Capacitive Deionization as an Effective Tool for Water Desalination

Abstract

This project is directed to design CDI system and to improve its electrode material. Carbon Nano-Fibers (CNF) with a different percent of Cobalt(Co), Titanium Carbide (TiC) modified by Reduced Graphene Oxide (RGO) and Vulcan Carbon (VC) were tested using three electrode setup structure. The Cyclic Voltammetry (CV), Potentiostatic Electrochemical Impedance Spectroscopy (PEIS) and Specific Capacitance (SC) graphs were plotted to examine the materials performance. The results show that 90% Co/CNF and RGO/TiC electrode materials have the best performance. The best electrode material RGO/TiC was tested in the designed CDI unit cell and compare it with VC and Carbon aerogel (CAG). The tests were performed under different conditions: voltage and flow rate to find the optimum operating conditions. The CDI system performance results illustrate that CAG is the best electrode.

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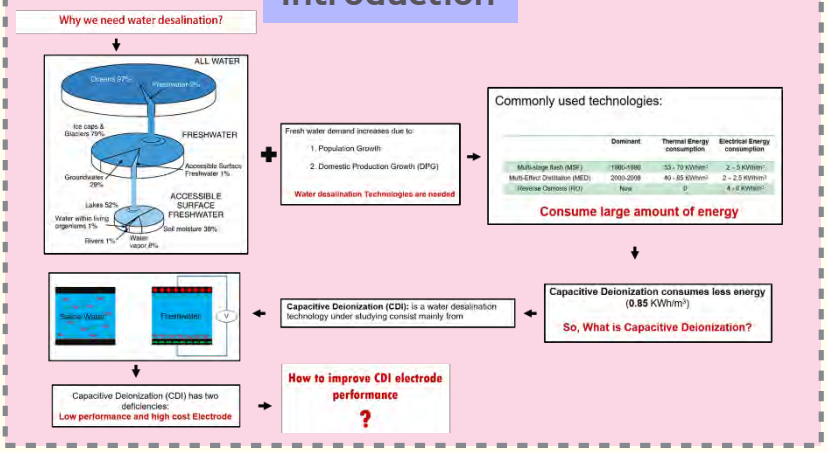
Introduction



Objectives

- Improve CDI electrode performance: TiC and CNF
- Design, Manufacturing, Operation CDI system
- Test the improved electrode materials performance in the designed system

Methodology

1. Adding different Co% in CNF and modifying TiC with RGO.
2. Chemical composition testing: SEM, XRD, and Raman.
3. Ex-situ testing : CV and, PEIS
4. Calculating SC from CV and plotting it versus scan rate.
5. Designing, Manufacturing, Operating CDI system.
7. CDI system performance using CAG, RGO/TiC.
8. Finding the optimum flow rate and voltage for the CDI system.
9. Depositing the material on the electrode
10. In-situ cell testing for the best electrode material.

Mathematical Section

Specific Capacitance: $C_s = \frac{\int i\,dV}{m.v.\Delta V}$

Results:

Scanning Electron Microscopy (SEM):

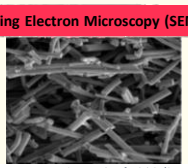


Figure 1: SEM for 0% Co/CNF material.

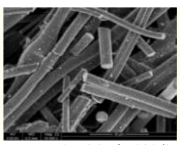


Figure 2: SEM for 70% Co/CNF material.

Cyclic Voltammetry (CV):

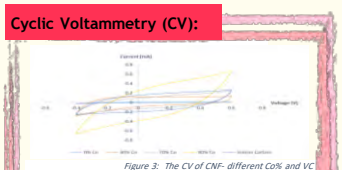


Figure 3: The CV of CNF- different Co% and VC for 100 mV/s scan rate.

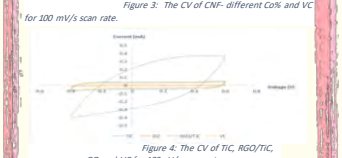


Figure 4: The CV of TiC, RGO/TiC, GO and VC for 100mV/s scan rate.

Specific Capacitance (SC):

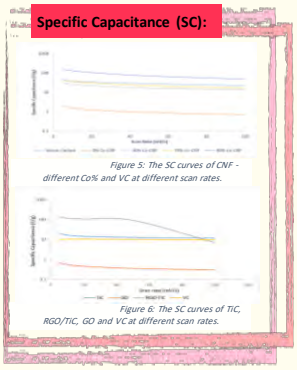


Figure 5: The SC curves of CNF - different Co% and VC at different scan rates.

Figure 6: The SC curves of TiC, RGO/TiC, GO and VC at different scan rates.

Voltage Effect:

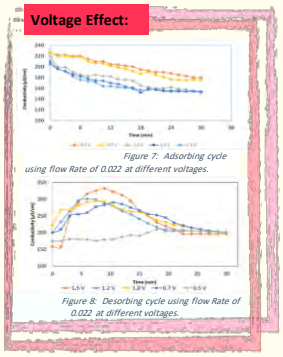


Figure 7: Adsorbing cycle using flow Rate of 0.022 at different voltages.

Figure 8: Desorbing cycle using flow Rate of 0.022 at different voltages.

Material Effect:

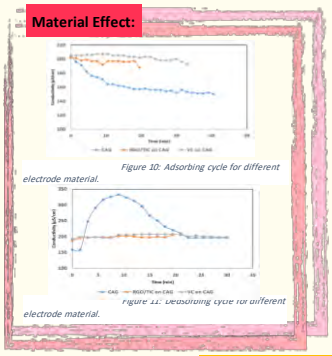


Figure 10: Adsorbing cycle for different electrode material.

Figure 11: Desorbing cycle for different electrode material.

Flow rate Effect:

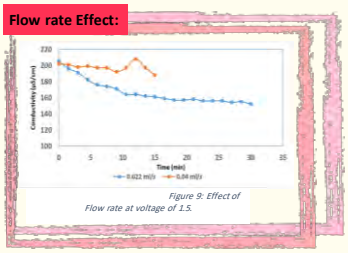


Figure 9: Effect of Flow rate at voltage of 1.5.

Conclusion:

1. The best electrode materials are 90% Co-CNF and RGO/TiC. The best-examined flow rate is 0.022 mL/s.
2. The optimum cell voltage of adsorption process is 1 V.
3. The optimum cell voltage of desorption process is 1.5 V.
4. The best-examined electrode material is Carbon Aerogel.

Future Studies:

- Using Graphite sheet instead of CAG.