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Investigation of the anode reactions in solid oxide electrolyte based carbon fuel cells

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ABSTRACT

The anode reactions of solid oxide electrolyte based carbon fuel cells (SO-CFCs) are explored by comparing the electrochemical behaviors of SO-CFCs under varying anode carrier gas flow rates (FAr) and at different contact modes. The electrochemical performance of four raw carbon fuels, including a graphitic carbon (GC), two coals (lignite CF and anthracite YQ) and an activated carbon (AC), and their chars is tested to investigate the influence of carbon fuel properties on the cell performance. The results show that CO electro-oxidation and C-CO_2 gasification were main anode reactions. The direct carbon electro-oxidation is insignificant under high F_{Ar}. Polarization performance of the chars under high F_{Ar} was similar with that of 5–10% CO. It is also concluded that the cell performance is greatly dependent on the carbon fuel gasification reactivity with CO_2. Thermal pretreated AC displays the best durability performance for its stable and moderate CO_2 gasification rate. Additionally, the coal ash does not affect the cell performance significantly.

Introduction

Conversion of solid carbonaceous fuels in fuel cells has a long history dating back as far as to the 19th century [1]. Recently, new interest and research activity on this technology is fueled by concerns over the global energy and environment situation. In direct carbon fuel cells (CFCs), solid carbon fuels can be directly fed to the anode chamber and electro-oxidized to CO_2. The overall reaction is quite simple and expressed as:

$$C + O_2 = CO_2 \tag{1}$$

Because of the negligible entropy change, the theoretical efficiency can be as high as 100% and is independent of temperature change. The anode product is CO_2-rich mixture gases, which is readily for CO_2 sequestration. Compared to conventional coal-burning power plants, the emissions including NO_x, SO_x, particulate matter released by CFCs are much lower because of no combustion process. For the unique advantages, CFCs have been widely regarded as a promising power generation technology with solid carbon consumption [2,3].

Solid oxide electrolyte based carbon fuel cells (SO-CFCs) have attracted much interest for the solid structure, fuel

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