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Membraneless Method for Electricity Generation from Salinity Gradients

Background

Blue energy, which is the Gibbs energy that results from mixing seawater and river water, is a promising source of clean energy. Pressure-retarded osmosis (PRO) and reverse electrodialysis (RED) are currently the most successful methods for extracting such energy. However, their performance is limited by challenging issues associated with the required membranes.

Invention Description

Researchers at the University of Hawai'i have developed a method for direct electricity generation, in which carbon electrodes with asymmetric distributions of nanopores are used to generate electrical power from salinity gradients. The researchers demonstrated that two electrodes made with carbon, e.g. carbon nanotubes, respond dierently to a salinity gradient if their pore distributions are dramatically dierent. Such dierent responses lead to a discrepancy in the capacity change of the electrical double layers (EDLs) that spontaneously establish at the solid-electrolyte interface, which can create a significant potential dierence between the electrodes, and thus, generate electrical power. When the electrodes are successively immersed in solutions of various concentrations, a concentration gradient is created between the solution captured in the pore and that in the ambient. The Gibbs free energy from mixing of the two solutions can be harvested through the potential dierence generated.

Using NaCl solutions and electrodes fabricated with commercially available carbon materials, the researchers observed an energy density of 69 mJ/g and a power density of 1.720 kW/m3, higher than that of current membrane-based methods (1.1 kW/m3). In the seawater stage, the power density reached 7.4 kW/m3.

Potential Applications

- Direct electricity generation (e.g., grid-level applications)
- Water desalination
- Recycling energy with normal seawater and waste brine

Benefits and Advantages

- Does not require membranes or turbines

- Does not require an external charge source
- Easy to integrate with existing systems
- Can provide high power density
- Scalable, can be used for grid-level applications
- Lower maintenance costs
- Ability to recycle energy consumed

Faculty Profile of Professor David T. Ma