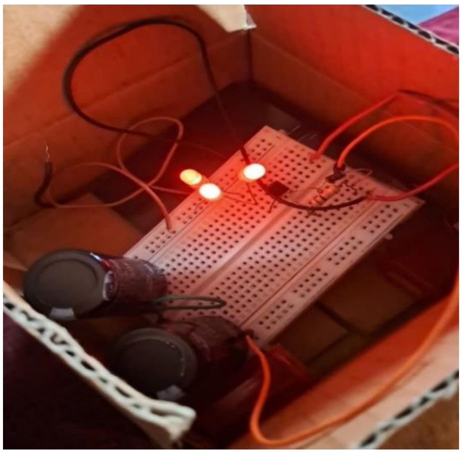

Figure 19: LED glowing

Solar panels are used in the circuit to convert sunlight into electrical energy. The electrical energy generated by the solar panels is stored in the supercapacitor for later use. This allows for more efficient use of renewable energy sources and can reduce reliance on traditional energy sources like fossil fuels.

The cyclic voltammetry (CV) of electrode material is used to study electrochemical properties, including the potential window, the redox potential of the components, and the electron transfer kinetics. In the case of the fabricated supercapacitor, the CV of the electrode materials was measured for both the anode (Manganese Cobalt Oxide) and the cathode (Activated Carbon).

Figure 20 shows the CV curve for Manganese Cobalt Oxide. The graph shows that the redox peaks are well-defined and have good symmetry, indicating good electron transfer kinetics. The oxidation peak occurs at around -0.016V and the reduction peak occurs at around -0.3V. This suggests that the potential window for the anode lies between 0.3V and 0.65V.

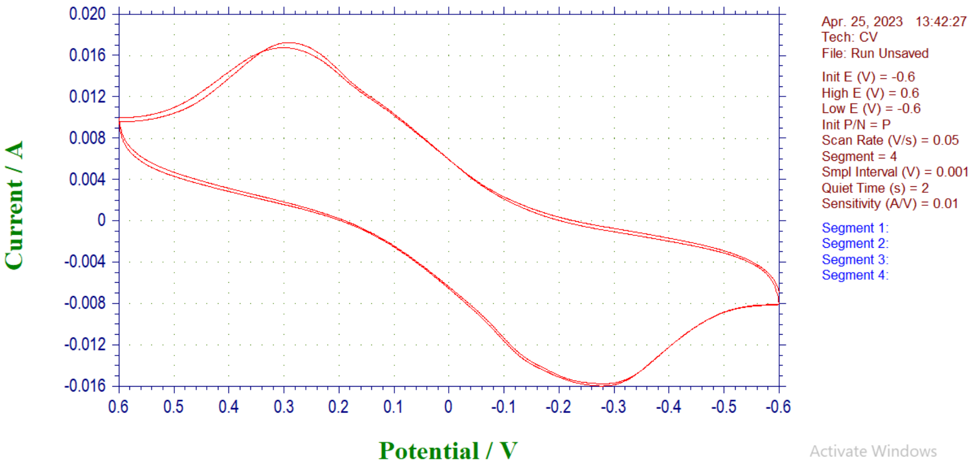

Figure 20: CV curve of $MnCo_2O_4$

Figure 21 shows the CV curve for the Activated Carbon cathode. Since the graph shows no peak values it can be used in both anode and cathode. This suggests that the potential window for the cathode lies between 0.5V and -0.7V.

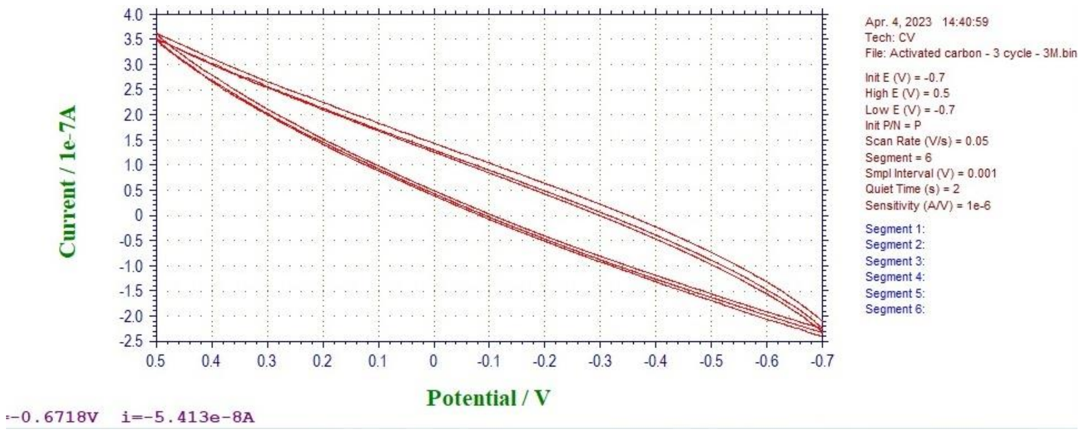

Figure 21: CV curve of Activated Carbon

The discharging curve of a fabricated supercapacitor typically represents the relationship between the voltage across the supercapacitor and the discharge time. During the discharge process, the stored energy in the supercapacitor is gradually released, resulting in a decrease in voltage over time. The shape of the discharging curve can provide insights into the performance characteristics of the fabricated supercapacitor.

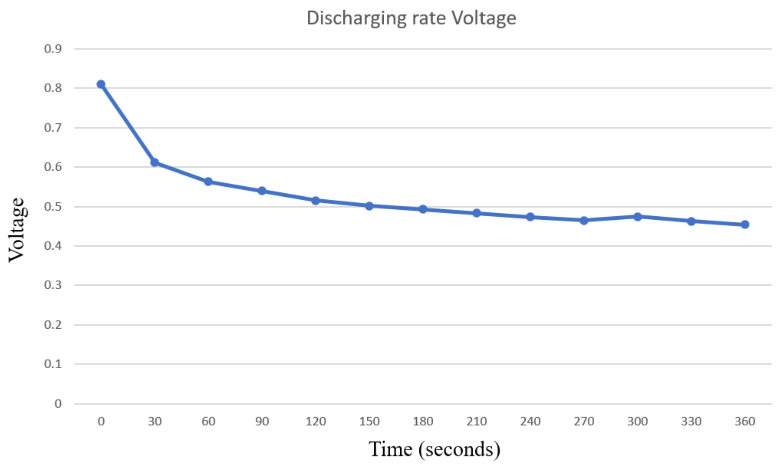

Figure 22: Discharging curve of fabricated supercapacitor

A steeper initial voltage drop suggests a higher power density, meaning the supercapacitor can release energy quickly. A more gradual voltage decline indicates a higher energy density, signifying the ability of the supercapacitor to store a larger amount of energy.

CONCLUSION

Supercapacitors offer several advantages over conventional batteries, including high power density, fast charging and discharging, and long cycle life. They are perfect for high-power applications like electric and hybrid vehicles since they can deliver bursts of power in a brief period of time. Supercapacitors also have a lower risk of fire than batteries because they don't contain flammable electrolytes. Supercapacitors can be used for energy storage applications that need high energy density; however, they are less energy dense than batteries.

Overall, supercapacitors offer a promising alternative to conventional batteries for applications that require high power density, fast charging and discharging, and long cycle life. The proposed system has displayed the importance and application of supercapacitors and a survey of late improvements. It also displays supercapacitors as a replacement for batteries because of their high efficiency. The structure and qualities of these power framework has been depicted and also the physical usage and quantitative demonstration of the supercapacitors has been studied.

SCOPE FOR FUTURE WORK

The scope for future work in the field of supercapacitors and energy storage is vast and offers numerous opportunities for research and development. Some potential areas for future work include:

1. Optimization of Fabrication Process:

The fabrication process can be further optimized to improve the capacitance, power density, and cycling stability of the supercapacitor by varying the concentration of the electrolyte, the mixing ratio of the electrode materials, and the thickness of the electrode layers. The fabrication can be done in a nitrogen environment to increase its efficiency.

2. Characterization of Supercapacitor:

To look into the behaviour of the constructed supercapacitor, advanced characterization techniques such as electrochemical impedance spectroscopy (EIS) can be applied. The effect of altering the charging and discharging rates, temperature, and humidity on supercapacitor performance can be investigated.

3. Integration with Solar Panel:

The supercapacitor can be integrated with a solar panel to create a standalone energy storage system. The charging and discharging characteristics of the supercapacitor can be studied under different illumination conditions, such as different intensities and angles of incidence of sunlight.

4. Materials Development

Exploring new electrode materials with improved energy storage capabilities, higher capacitance, and enhanced stability. This involves investigating novel carbon-based materials, metal oxides, conductive polymers, and composites for electrode fabrication.