The Enhancement of a Novel 3D-Printed Electrodialysis Device Through the Implementation and Optimization of Spacer Designs

Yoon, Dylan (School: Manhasset High School)

Despite the Earth's abundance of salt water, water access remains one of the greatest global challenges, underscoring the urgent need to improve technologies for desalination treatment. Electrodialysis, a novel desalination technology, uses electric charge to separate NaCl ions from feed water. It operates within a device made up of electrodes and ion exchange membranes separated by spacers. The flow of water is critical to the effectiveness of electrodialysis. To address this, spacers can be modified to enhance fluid movement and turbulence. Research on enhancing fluid turbulence in electrodialysis, particularly through the creation of different spacer designs, and its effect on desalination performance is currently lacking. This study addresses this gap by evaluating self-made 3D-printed spacer designs—tortuous pathway, cubic, and column—against a spacer-less control within a 3D-printed electrodialysis module. Results demonstrated that desalination performance was enhanced with the incorporation of spacer designs, with the average salinity changes of each spacer ranking in order of increasing magnitude from the control, column, cubic, and tortuous pathway. Similarly, the Reynolds numbers ranked in identical order, indicating that increasing fluid turbulence improves desalination. The tortuous pathway spacer was found to be the most effective, significantly improving desalination in comparison to the control ($p<0.05$). This was due to its design creating the greatest fluid turbulence, with a Reynolds number nearly triple that of the control. Overall, this study not only developed an innovative and low-cost 3D-printed electrodialysis system but also demonstrated the potential of customized spacer designs to significantly enhance desalination.