The Proton Flow Battery for Storing Renewable Energy: A Theoretical Model of Electrochemical Hydrogen Storage in an Activated Carbon Electrode

Authors : Sh. Heidari, A. J. Andrews, A. Oberoi

Abstract : Electrochemical storage of hydrogen in activated carbon electrodes as part of a reversible fuel cell offers a potentially attractive option for storing surplus electrical energy from inherently variable solar and wind energy resources. Such a system – which we have called a proton flow battery – promises to have a roundtrip energy efficiency comparable to lithium ion batteries, while having higher gravimetric and volumetric energy densities. In this paper, a theoretical model is presented of the process of H+ ion (proton) conduction through an acid electrolyte into a highly porous activated carbon electrode where it is neutralised and absorbed on the inner surfaces of pores. A Butler-Volmer type equation relates the rate of adsorption to the potential difference between the activated carbon surface and the electrolyte. This model for the hydrogen storage electrode is then incorporated into a more general computer model based on MATLAB software of the entire electrochemical cell including the oxygen electrode. Hence a theoretical voltage-current curve is generated for given input parameters for a particular activated carbon electrode. It is shown that theoretical VI curves produced by the model can be fitted accurately to experimental data from an actual electrochemical cell with the same characteristics. By obtaining the best-fit values of input parameters, such as the exchange current density and charge transfer coefficient for the hydrogen adsorption reaction, an improved understanding of the adsorption reaction is obtained. This new model will assist in designing improved proton flow batteries for storing solar and wind energy.

Keywords : electrochemical hydrogen storage, proton flow battery, butler-volmer equation, activated carbon
Conference Title : ICSREE 2015 : International Conference on Sustainable and Renewable Energy Engineering
Conference Location : Montreal, Canada
Conference Dates : May 11-12, 2015