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Direct Electrochemical Method for Cooling and Refrigeration

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ABSTRACT

Electrochemical systems have the potential of producing cooling effects in various ways, due to the strong coupling of electrochemical processes to pressure generation and thermal processes. The heat absorbed or rejected during electrochemical reactions can be directly used for cooling. The electrical energy consumed or produced by an electrochemical reaction is equal to the Gibbs free energy change of the reaction (ΔG) which consists of the enthalpy of reaction minus the reversible heat effect ($T\Delta S$). At constant temperature, the reversible heat effect is heat transferred to the environment. A reversible electrochemical cell that absorbs heat when voltage is applied will release the same amount of heat when the voltage is reversed. Part of the enthalpy change of reaction is due to the electricity into or out of the cell and part of the enthalpy change is due to the heat transfer in or out. Theoretically, a water electrolyser will absorb heat and a hydrogen-oxygen fuel cell will release heat (Newell, 2000). However, the sign of the reversible heat effect is dependent on the particular reaction involved. For instance, a nickel-cadmium (NiCad) battery absorbs heat during charging and rejects heat during discharge, while a lead-acid battery behaves in the opposite manner (Berndt, 1993). A continuous flow process could achieve a lower temperature than a batch process, e.g. battery charging and discharging, by using two electrochemical cells at different temperatures and exchanging heat between the streams of working substance as it is pumped between the cells. The equilibrium thermodynamics of this ideal electrochemical cycle have been analyzed and the theoretical COP equals the Carnot COP. Basic modeling of the losses involved indicates technical feasibility. Preliminary proof of concept tests have demonstrated a cooling effect.

References:

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