Supercapacitor Electrodes Based on Modified Carbon Nitride for Applications in Renewable Energy Storage

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TITLE V STEM
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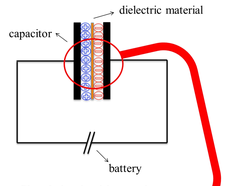
INTRODUCTION

Supercapacitors are rechargeable electrochemical energy storage devices, whose can store much larger amount of electrical energy in the interfaces between electrodes and electrolyte.

There are two types of supercapacitors:

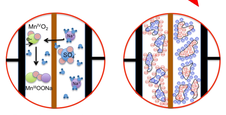
- **The double layer capacitors (EDLC)**, which charge accumulation is at the vicinity of electrode.
- **Pseudo-capacitors** where charge transfers across the electrode interface.



Closed circuit with capacitor

Advantages of EDLCs
- Rating up to 9000F
- Fast charge and discharge
- Physical charge storage
- Large surface area

Disadvantages of EDLCs
- Low maximum voltage
- Store small quantity of energy
- High self-discharge



Pseudo-capacitor

EDLC

Why the use of nickel modified carbon nitride (Ni-CN)?
- Light material
- Simple fabrication
- Excellent mechanical stability
- CN has an excellent chemical stability
- High surface area
- High density of N atoms
- Redox reactions due to the presence of Ni^{2+} could increase the pseudo-capacitance of CN

OBJECTIVES

The main objective of this project is to develop supercapacitor electrodes using the modified CN to obtain higher capacitances and longer life cycles than those achieved with activated carbon (AC) or traditional metal oxides.

To reach this goal, the main tasks are:

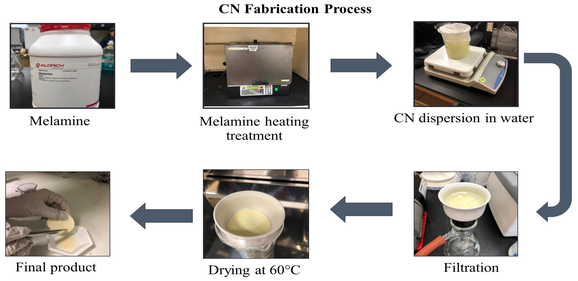
(1) Fabrication and characterization of CN

(2) CN complexation with nickel cations (Ni^{2+})

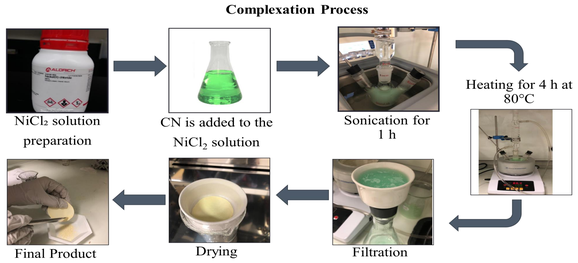
(3) Evaluation of the electrochemical performance of the fabricated electrodes using techniques such as cyclic voltammetry (CV) and charge-discharge method (CDC).

METHODOLOGY

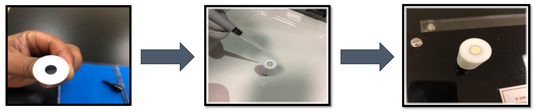
CN Fabrication Process



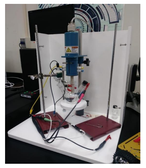
Complexation Process



Electrode Fabrication Process



Three-electrode cell experimental set-up


Three-electrode cell set-up

1. Reference Electrode
2. Counter Electrode
3. Working Electrode

Inks list

NAME	COMPOSITION	STATUS
CN	100%	DONE
Ni/CN	100%	DONE
HC	100%	FUTURE WORK
HC/CN	50%-50%	FUTURE WORK
HC/Ni-CN	50%-50%	FUTURE WORK

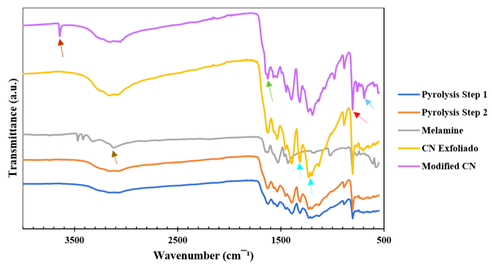
HC = Hard Carbon

Electrochemical experiment conditions

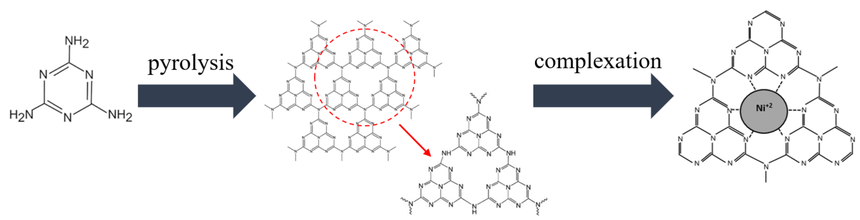
ITEM	DESCRIPTION
Counter Electrode	Pt wire
Reference Electrode	Ag/AgCl
Electrolyte	0.1M H_2SO_4
Scan rates	0.1 V/s – 1.0 V/s
Potential window	-0.2V – 0.8 V
RPM	500 – 2000 rpm
Scans number	15

RESULTS

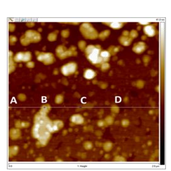
Chemical Characterization: FTIR



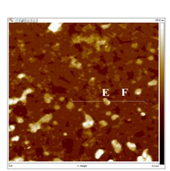
Wavenumber (cm^{-1})	Description
800	heterocycles
1228 1315	tertiary amines
1625	vibration of C=N bonds
3111	amino functional groups
3645	presence of impurities
690	Cl-C stretching
500- 600	Ni-N bond



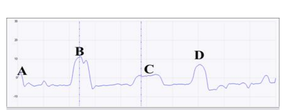
Physical Characterization: AFM



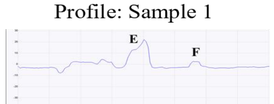
CN Nanosheets Sample 1



CN Nanosheets Sample 2



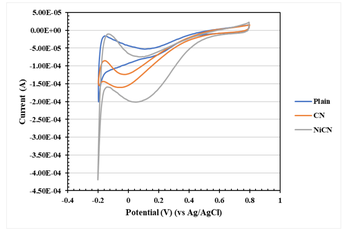
Profile: Sample 1

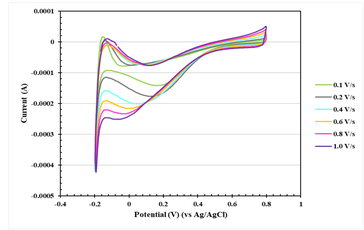


Profile: Sample 2

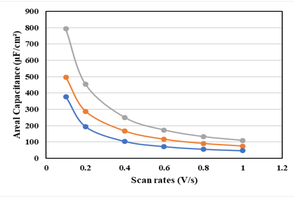
Electrochemical Characterization

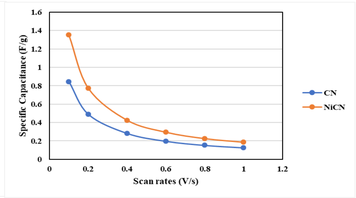
Cyclic Voltammetry





Capacitance





CONCLUSIONS

- FTIR, Raman, UV-Vis and XRD analysis indicates that the carbon nitride was successful fabricated. These results also suggest the complexation of CN with nickel.
- The electrochemical results indicate that complexation of CN with nickel cations increase its capacitance.

FUTURE WORK

- Ink fabrication with the following compositions: HC (100%), HC/CN (50%-50%) and HC/Ni-CN (50%-50%)
- Cyclic voltammetry analysis of the remaining fabricated inks
- Capacitance analysis of the remaining fabricated inks
- Evaluating the supercapacitors performance using a split cells.

ACKNOWLEDGMENTS

This research project was supported by the Title V STEM grant “Bridges to STEM success” P0031C160141.

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