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Executive Summary

The direct use of coal in the solid oxide fuel cell to generate electricity is an innovative concept for power generation. The C-fuel cell (coal-based fuel cell) could offer significant advantages: (i) minimization of NOx emissions due to its operating temperature range of 700 – 1000 °C, (ii) high overall efficiency because of the direct conversion of coal to CO_2, (iii) the production of a nearly pure CO_2 exhaust stream for the direct CO_2 sequestration, and (iv) low investment and maintenance costs due to simplicity of the process. The objective of this proposal is to develop a highly efficient coal fuel cell (C-fuel cell) for the direct use of coal for electric power generation. Results of our year 1 study showed that the electric power generation from Ohio No 5 coal (Lower Kittanning) Seam, Mahoning County, is higher than those of coal gas and pure methane on a solid oxide fuel cell assembly at 950 °C for a period of more than 100 hours. The final resulting solid residue is in the form of yellowish fine ash powder which did not stick on the anode catalyst surface. Following removal of the ash and reloading the coal, the C-fuel cell produced the same level of electric power as that in the first run. The results of this study validate the year 1 proposed concept that the solid oxide fuel is capable of generating electric power with the direct contact between pulverized coal particles and the anode catalyst surface. Year 2 research will focus on identification of the lead catalysts (i.e., the catalysts which show a great potential) and preparation of a thin electrolyte to enhance the power density (mA/cm2). Catalyst finetuning and testing will be carried out in a parallel manner with a computer data acquisition system to facilitate identification of the optimal catalyst formulation. Year 3 research will be directed toward optimizing both catalyst and solid electrolyte compositions as well as designing the fuel cell stack and its accessories for loading of coal and the removal of fly ash. Year 4 will optimize the fuel cell system including fuel cell assembly and the heat transfer as well as determine the technical and economic feasibility for scale up. The proposed 4 year research will address all of the issues on bringing the innovative concept of the solid oxide C-fuel cell to the practical technology.