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Effect of Chemical Treatment on the Electrochemical Properties of Carbon Nanotubes

Tucker Morey
Pittsburg State University

The Effects of Chemical Treatment on the Electrochemical Properties of Carbon Nanotubes

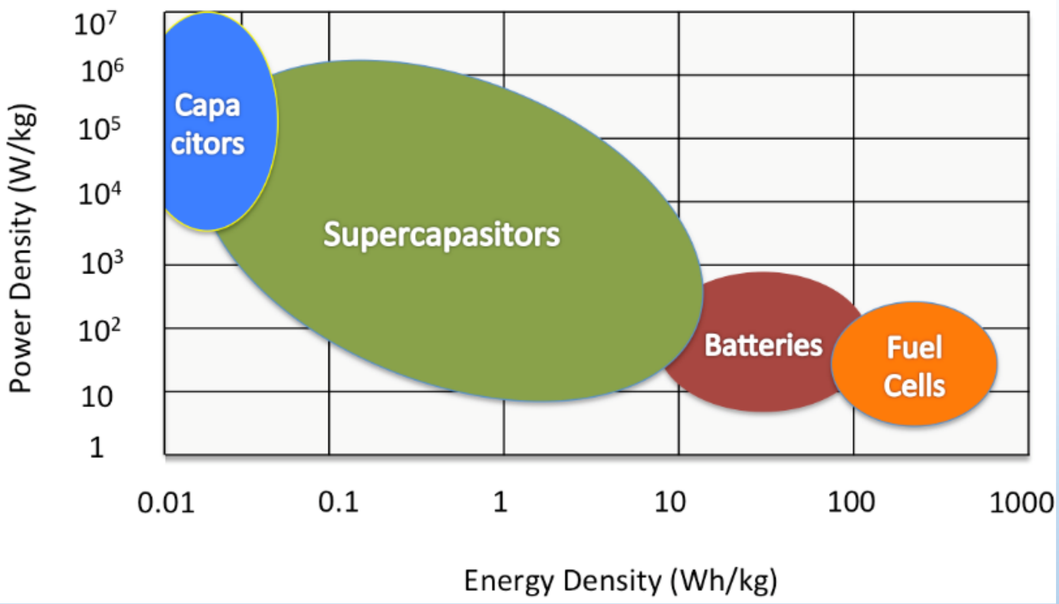
Tucker Morey, C. Ranaweera, Sanket Bhoyate, P. K. Kahol, Ram K. Gupta

Department of Chemistry, Pittsburg State University, Pittsburg, KS 66762, USA

Supercapacitors

- Electrochemical energy storage device
- Bridge the gap between dielectric capacitors and batteries

- Types of Supercapacitors
    - Pseudo capacitors (metal oxides)
    - Electric Double Layer Capacitors
        - Activated carbon
        - Carbon aerogel
        - Graphene
        - Carbon nanotubes

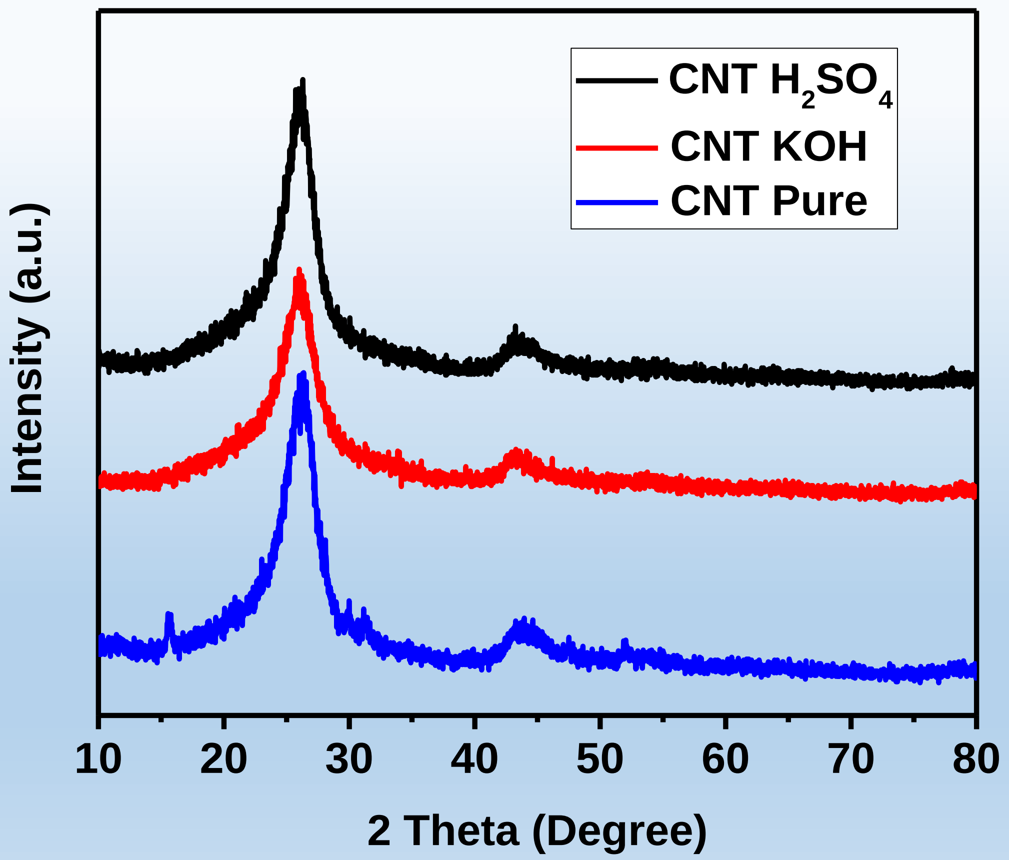


Ragone Plot

Structural Characterization

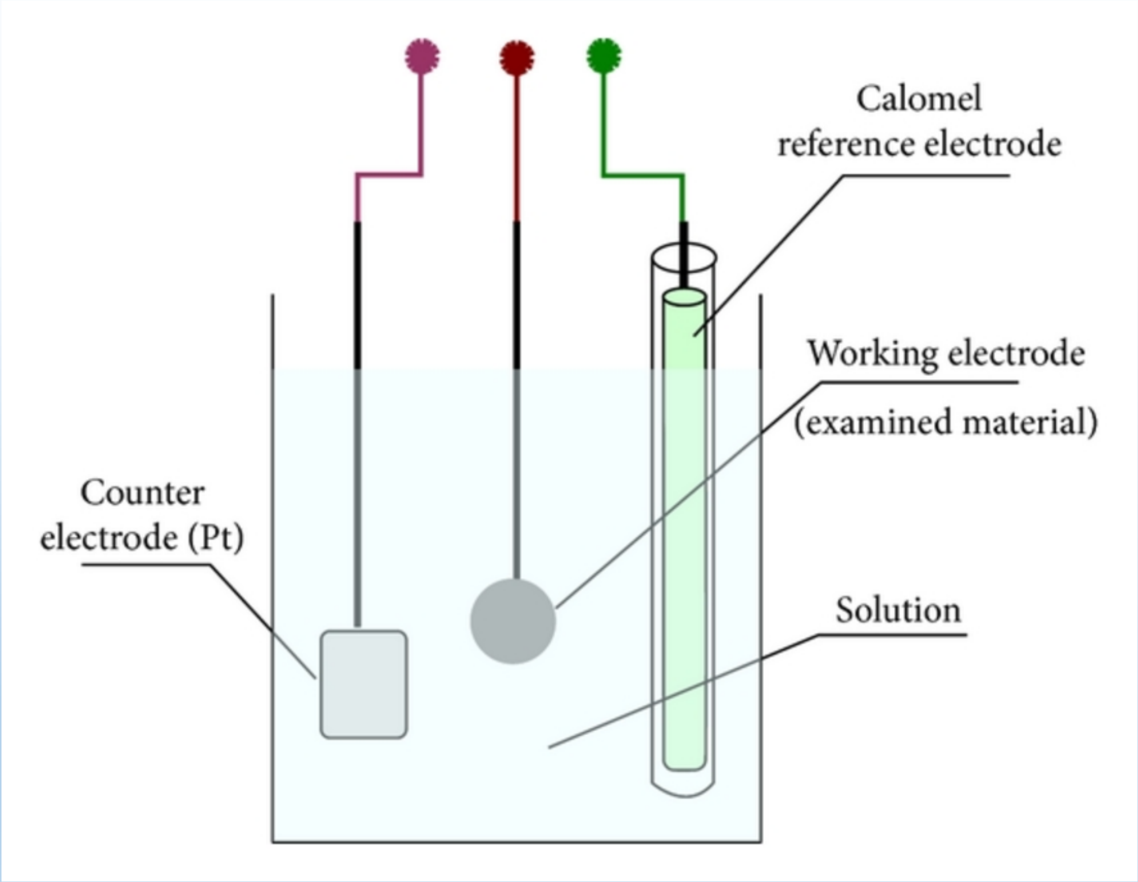
- X-ray diffraction
- Pure CNT was most graphitic (conductive phase of carbon)

- $6\ KOH + C \rightarrow 2K + 3H_2 + 2K\ CO_2$
- Nano pores caused by KOH activation
  - EDL formed inside porous carbon
  - Increase surface area increases ion absorption and therefore capacitance
- Brunauer-Emmett-Teller absorption method
  - Pure CNT = 210 m^2/g
  - KOH activated = 239 m^2/g
  - H_2SO_4 treated = 236 m^2/g



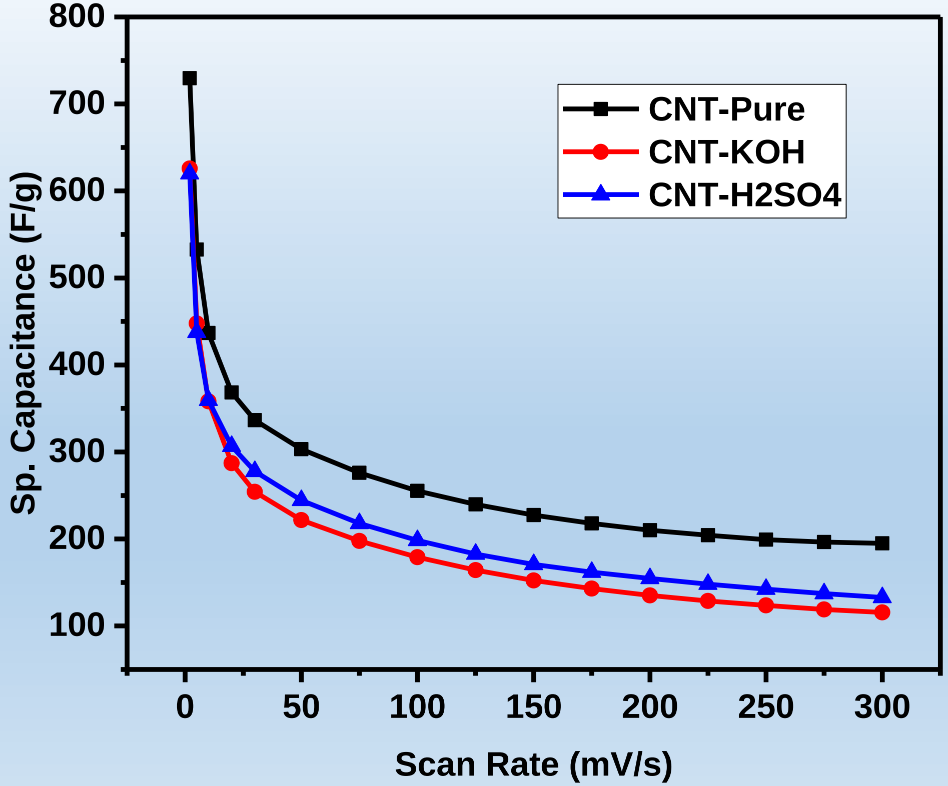
Electrochemical Characterization

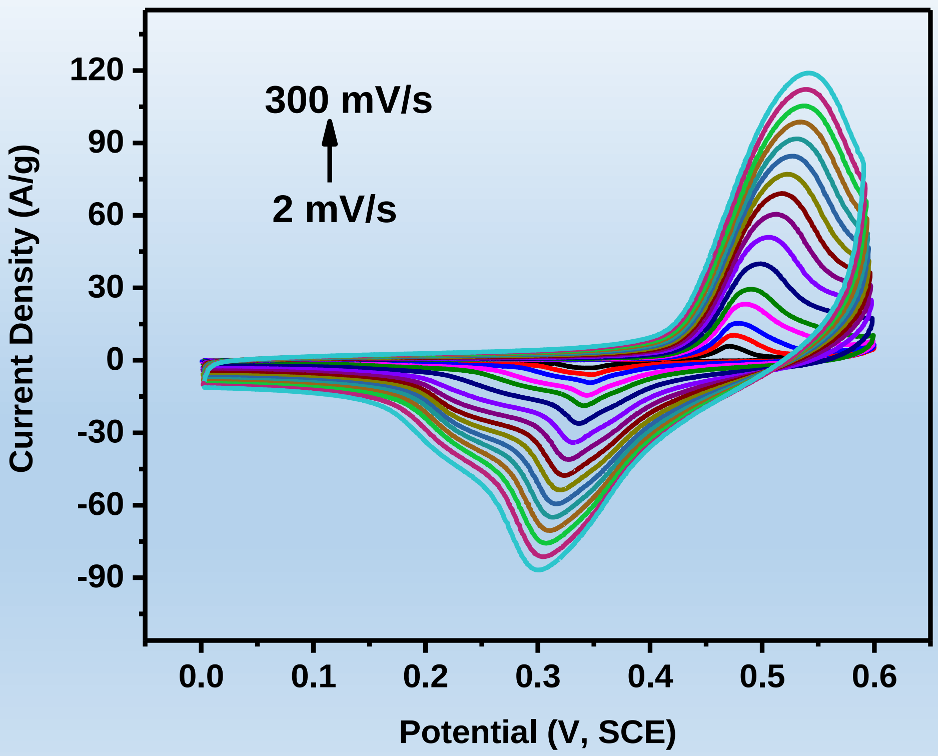
- Working Electrode Preparation:
  - Mixed 80 wt.% CNT, 10 wt.% acetylene black, 10 wt.% polyvinyllidene difluoride (PVdF) in N-methyl pyrrolidinone (NMP).
  - Slurry was pasted on nickel foam
- Charge storage capacity was measured using both cyclic voltammetry (CV) and galvanostatic charge-discharge (CD)



Cyclic Voltammetry (Positive Potential)

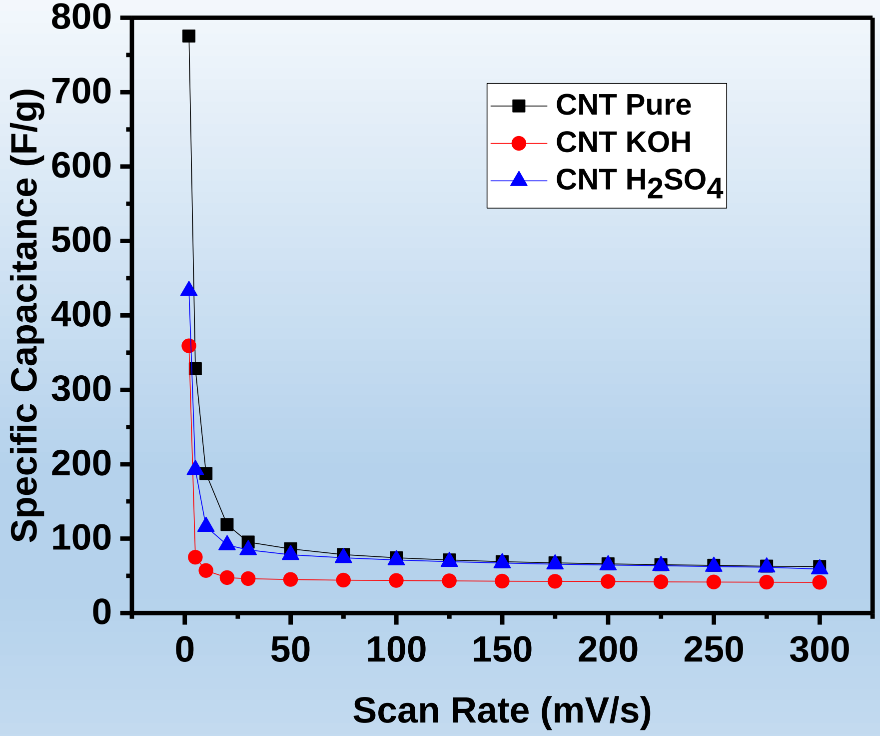
- Peaks represent the transfer of electrons
- Specific Capacitance decreases with increasing scan rates
  - Insufficient time for electrolyte to absorb and desorb from electrode surface

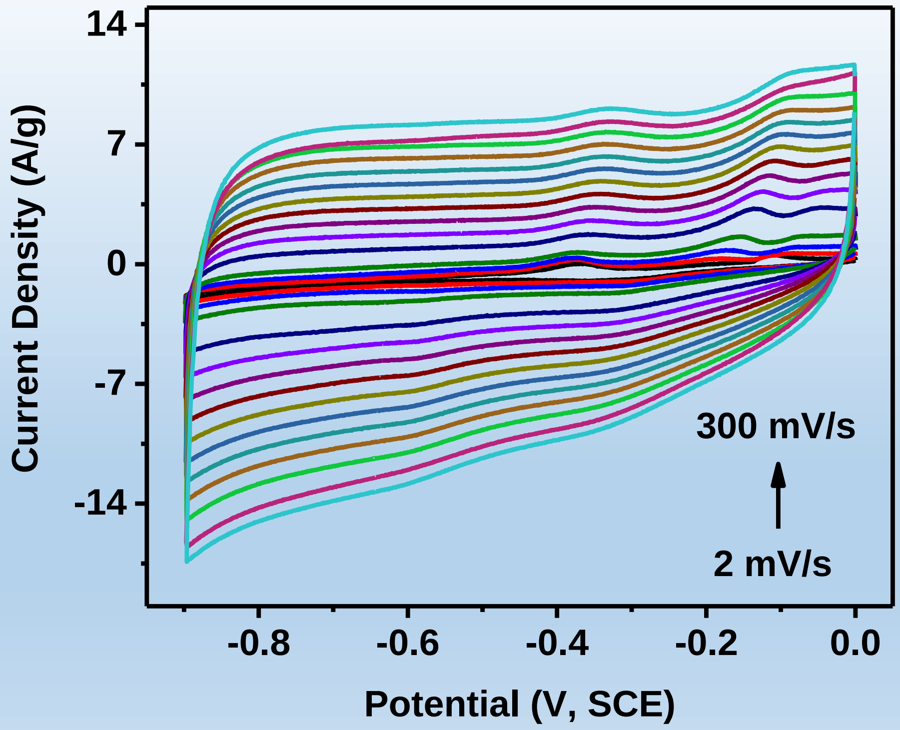




Cyclic Voltammetry (Negative Potential)

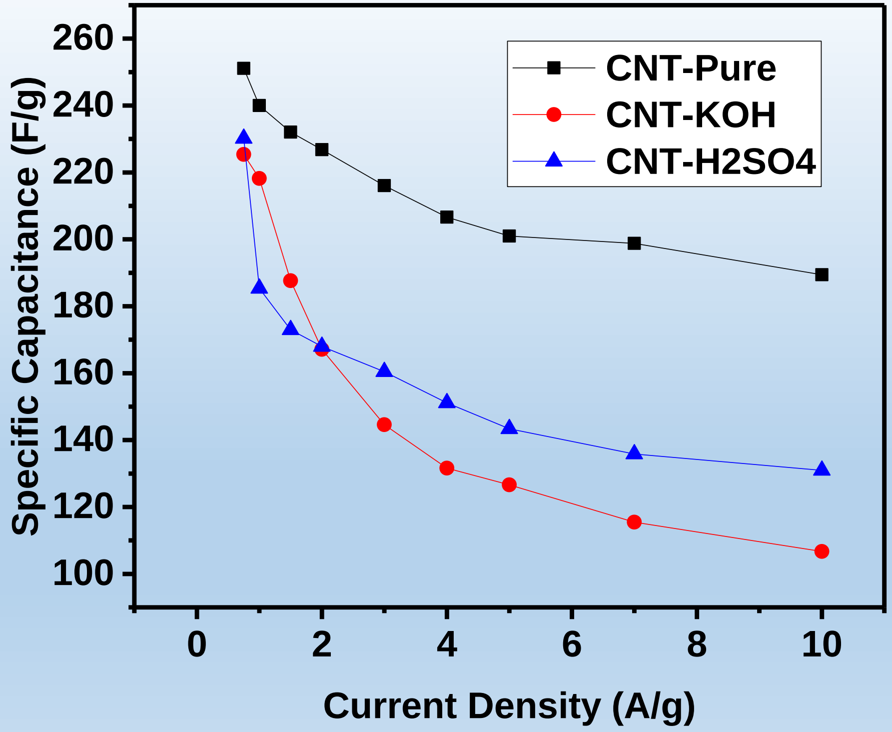
- The shape of the graph confirms the electrochemical double layer
- Similar shape over various scan rates shows electrochemical stability of electrode

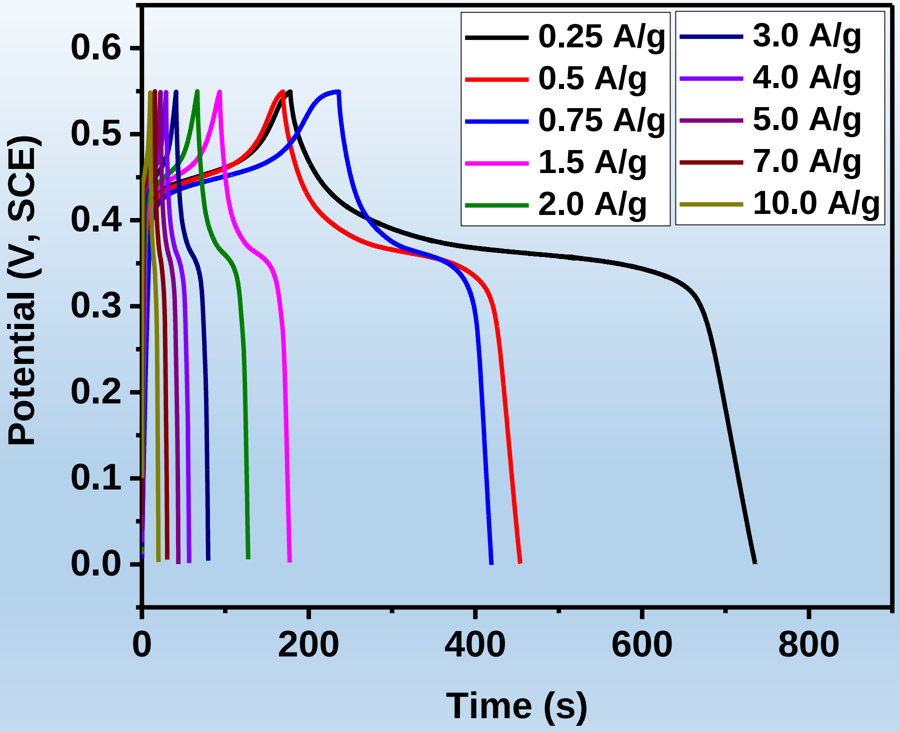




Galvanostatic Charge-Discharge (Positive Potential)

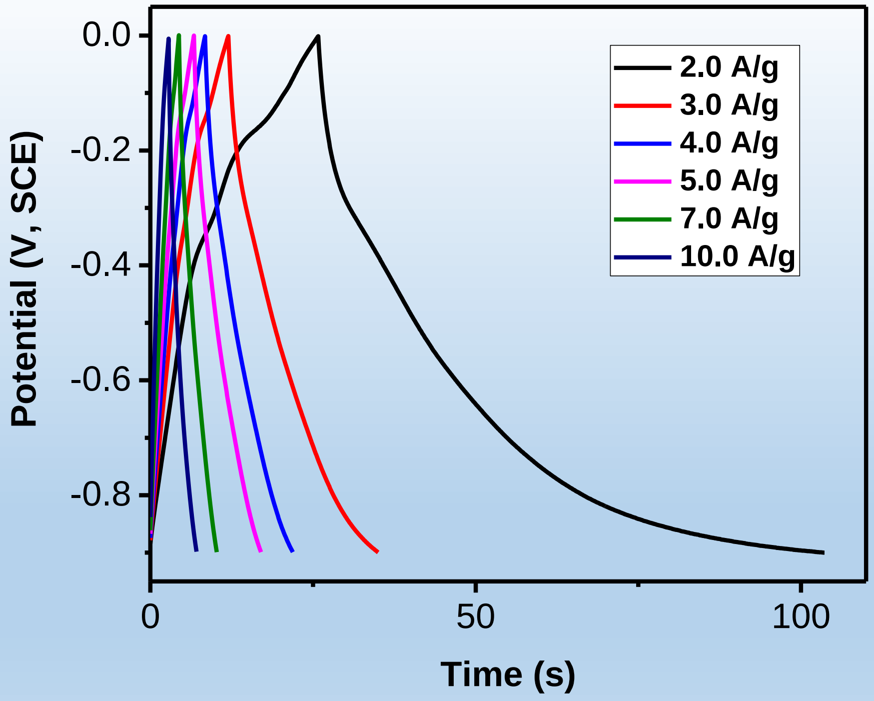
- $C_{sp} = \frac{I \times \Delta t}{\Delta V \times m}$
- Specific Capacitance decreases with increasing current densities
  - Insufficient time for electrolyte to diffuse into pores

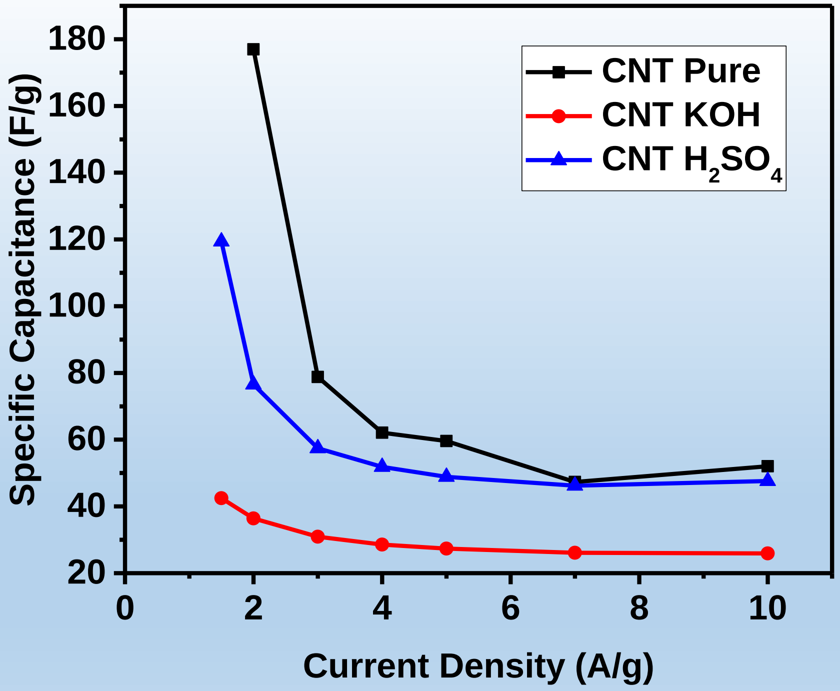




Galvanostatic Charge-Discharge (Negative Potential)

- Symmetrical and linear curves at high current densities
  - Suggests the stability of the electrode
- Specific capacitance decreased with increasing current densities





Summary

- Pure carbon nanotube had the highest specific capacitance of 769 F/g at 2 mV/s
- The reduced capacitance of the sulfuric acid and KOH treated samples was likely due to the creation of functional groups that would increase resistivity
- Carbon nanotubes are still a promising material for supercapacitors given their relatively high surface area and crystalline graphitic structure