Department of Mechanical Engineering

Thursday, April 12, 2012 • 3:00 pm • SAK A101

ME Master Thesis Presentation

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Study of the Chemistry of the Carbon Fuel Cell Electrolyte at Near Critical Conditions

Abstract: The carbon fuel cell can theoretically convert the chemical energy of carbon into electric power with an efficiency of almost 100 %. As a result of this surprising aspect, different attempts have been undertaken to develop it for more than a century. In our laboratory, an aqueous-alkaline carbon fuel cell that works at moderate temperatures (over 200 °C) and high pressures (≈48 bar) has been under development since 2000. When the electrolyte used was potassium carbonate at a high concentration, unexpected crystals were found. TGA analysis of this precipitate in the Hungarian Academy of Science revealed that the crystals were mainly potassium bicarbonate. TGA showed the decomposition of the potassium bicarbonate into potassium carbonate and CO_2 at temperatures above 200 °C. This caused us to wonder if the decomposition also occurs in solution; thereby solving the precipitation problem.

The liquid phase chemistry was studied by exposing solutions of potassium bicarbonate in a pressure vessel to temperatures near 300 ^oC at their saturation pressure, different time frames and different cooling treatments.Three different analyses of the final solutions were utilized: (1) pH measurement, (2) TGMS of the dry crystals in the Hungarian Academy of Science and (3) Titration. The significant pH increase of the final solutions suggested the potassium bicarbonate decomposed via the reaction:

$2HCO_3^- \leftrightarrow CO_3^{2-} + CO_2 + H_2O$

The determination of the nature of the dry crystals by titration confirmed the decomposition and gives more accurate values of the extents of reaction. All these findings can finally be used to evaluate the temperature dependent equilibrium constant of the reaction in saturated liquid water at temperatures near 300 ^oC, and, therefore, predict the behavior of the carbonate electrolyte in the carbon fuel cell. In this presentation, we describe the results of this study and our measurements of the equilibrium constant.