75g Electrolysis of Coal for the Production of Hydrogen

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Introduction

Coal can be used for the production of hydrogen by electrochemical oxidation. Some advantages of the technology are 1. Production of hydrogen at lower cost than the current technology (natural gas reforming) for distributed power, 2. Fuel flexibility, 3. Enhancement of the national security in the United States through less reliance on foreign fuel, and 4. Zero hazardous environmental emissions. In addition, the storage of coal/water slurries is commercially feasible; therefore, the electrolysis of coal/water slurries helps solve the problem of hydrogen storage.

The electrolysis of coal takes place according to the following reactions:[1]

$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$ (1)

$4H^+ + 4e^- \rightarrow 2H_2$ (2)

where reactions (1) and (2) take place at the anode and cathode, respectively. Downstream separation of the gases is not necessary as pure H_2 and CO_2 are generated in different compartments of the cell. The coal electrolytic cell (CEC) is a reversible fuel cell; furthermore, because of the purity of the hydrogen produced it can be integrated with any other type of fuel cell.

The electrolysis of coal was first investigated in the 1980s.[1-7] These early studies concluded that the technology was not economically feasible for the production of hydrogen due to the low current densities achieved in the reaction (about 2.5mA/cm^2 at 1 V and 70 ^{o}C). As a result, there was no further intensive study in the next two decades. Recently, the Electrochemical Engineering Research Laboratory (EERL) at Ohio University (OU) developed new catalysts for the electrolysis of coal.[8,9] Using these new catalysts significantly higher current densities have been observed (30mA/cm^2 at 0.8 V).

Within this context, the objective of this paper is to evaluate the technical and economical feasibility of producing hydrogen from the electrolysis of coal for distributed power generation using the novel electrodes. These results will be presented at the meeting.

References

1. R. W. Coughlin and M. Farooque, "Hydrogen Production from Coal, Water and Electrons," Nature 279, 301-303 (1979).

2. R. W. Coughlin and M. Farooque, "Anodic Coal Reaction Lowers Energy Consumption of Metal Electrowinning," Nature 280, 666-668 (1979).

3. R. W. Coughlin and M. Farooque, "Electrochemical Gasification of Coal (Investigation of Operating Conditions and Variables)," Fuel 58, 705-712 (1979).

4.R. W. Coughlin and M. Farooque, "Thermodynamic, Kinetic, and Mass Balance Aspects of Coal-Depolarized Water Electrolysis," Ind. Eng. Chem. Process Des. Dev. 21, 559-564 (1982).

5. P. M. Dhooge, D. E. Stilwell, and S. Park, "Electrochemical Studies of Coal Slurry Oxidation Mechanisms," J. Electrochem. Soc. 129, 1719-1724 (1981).

6. P. M. Dhooge and S. Park, "Electrochemistry of Coal Slurries. II. Studies on Various Experimental Parameters Affecting Oxidation of Coal Slurries," J. Electrochem. Soc. 130, 1029-1036 (1983).

7. P. M. Dhooge and S. Park, "Electrochemistry of Coal Slurries. III. FTIR Studies of Electrolysis of Coal," J. Electrochem. Soc. 130, 1539-1542 (1983).

8. G. G. Botte, "Electrocatalysts and Additives for the Oxidation of Solid Fuels and their Application to Hydrogen Production, Fuel Cells, and Water Remediation Processes", Pending Patent, US, 2005.

9. G. G. Botte, "Carbon fiber-electrocatalysts for the Oxidation of Ammonia, Ethanol, and Coal, and their Application to Hydrogen Production, Fuel Cells, and Purification Processes", Pending Patent, US, 2004.