ELECTROSTATIC COOLING AT ELECTROLYTE-ELECTROLYTE JUNCTIONS

Maarten BIESHEUVEL

Wetsus, Centre of Excellence for Sustainable Water Technology, Leeuwarden, The Netherlands
maarten.biesheuvel@wetsus.nl

Heat effects are of great importance in nanotechnology and electrochemical engineering and other fields. Electrostatic heating and cooling is observed when current is driven through an electrical double layer (EDL), i.e., the structure formed at the interface of two oppositely charged materials. Dependent on current direction, there is either cooling or heating. This is exactly what happens in a Peltier element at the interface of two solid, electron-conducting phases. The same also happens at the water-metal interface, e.g., in microporous carbon electrodes. Here we report heating and cooling at a water-water interface between two electrolyte phases. These phases are water + salt, and an ion-exchange membrane. Such a membrane is a highly charged (5 M of fixed charges !) microporous structure filled with water and ions. We discuss the theory and experimental validation of reversible heating and cooling at electrolyte-electrolyte junctions. Key to the theory is identification that the heating and cooling is described by the dot product of the vectors current and field strength, which can be both positive and negative, and not by Joule heating, an approximation only valid under strict assumptions, and which is strictly positive, and cannot explain electrostatic cooling.

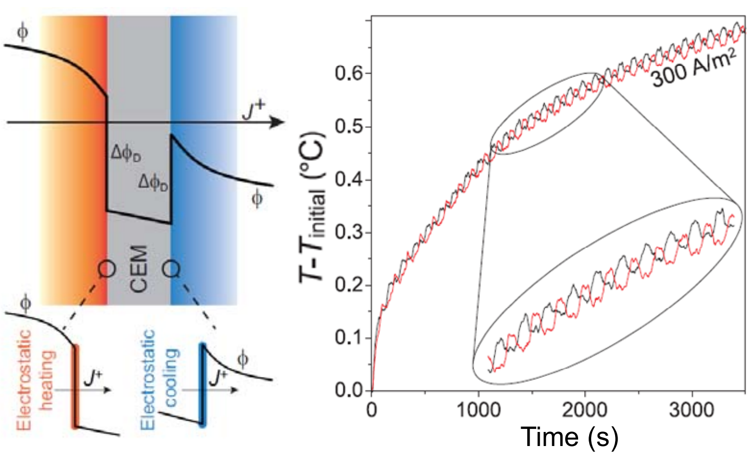

Figure 1. (Left) Heating and cooling at the junctions between two aqueous phases, in this case at the two outsides of a cation-exchange membrane (CEM), which is a charged, water-filled, microporous structure. (Right) Heat prodution at each membrane interface (red and black curves) fluctuates between heating and cooling upon changing the direction of current.

References

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