Photo-catalytic Preferential Oxidation of Carbon Monoxide in Hydrogen

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INTRODUCTION

Due to issues such as metropolitan pollution, energy crisis and global warming, attention has increased on fuel cell systems. Fuel cell powered systems has expectedly low environmental impact, and are a cornerstone to the hydrogen society.
The PEM-fuel cell is fueled with clean hydrogen, today produced from the so-called steam-reforming process, where hydrogen is extracted from natural gas.
Besides hydrogen, a side-product of CO is also made, which is reduced to 1% by a water gas shift reaction. When the hydrogen later is used in a fuel cell, even trace amounts of CO will poison the catalyst in the fuel cell and thereby prevent the hydrogen from reacting. Thus if hydrogen is to be a viable fuel for a cleaner society, a cheap and efficient purification method must be provided.

A way of removing these trace amounts of CO from the hydrogen is by illuminating certain photo-catalysts with UV light and thereby oxidize the CO molecules to CO_2. As a gas mixture of hydrogen and CO are in contact with an illuminated photo-catalyst, both gases can be subject to oxidation, and if the catalyst is not strongly preferential towards oxidizing CO, much hydrogen would be lost during the purification process. This project have investigated a purification method relying on preferentially oxidizing the CO (CO-PROX) by photo-catalysis.

METHOD

Experiments are performed in a so called µ-reactor with different TiO_2 nano-particle catalysts. The µ-reactor gives the opportunity of making both qualitative and quantitative measurements on tiny amounts of catalyst material with a fast time-response. Thereby making it possible to monitor the photo-catalytic reactions in-situ.
The CO-PROX using TiO_2 has been investigated under different reaction conditions, all pointing towards strong selectivity. Especially a modified TiO_2 catalyst was found to be a very promising candidate for CO-PROX. This is of course only if the reaction is applicable to larger industrial production systems.

PERSPECTIVE

During his work as Ph.D. student, Morten G. Nielsen (DTU Physics) worked on a cylinder reactor for photo-catalytic oxidation of a certain gas over TiO_2. This reactor forms a macroscopic system compared to the µ-reactor (nL) and are capable of illuminating m^2's of catalyst area and gas flows of 1000's of m^3 pr. h. Under proper conditions, the gas was entirely removed, showing scalability of the TiO_2 catalyst from µ-reactor to macroscopic system, thus bridging the gab between lab testing and installing a pilot plant.

This might be a generic trend for TiO_2 nano-particle catalysts and the experimental CO-PROX results therefore look very promising for commercial applications in real industrial hydrogen production plants.