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Redox Electrodes for Electrochemical Energy Storage and Thermal Energy Conversion

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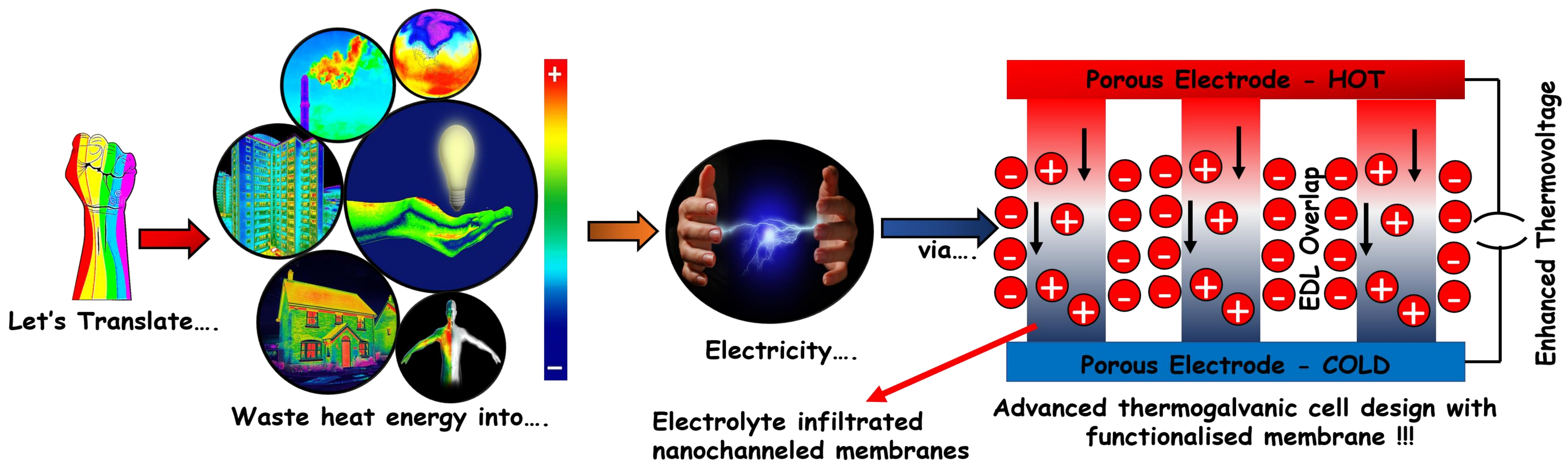
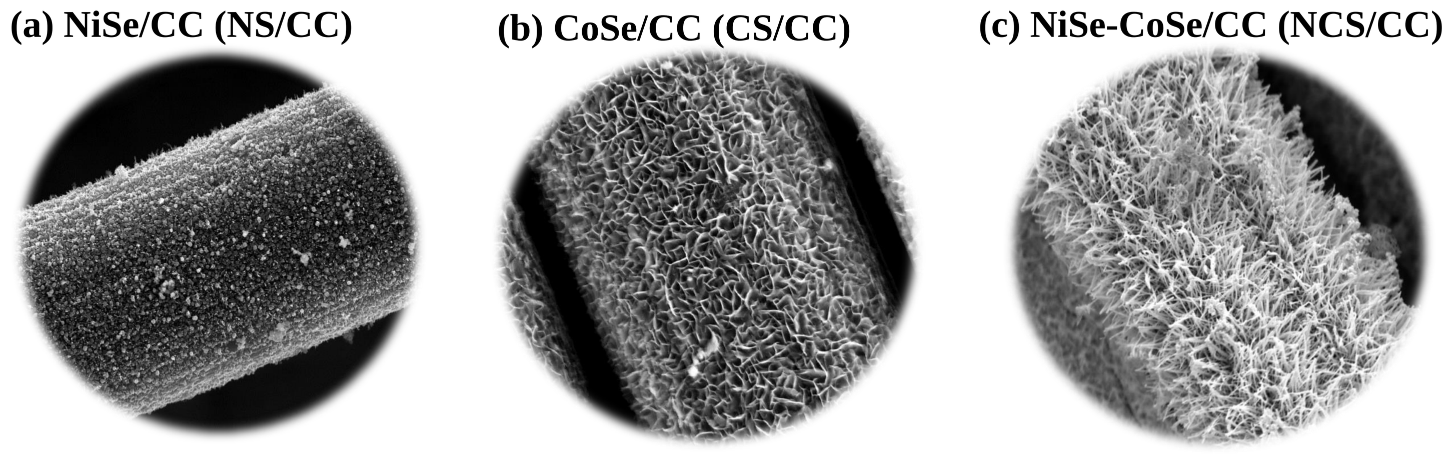
Introduction to "TRANSLATE"



Schematic representation of sustainable energy conversion from low grade waste heat through nanofluidic channels.

- TRANSLATE – Conversion of waste heat (near room temperature) into electricity.
- Developing novel porous electrodes and functionalised membranes for advanced thermogalvanic cell and thermophoretic design.
- Enhancing the Soret effect to obtain a high thermo-voltage for thermal charge storage application.

Research Objective



- Development and optimization of novel electrode materials to enhance the electrochemical and thermal charge storage performance.

Motivation

- Bimetallic selenides are known for their excellent electrical conductivity and enhanced electrochemical activity.
- Flexible carbon cloth (CC) can provide high mechanical integrity and large surface area.
- Direct integration of metal selenide on conducting substrates increase the electrochemical activity and stability.

Physico-chemical and Electrochemical analysis

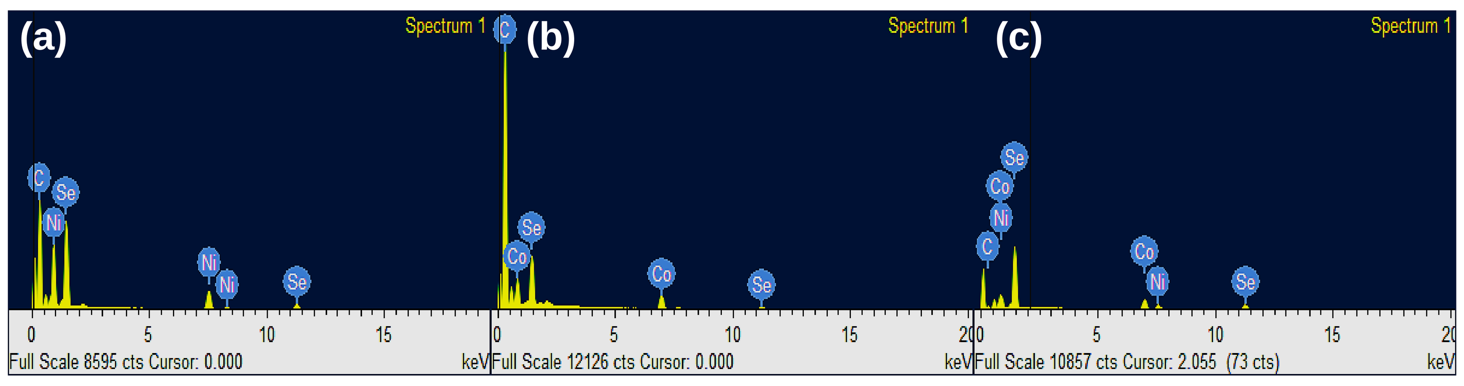


Figure. (a-c) EDX spectra of hydrothermally synthesised NS/CC, CS/CC and NCS/CC electrodes at 180 °C for 12 h.

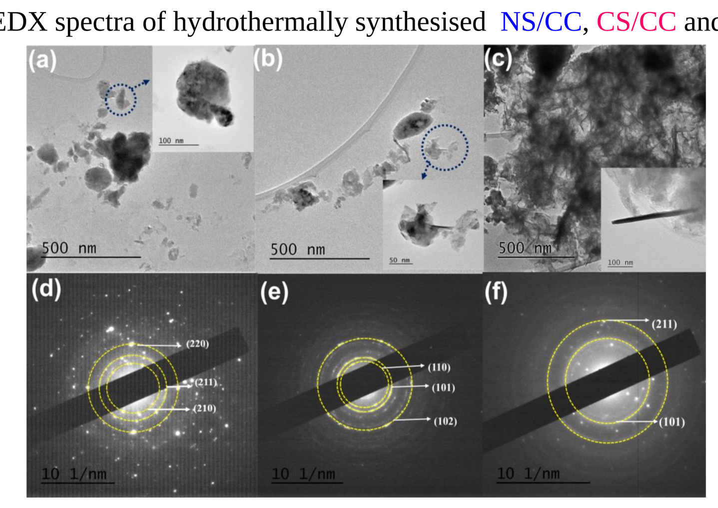


Figure. (a-c) Low magnification TEM images, (d-f) SAED pattern of NS/CC, CS/CC and NCS/CC.

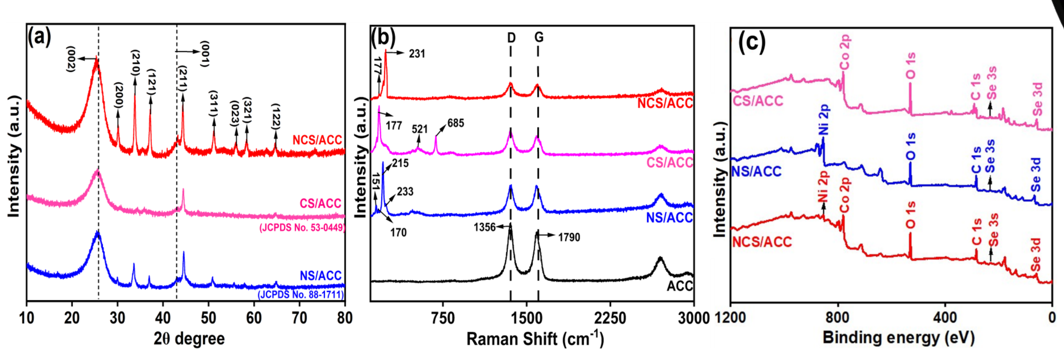
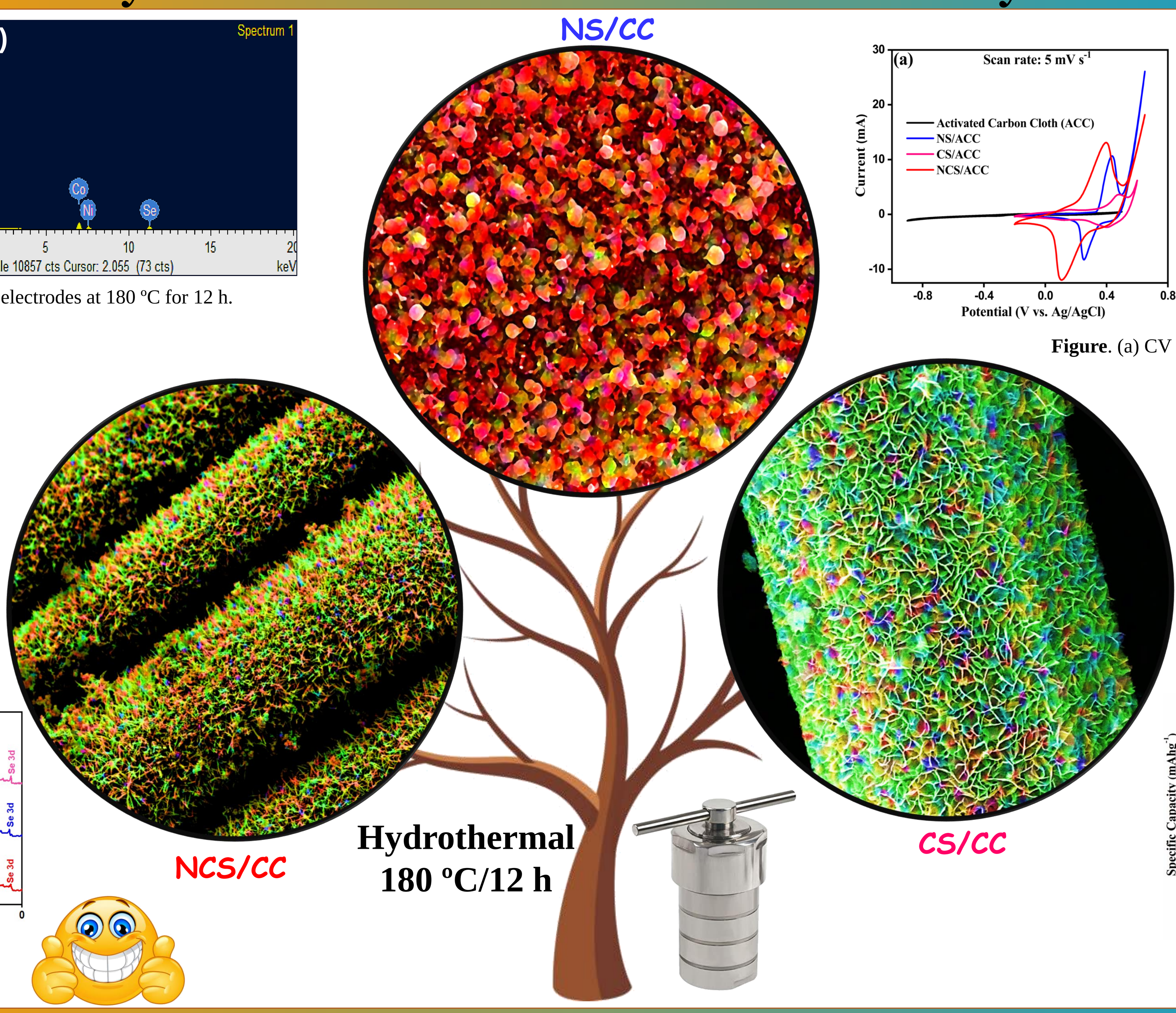


Figure. (a) XRD and (b) Raman spectra and (c) XPS survey spectrum of hydrothermally synthesised of NS/CC, CS/CC and NCS/CC.



Electrochemical Performance

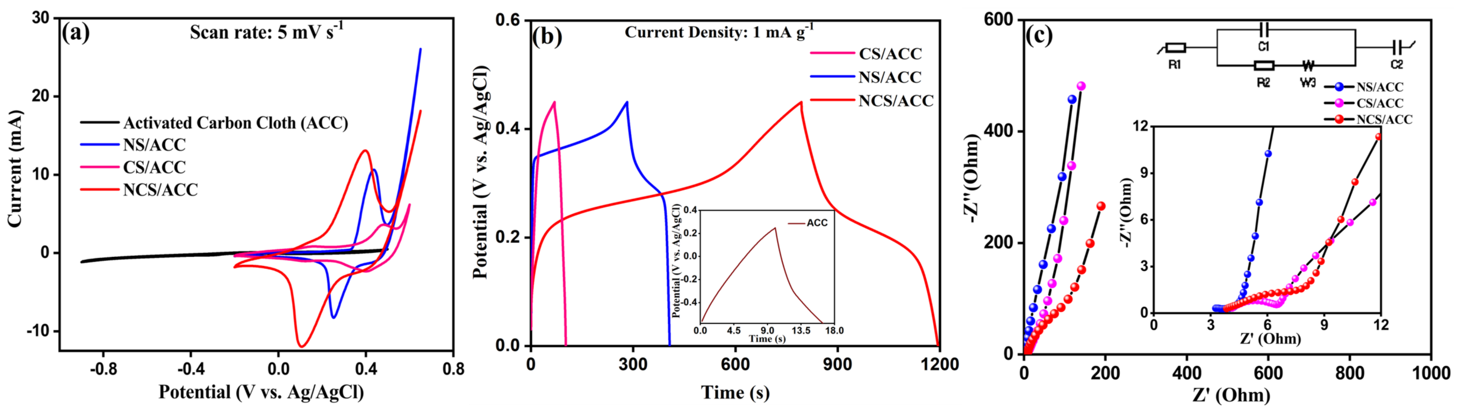


Figure. (a) CV profile at scan rates of 5 mV s⁻¹, (b) GCD profile at a current density of 1 mA g⁻¹ (c) Nyquist plots of NS/ACC, CS/ACC and NCS/ACC.

- CV profile shows the explicit oxidation and reduction peaks due to the $Ni^{2+/3+}$ and $Co^{2+/3+}$ redox couples.
- GCD graph at various specific current denotes the battery-type charge storage process at the electrodes. At 1 mA g⁻¹ NS/CC, CS/CC and NCS/CC shows a high specific capacity of 10, 17 and 112 mAhg⁻¹ (893 F g⁻¹).
- The R_s values obtained for the fabricated electrodes ranges between 3 - 5 Ω and the R_{ct} values lies in the range between 0.5 -2.5 Ω.

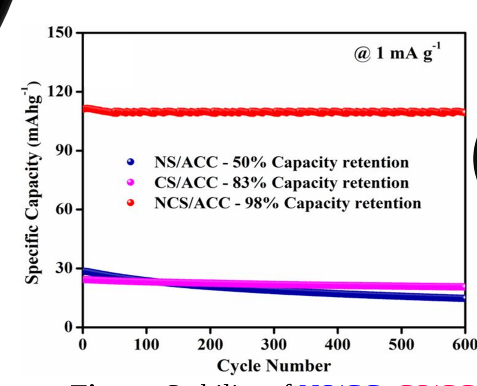


Figure. Stability of NS/CC, CS/CC and NCS/CC.

NCS/CC electrode exhibits a good capacitive retention of **98% over 600 charge-discharge cycles**, respectively.

Thermocell Characterization

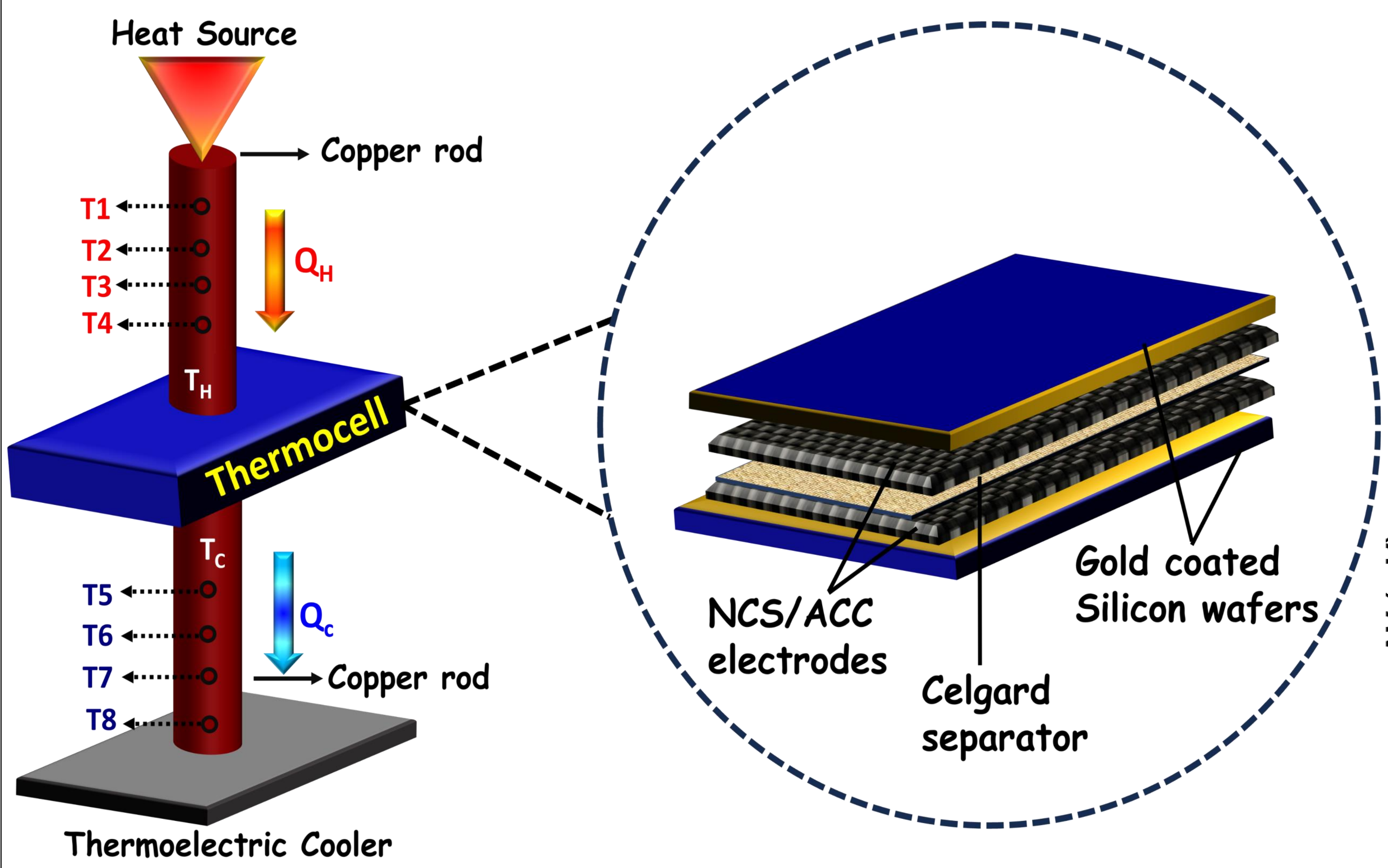


Figure. Thermoelectric Measurement system.

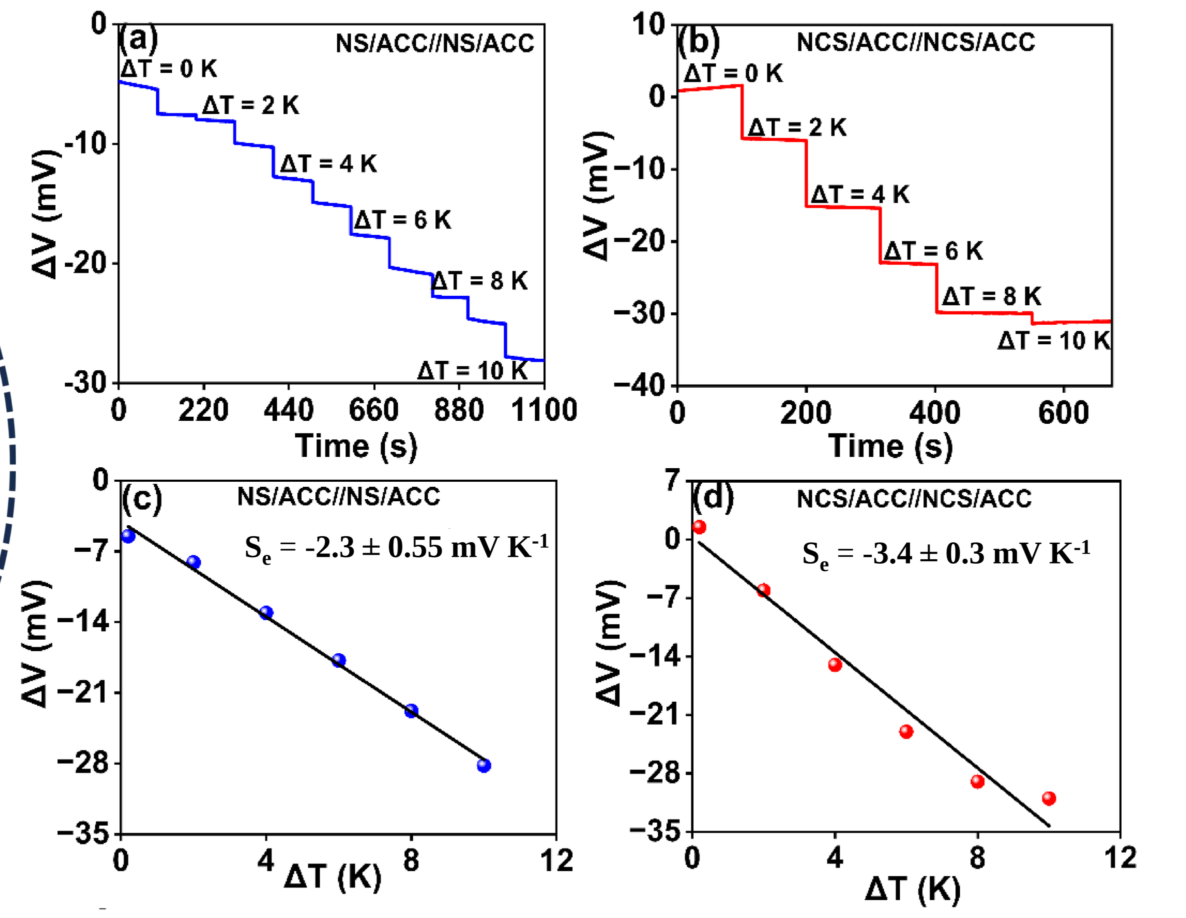


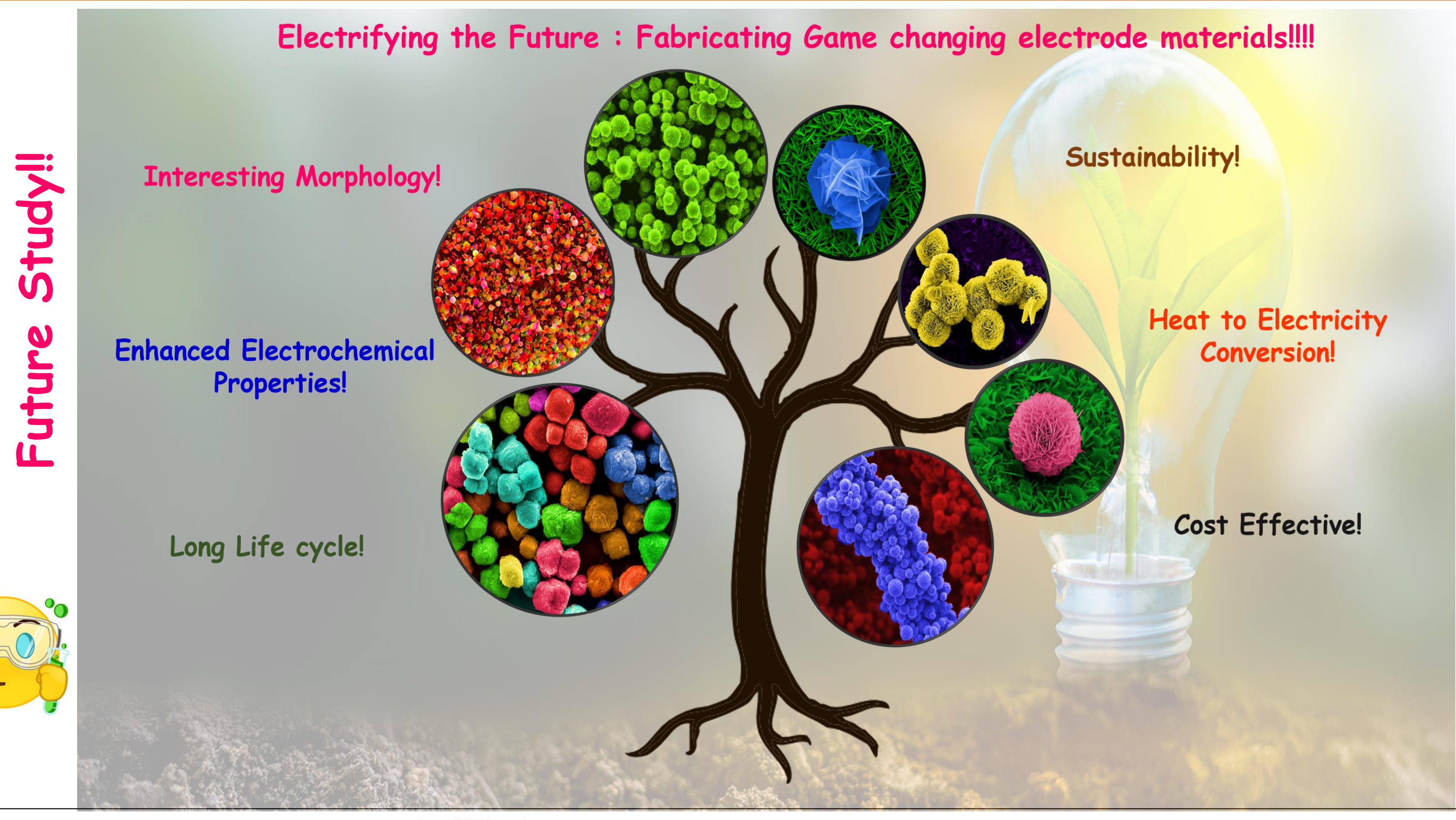
Figure. Thermoelectric measurement (a and b) Voltage (ΔV) as a function of time under different temperature gradient (ΔT = 0 to 10 K), (c and d) corresponding linear fitting result for the calculation of Seebeck voltage, S_e.

- The thermo-cell is assembled by sandwiching the 1 M NaOH infiltrated celgard separator between two symmetric porous selenide electrodes.
- The thermo-voltage obtained from NS/CC based thermo-cell is **-2.3 ± 0.55 mV K⁻¹** .
- The maximum thermo-voltage obtained from NCS/CC based thermo-cell is **-3.4 ± 0.3 mV K⁻¹** .
- This results can be further improved by increasing specific surface area and can extended to thermally chargeable supercapacitor application.

Conclusion and Future Work

Conclusion

- NCS/CC shows enhanced electrochemical properties with a high specific capacity of **112 mAhg⁻¹ (893 F g⁻¹) at a current density of 1 A g⁻¹.**
- NCS/CC symmetric thermo-cell has been successfully fabricated and a thermo-voltage of **-3.4 ± 0.3 mV K⁻¹** is obtained.
- From this study, it can be concluded that NS/ACC can be a better choice of porous electrode when compared to metal electrodes for conventional supercapacitor or thermo-cell application.
- This work can be extended to fabricate sustainable ternary metal selenides or sulphides (CuFeSe, NiCuSe etc.,)based chalcogenides for high performance thermo-energy application.
- Further, research on improving thermo-voltage is in progress.



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