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Hydrothermal Synthesis and Electrochemical Examination of Nanostructured Cobalt Sulfide for High Performance Energy Storage Devices

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Outline

➤ Introduction

- The importance of energy
- Recent advance in materials for energy storage applications
- The objective of the research

➤ Experimental sections

Synthesis of cobalt oxide
Synthesis of cobalt sulfide
Structural and electrochemical characterizations

➤ Results and Discussion

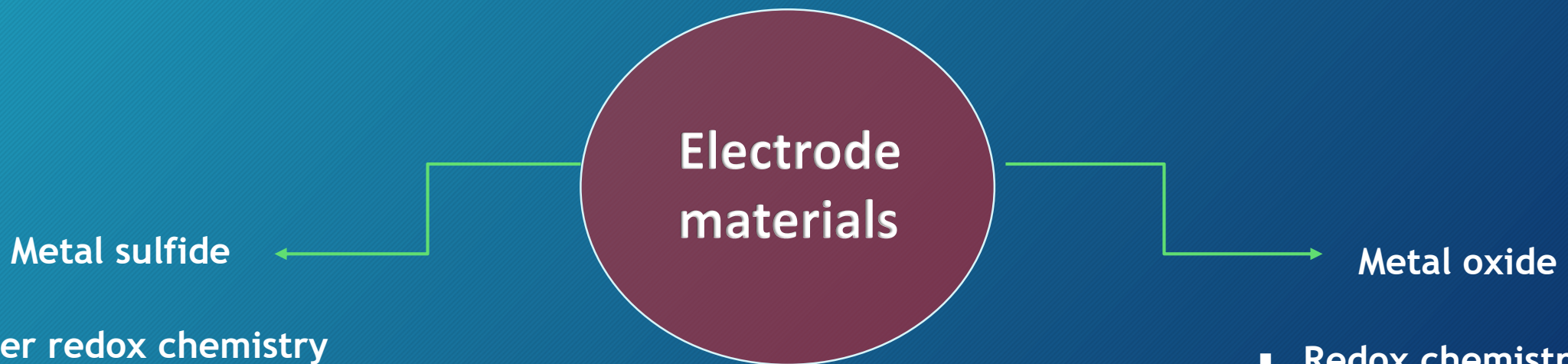
X-ray diffraction analysis
Scanning electron microscopy studies
Electrochemical measurements
Electrochemical behavior of the device

➤ Conclusion

The importance of energy

- Energy, electricity, is a fundamental input in the modern world
- Energy has become a main focus of science and worldwide as a response to growing environmental concerns
- Energy demand will increase significantly in the future due to increase use of electronic devices

Materials for energy storage applications

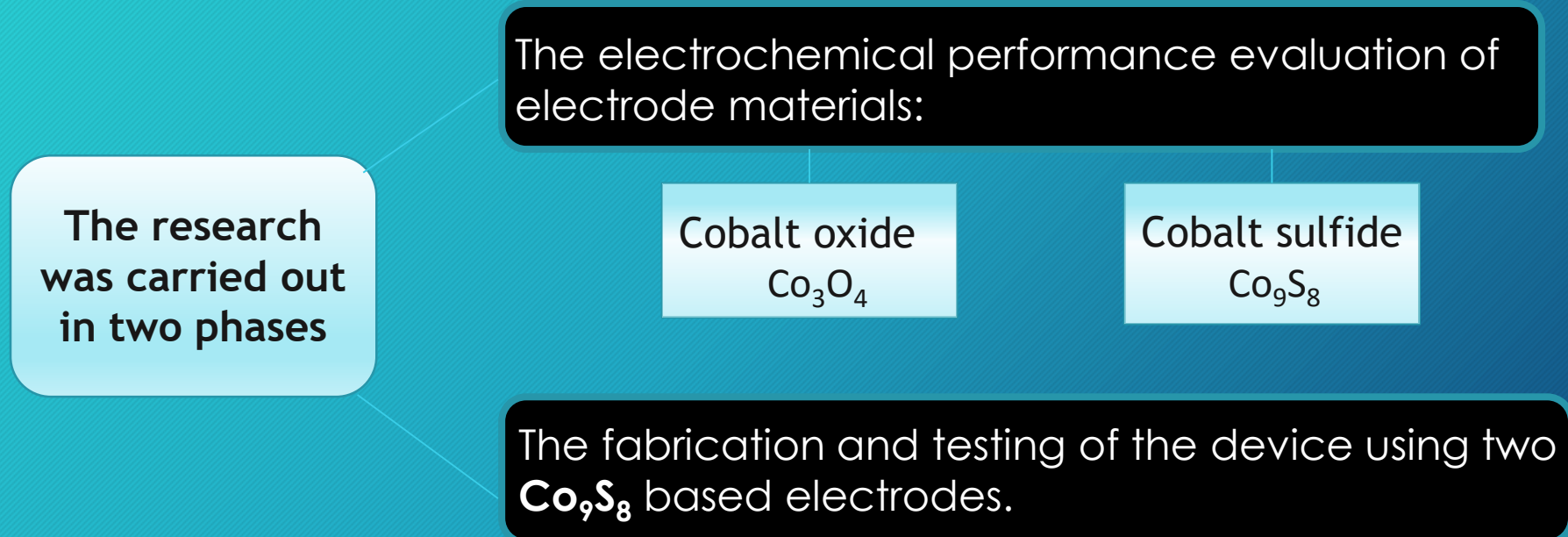


- Richer redox chemistry
- Better electrical conductivity

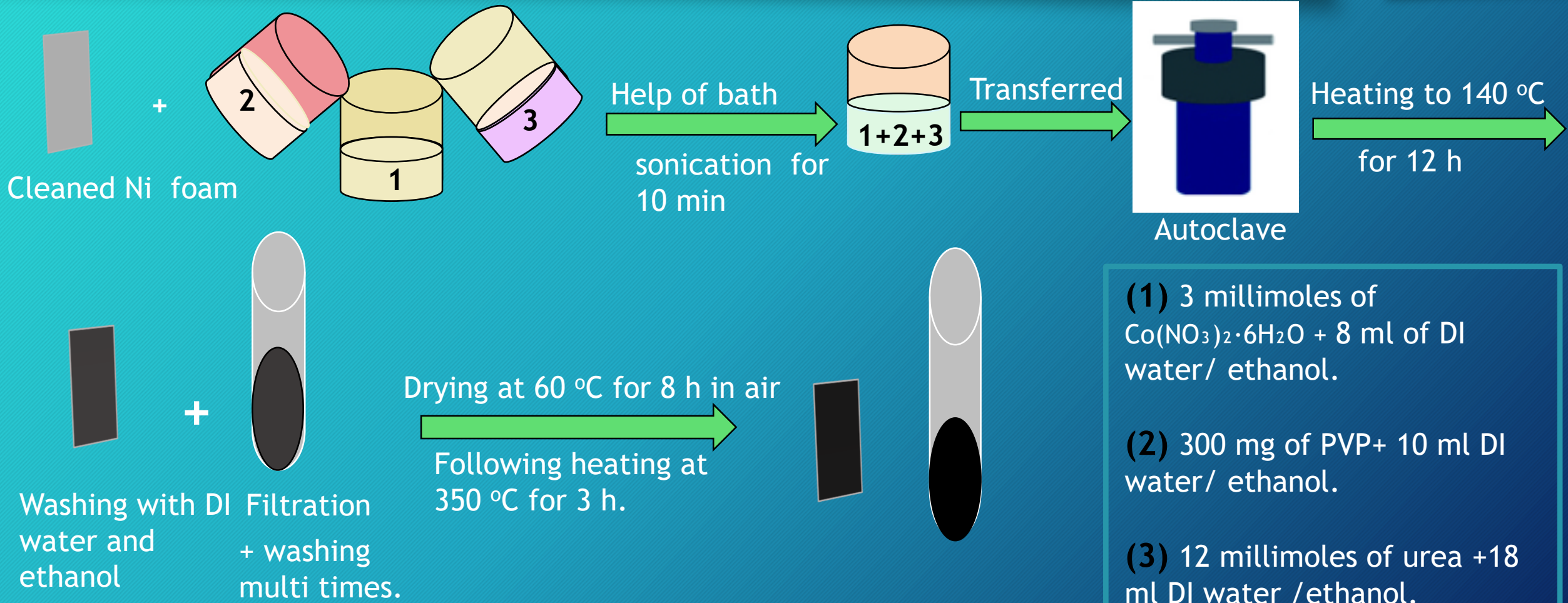
- Redox chemistry
- Controlled size and shape

The objective of the research

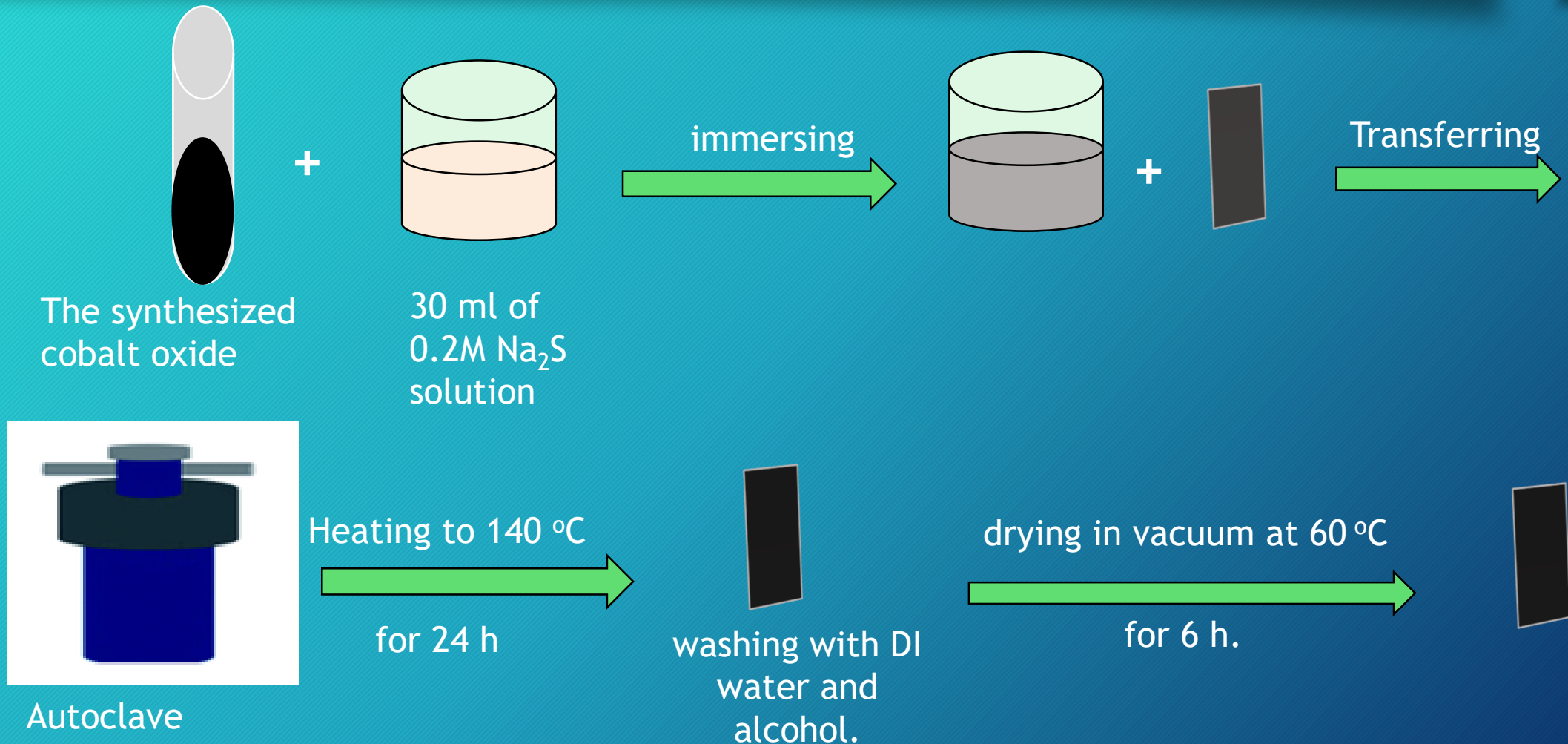
The main objective of the research is to synthesis nanostructured materials based on oxide and sulfide and compare their electrochemical properties, and then fabricate high performance energy storage devices which could be flexible as well as operate at high temperatures.



Synthesis of cobalt oxide nanostructures



Synthesis of cobalt sulfide nanostructures



Characterizations



- X-ray diffraction



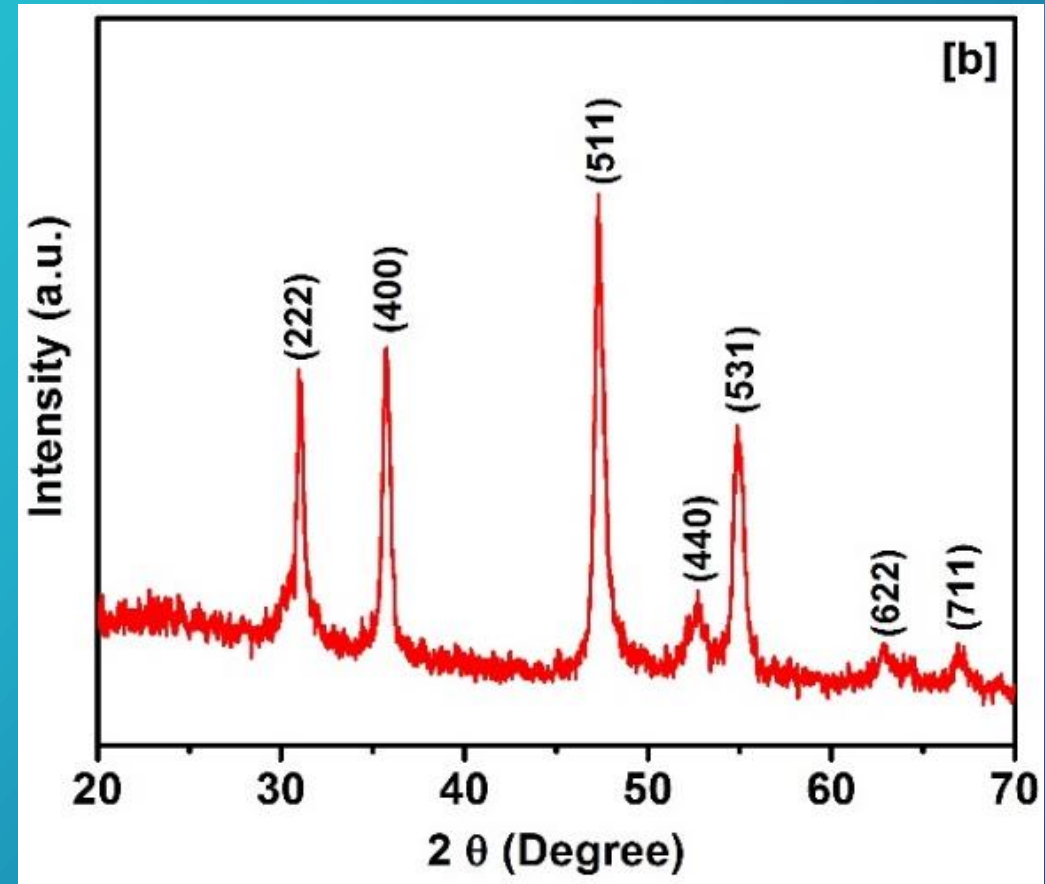
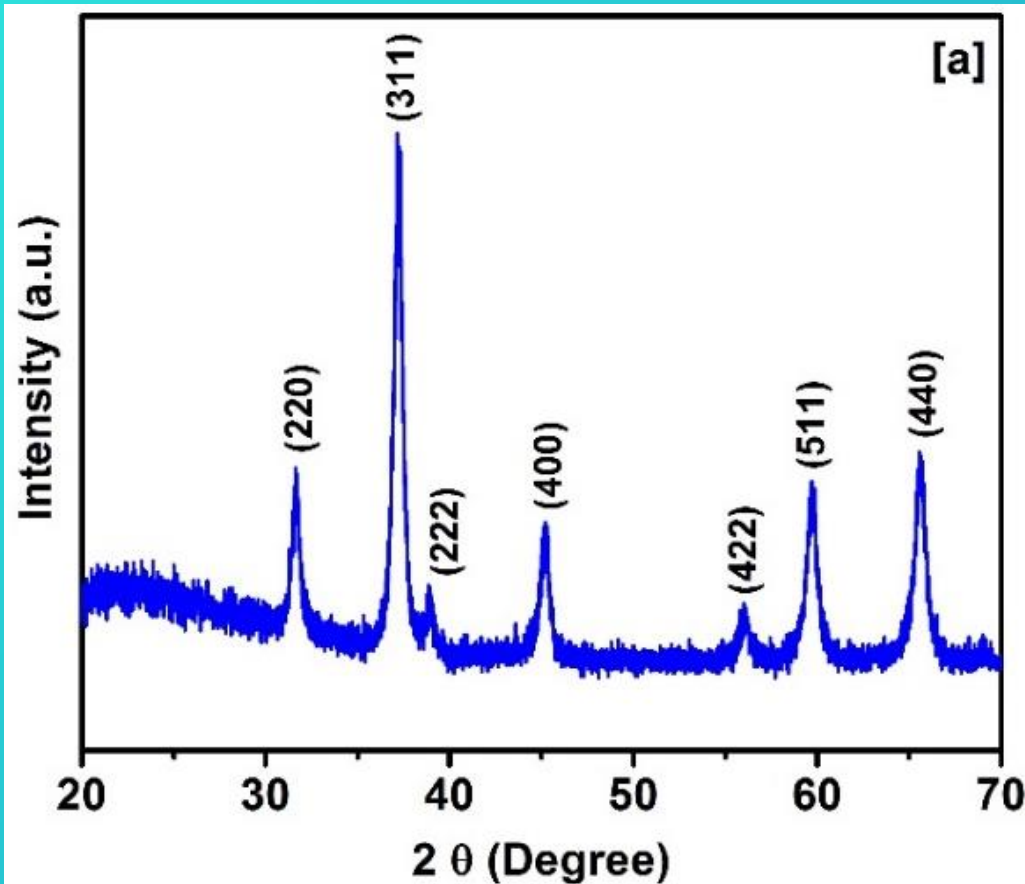
- Scanning electron microscopy



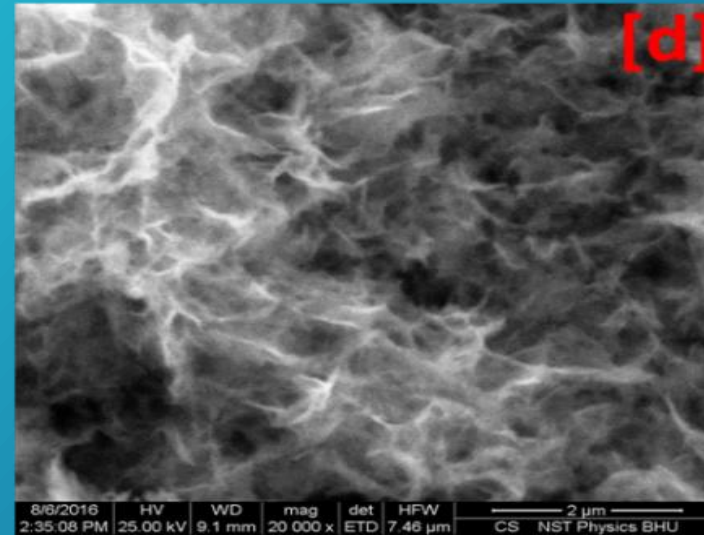
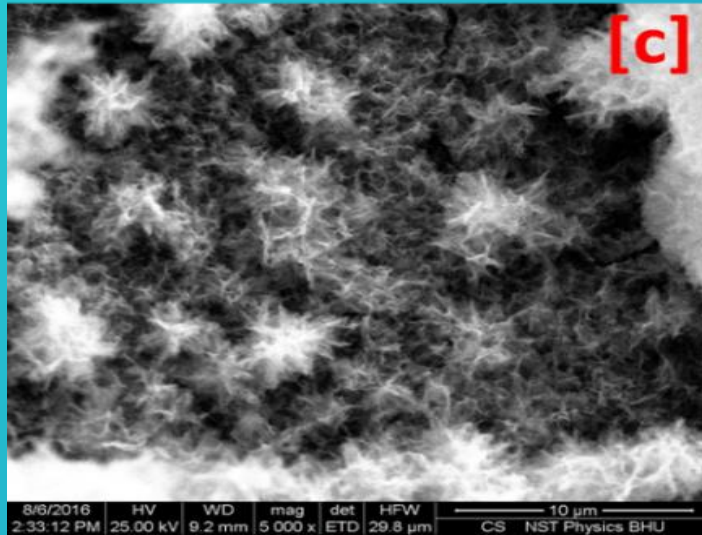
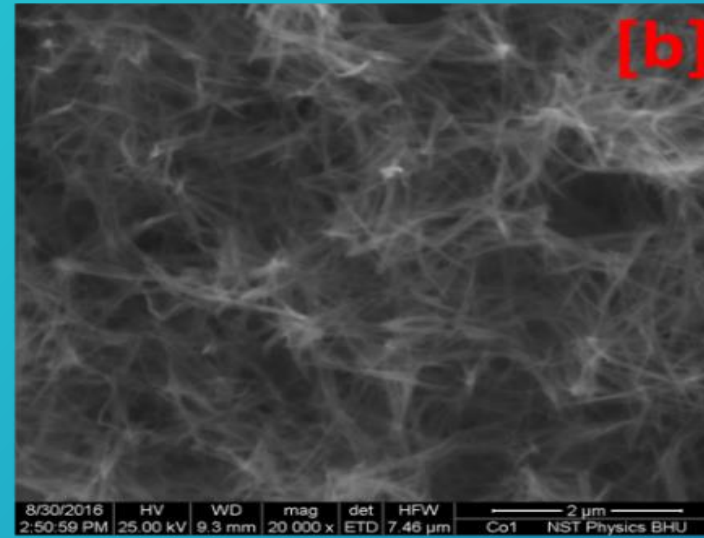
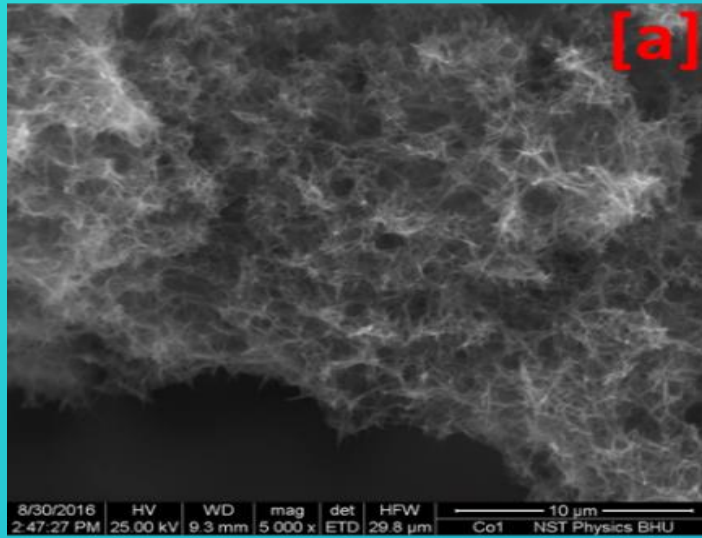
- Energy-dispersive X-ray spectrometer



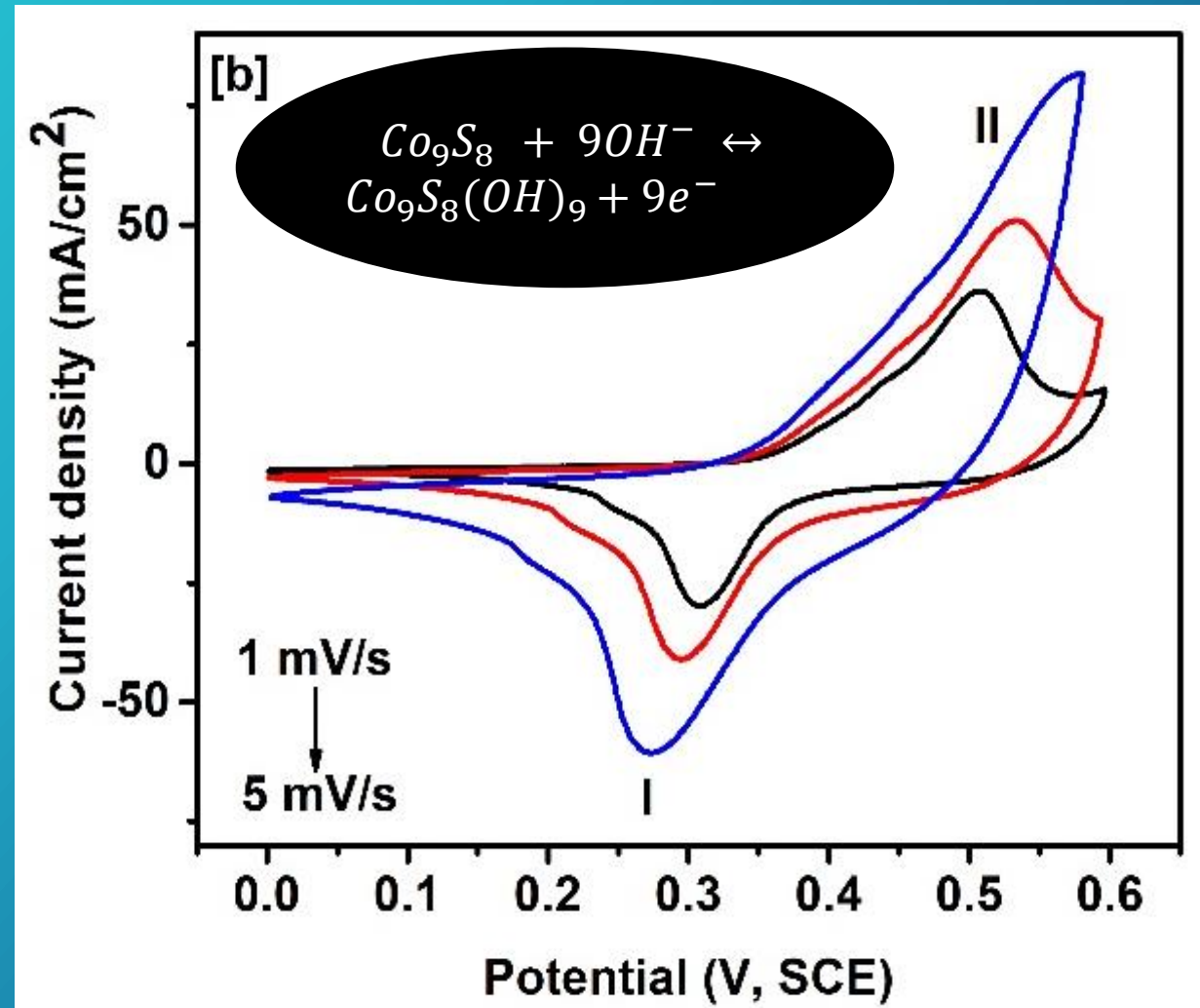
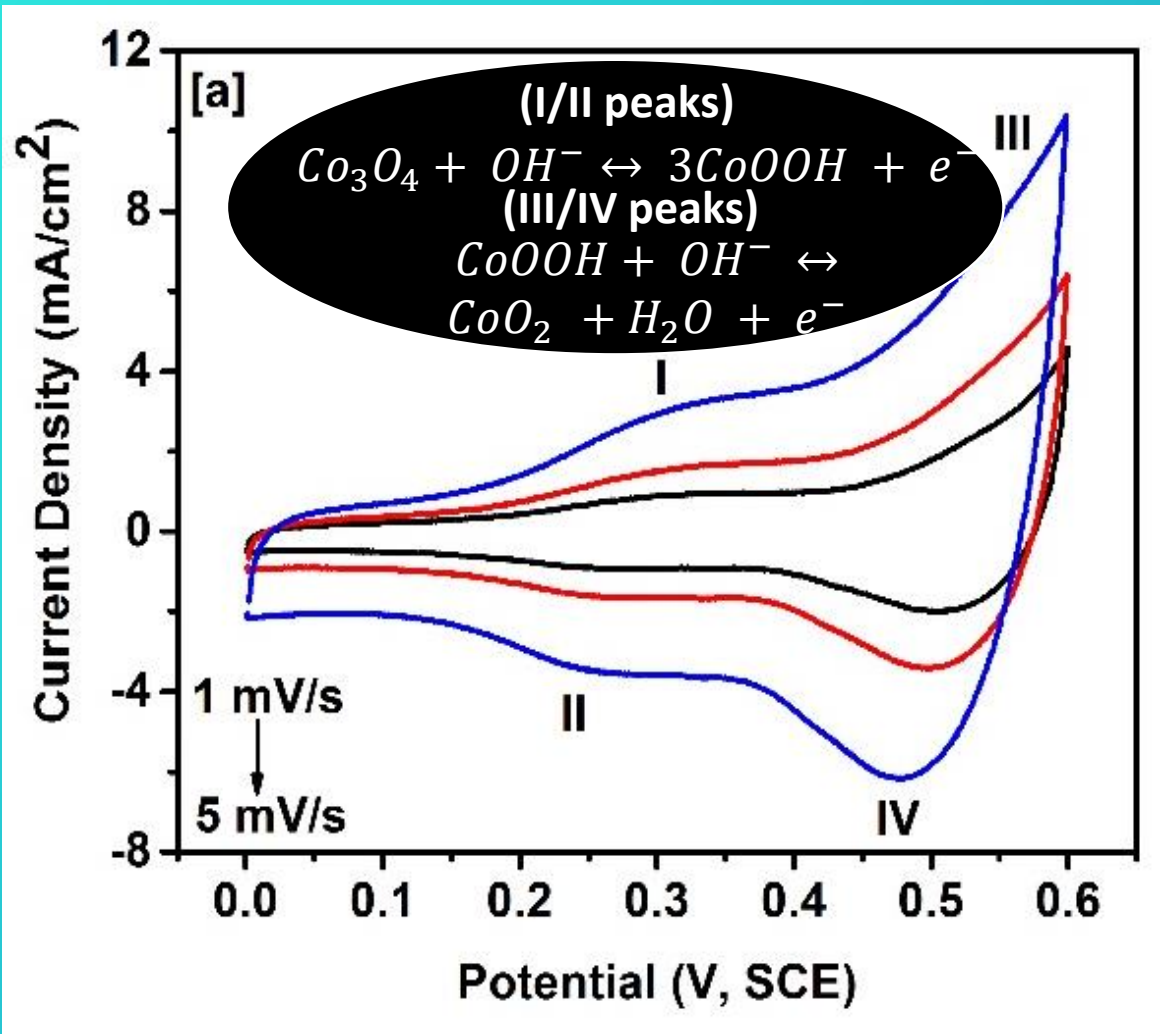
- Electrochemical techniques



XRD patterns of (a) cobalt oxide (Co_3O_4) and (b) cobalt sulfide (Co_9S_8).



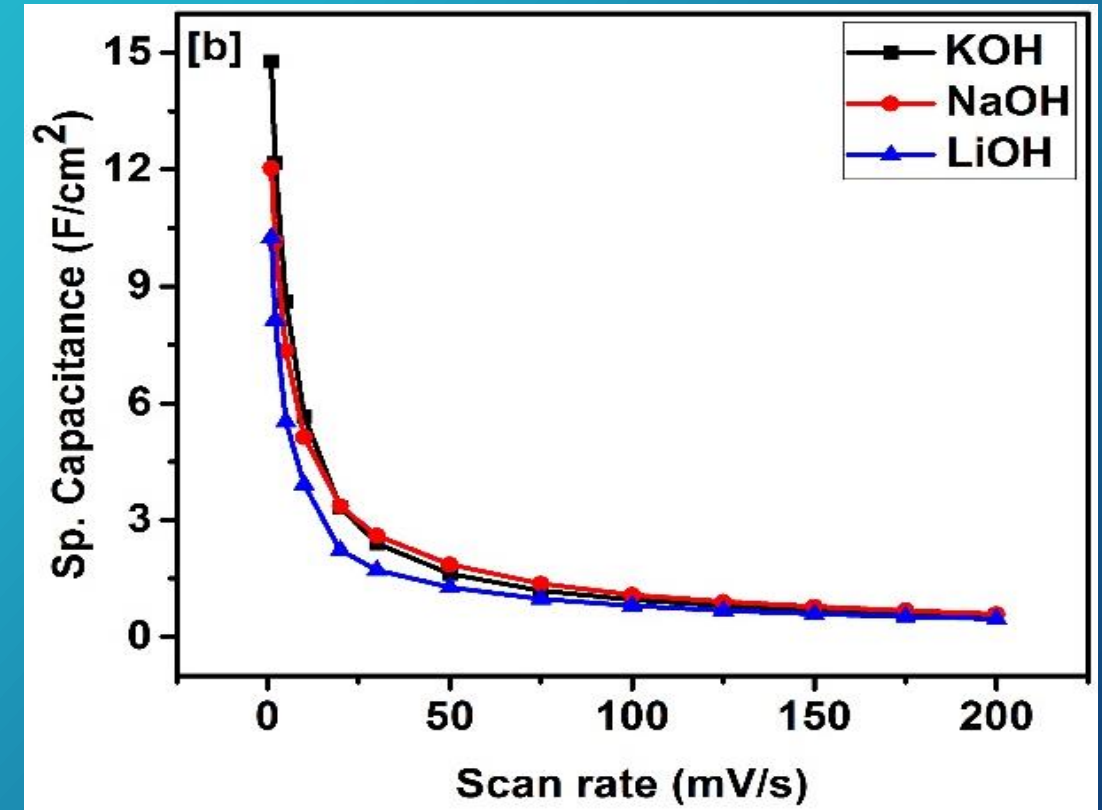
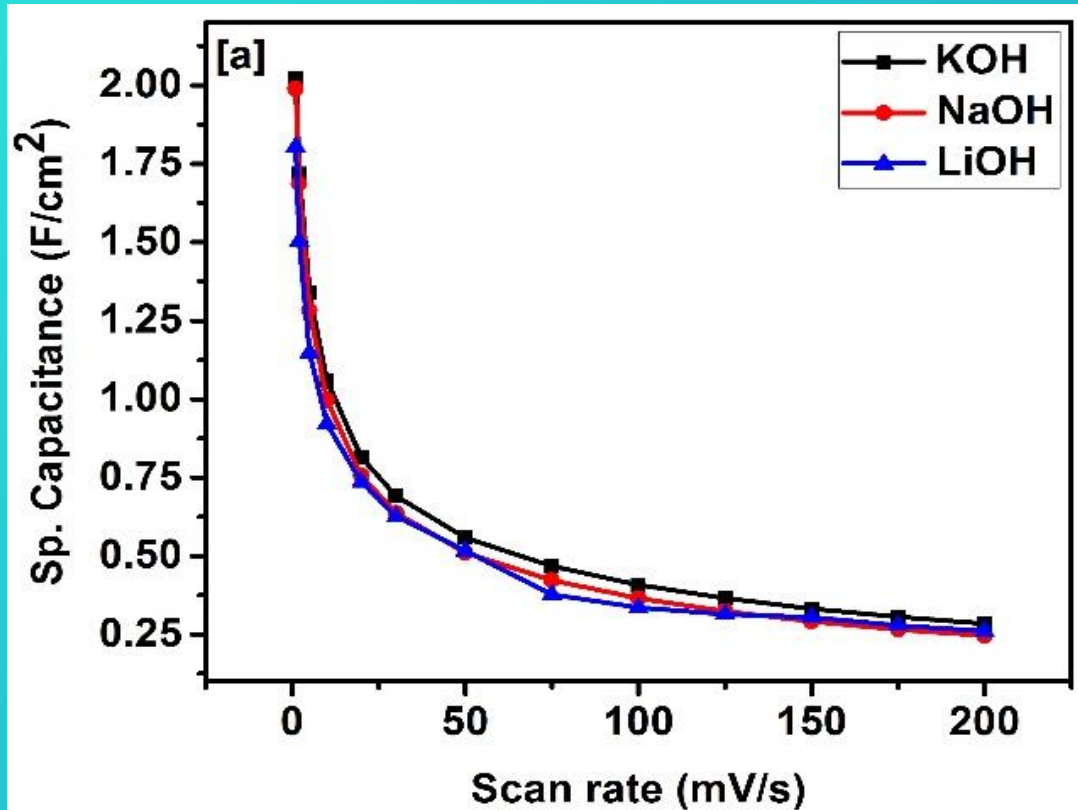
SEM images of Co_3O_4 (a,b) and Co_9S_8 (c,d) at various magnifications.



CV curves of (a) Co_3O_4 and (b) Co_9S_8 at various scan rates in 3M KOH electrolyte.

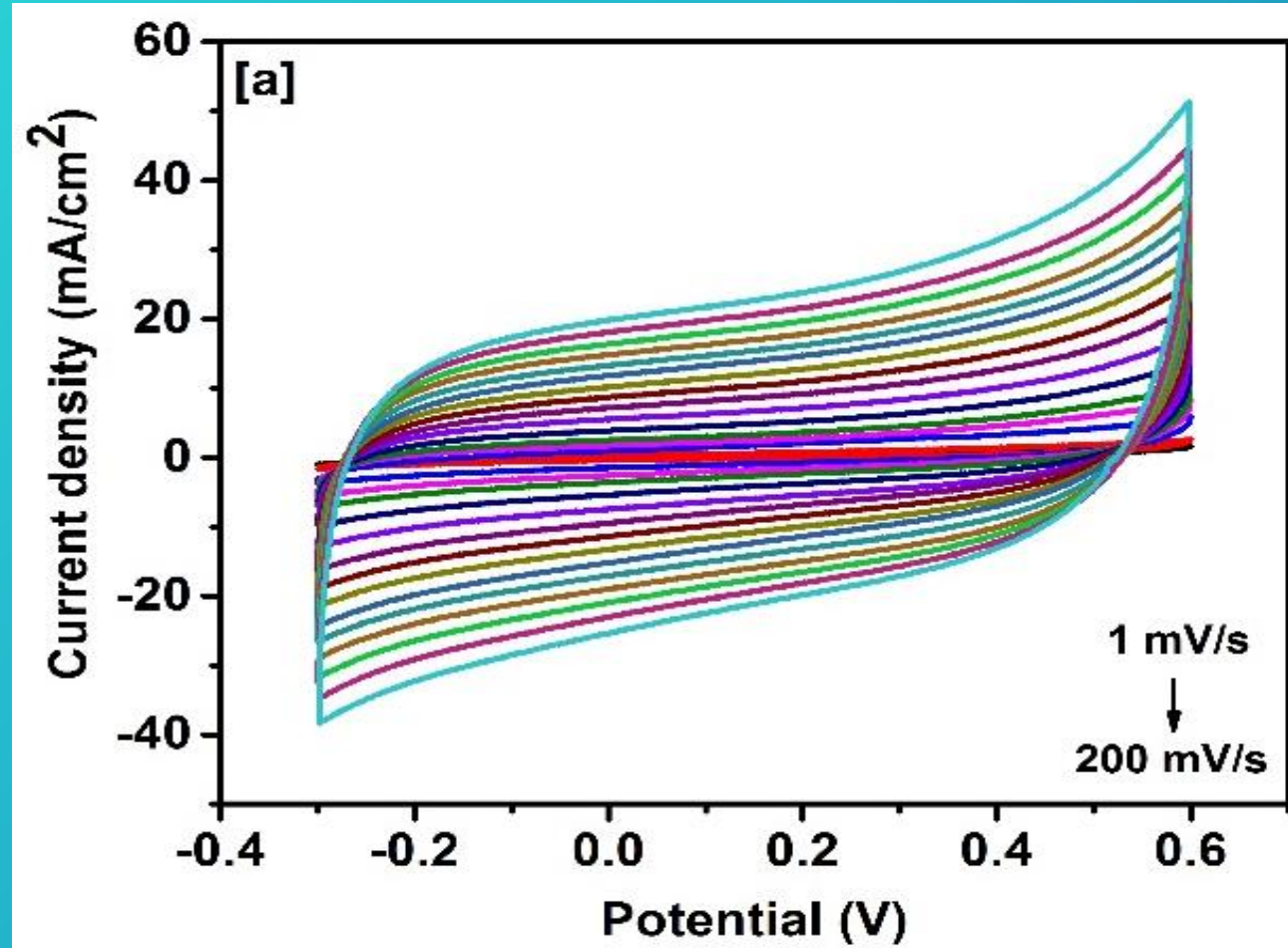
❖ The specific capacitance calculated by using data from CV measurements :

$$C_{sp} = \frac{Q}{\Delta V \times \left(\frac{\partial v}{\partial t}\right) \times A}$$



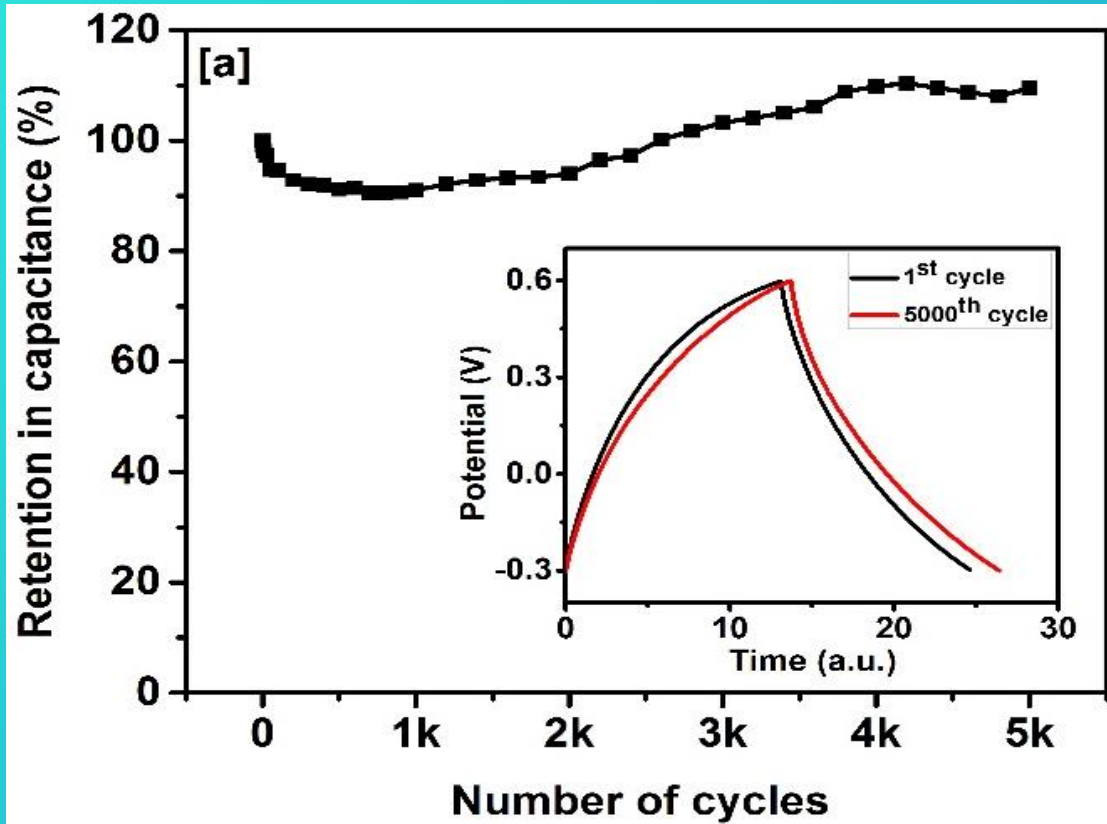
Effect of scan rate on specific capacitance of (a) Co₃O₄ and (b) Co₉S₈ in various electrolytes.

Cyclic voltammetry of the device

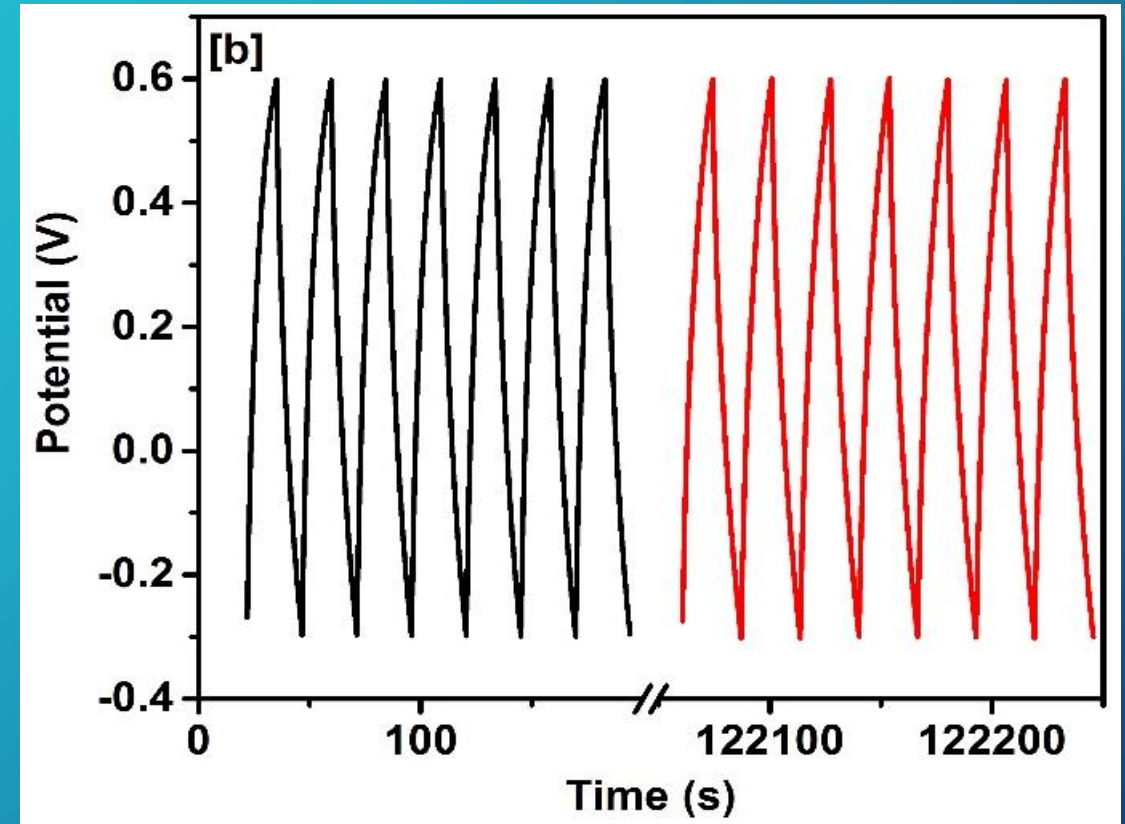


Cyclic voltammograms of the device at room temperature in various scan rates.

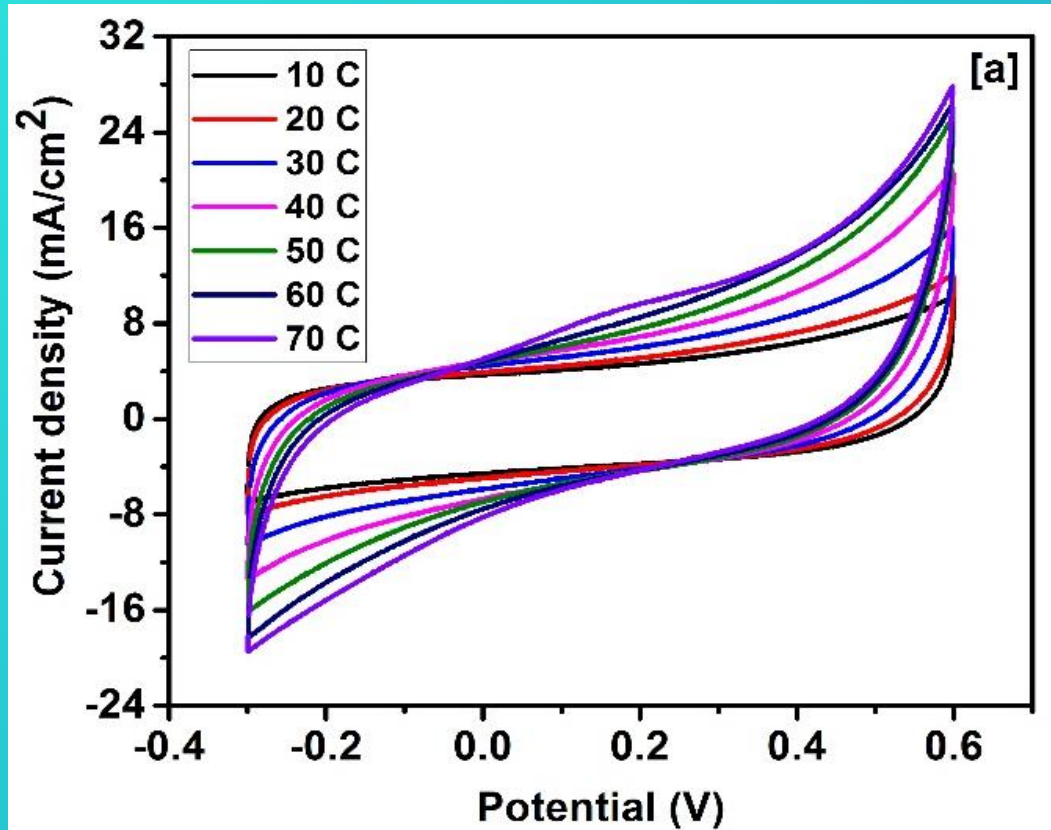
Stability Test



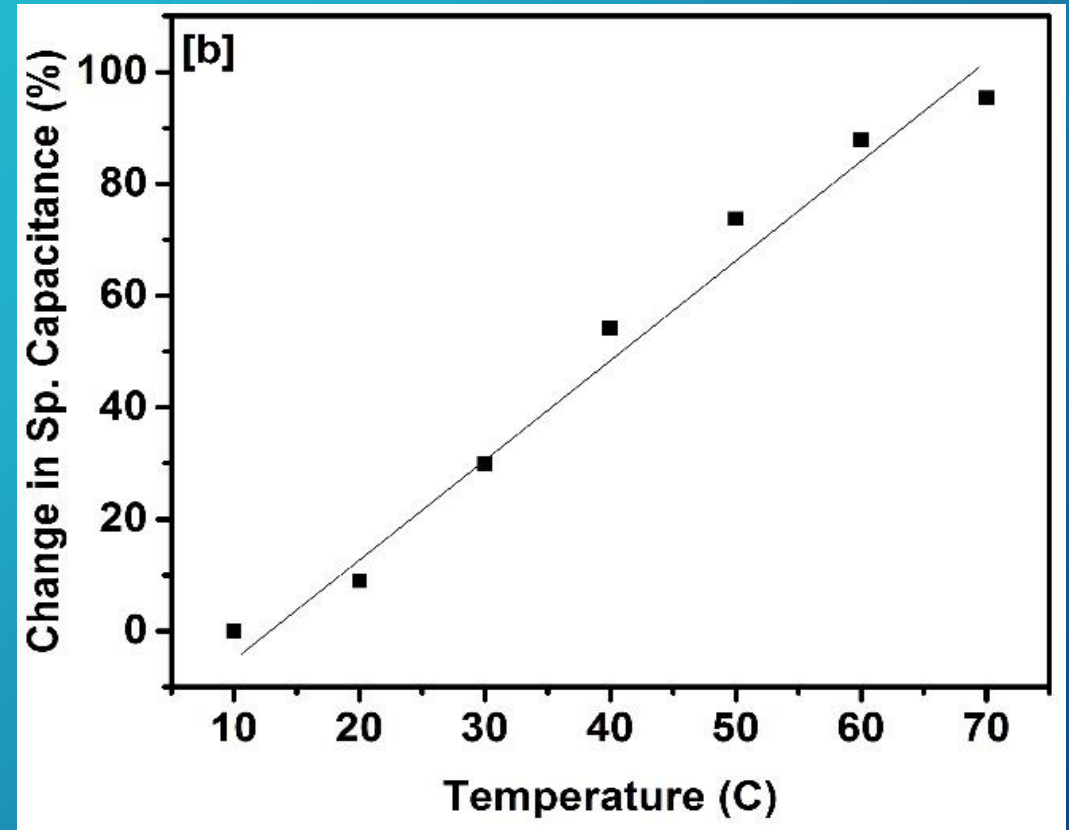
Capacitance retention versus number of charge-discharge cycles for the device (inset figure-potential vs. time plot for 1st and 5000th cycle of charge discharge).



First few and last few cycles of charge discharge profile of the device.



Cyclic voltammograms of the device at various temperatures.



% change in specific capacitance of the device versus temperatures.

CONCLUSION

- ❖ Phase pure Co_8S_9 was synthesized from Co_3O_4 using hydrothermal method.
- ❖ Cobalt oxide and cobalt sulfide showed specific capacitance of 983 and 7358 mF/cm^2 at 2 mA/cm^2 , respectively with outstanding flexibility and stability.
- ❖ About 100% improvement in the charge storage capacity of the device was observed by increasing temperature from 10 to 70 $^\circ\text{C}$.
- ❖ Our results suggest that cobalt sulfide could be used as an appropriate material for flexible energy storage devices.