

Thermoelectrochemistry: Using entropy and electrochemistry to convert waste heat to electricity

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Abstract:

Heat is an ubiquitous waste; for each joule of energy deliberately produced and utilised by humans, a further two joules of energy are lost as waste energy, typically as low grade waste heat.[1] This extends even to biology, where typically ca. two-thirds of our calorie intake is lost as waste body heat.

Electrochemistry offers some non-mechanical routes to capture some of this vast quantity of waste energy. One method is to convert a thermal gradient into an electrical current using the thermogalvanic effect. The temperature dependence of standard electrode potentials is well known, and therefore electrodes at dissimilar temperatures in the same redox active electrolyte will have a potential difference across them (sometimes referred to as the 'Seebeck coefficient'). If both oxidised and reduced states are present, this difference in free energy can therefore generate power, due to both a potential difference and a resulting flow of current. The 'state of the art' electrolyte is a mixture of $[\text{Fe}(\text{CN}_6)]^{4-}$ and $[\text{Fe}(\text{CN}_6)]^{3-}$. [2]

This talk will summarise our recent investigations into combining aqueous redox couples electrically in-series and in-parallel, as a route to boost the potential [2], and our recent progress in developing new cost-effective redox couples [3]. We have also moved from water to highly coordinating glyme solvents, to boost (de)solvation dynamics and thus the temperature effect upon the potential difference [4], and to novel ionic liquid-based systems [5]. We have also introduced 'charge additivity', a method of combining charges to improve thermogalvanic efficiency [6], and are using this now in an effort to move beyond the limitations of simple metal complexes. Finally, recent fundamental investigations, as well as exciting applications (such as thermogalvanic bricks, for energy-generating buildings) will be introduced.

References:

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