Simulation of Solar-Powered Capacitive Deionization (CDI) for the Removal of Bacteria, Viruses, and Heavy Metals from Water

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Currently, reverse osmosis serving as the most widely used drinking water purification method is very costly and energy-intensive, which calls for innovative alternatives. Capacitive deionization (CDI) is a water treatment technology that uses a charging voltage to create an electric field in the water for removal of contaminants. The electric field attracts the charged water contaminants onto the oppositely charged electrode through electrostatic forces. The purpose of this study was to explore the potential of a CDI cell to efficiently remove bacteria and viruses, while comparing their removal efficiency with that of heavy metals. The application of a solar cell to power the CDI device makes it independent of fossil fuels. E. coli, SARS-CoV-2, and lead ions were used as the model contaminants. In idealized conditions, all three contaminants were predicted to be successfully removed by the CDI, as their characteristic separation time (all <1 s) was significantly less than the flow residence time (33 s) of the CDI cell. Under non-idealized conditions, pH of water impacted removal of E. coli and lead ions due to fluctuations in charge, while water temperature impacted all three contaminants as it impacted their desorption rate. However, neither effect was significant enough to impact the overall removal efficiency of these water contaminants. The solar cell could provide a sustainable voltage of 1.6 V to power the CDI. This study suggests that the solar-powered CDI device is promising for a more energy-efficient and versatile method for water purification.

Awards Won:

YM American Academy: Second Award of $1000

Serving Society Through Science: First Award of $1000