A comprehensive study of Pt/CeO2 catalysts for the water gas shift reaction

M.H. Rijnveld

Abstract

The global energy demand will continue to rise as a consequence of the worldwide population growth and the progressive industrialisation. The stronger dependency on fossil fuels will accelerate the depletion of fossil fuel reserves, increase its costs due to scarcity and destabilise the global economy. A powerful alternative for fossil fuels that can be used in the automotive industry is the proton exchange membrane fuel cell (PEMFC) that uses hydrogen as the fuel and air as the oxidant. However, the effect of CO contaminants on fuel cells, is one of the most important issues in fuel cell operation and therefore a high purity hydrogen stream is required. An important component of the fuel processors for purification is the Water Gas Shift reaction. A promising catalyst for the conversion of CO in CO2 is platinum supported by cerium oxide due to its high Oxygen Storage Capacity and redox activity. This thesis offers a comprehensive study of the inner workings of Pt/CeO2 with various platinum loadings (0.4-5wt% Pt) and two different morphologies of ceria (cubes and rods) that affect the activity, and aims to answer the following research question: What are the differences in catalytic activity and stability of Pt/CeO2 catalysts during the water gas shift reaction and are these related to ceria morphology and Pt loading? In order to answer this research question, catalytic tests at realistic industrial conditions are performed and the catalyst and support are characterised using state-of-the-art techniques. The results showed that 0.4wt% Pt/cubes performed 5 times higher catalytic activities compared to 0.4wt%Pt/rods. The smaller crystallite size, higher surface area and strong metal-support interaction implying that the ceria surface of the rods is more reducible and should perform better redox properties compared to the cubes. This study suggests that the exposed planes by cubes (100) and rods (111) affects the WGS activity by the formation of oxygen vacancies on the exposed surfaces. Based on these findings it is suggested that the reaction occurs via an associative mechanism with the creation of oxygen vacancies on the (100) surface that enhances the WGS activity.