Catalytic Performance of a $CuO/ZnO/Al_2O_3$ Methanol Steam Reforming Catalyst Coated on Micro-Channel Surfaces.

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Introduction

Methanol is the fuel of choice for hydrogen supply to PEM fuel cells for small portable devices. Unlike other fuels, steam-reforming of methanol may not require subsequent processing to remove excess CO which is a poison for the PEM anode electrocatalyst [1]. The catalyst that shows high activity at low temperature is the $CuO/ZnO/Al_2O_3$ catalyst, which is also the catalyst used for methanol synthesis [2]. Using the catalyst in packed bed for portable devices is not convenient due to high pressure drop, poor heat transfer and channeling of gases. A wall-coated catalyst represents a superior geometry since it provides lower pressure drop and ease of manufacturing. Due to their small size, micro-reactors are especially suited for endothermic reactions whose reactivity depends on the rate of heat input.

In this work, we report on the coating of this methanol steam reforming catalyst on micron sized channels. Catalyst adhesion to the walls of a glassy surface was a significant challenge. Due to their preparation techniques, micro-reactor surfaces tend to be very smooth and hence bond weakly to deposited catalyst. The development of methods to coat catalyst powders without affecting their activity is a key challenge in developing micro reactors for mobile applications.

Results and Discussion

We have developed a method to slurry-coat a commercial $CuO/ZnO/Al_2O_3$ onto smooth surfaces without loss of catalytic activity. We have preliminary adhesion and catalytic data for slurry coated catalyst onto quartz tubes of 4.1mm ID as well as on micro-reactor materials. The SEM image on the next page shows the excellent adhesion of the catalyst to a quartz tube surface. The film thickness is about 25 microns. We will present a comparison of the reactivity of the wall coated catalyst to packed beds of $CuO/ZnO/Al_2O_3$ catalyst. One major obstacle was the design of a vaporizer that would ensure complete flash evaporation of low flow rates of methanol-water without causing fluctuations in the output gas flow rate or the methanol to water molar ratio. We have developed an in-house vaporizer that yields minimal fluctuations in both flow rate as well as molar ratio of methanol to water. Our initial tests consisted of quartz tube reactors, with future work involving micro capillaries.

The product gas was analyzed using an on-line gas chromatograph (Varian CP-3800) equipped with a TCD detector. The wall coated catalytic film was characterized with the use of TEM, SEM, XPS, XRD, and TGA. Figure 1 shows the catalyst activity and selectivity versus space velocity kg catalyst/(mol/s of Methanol) for 50mg wall coated catalyst. The data shows high activity and selectivity with 97% conversion and 97% selectivity. Selectivity is defined as moles CO2/(moles CO + CO2), which in this case corresponds to 0.8% CO by volume in the reactor products.

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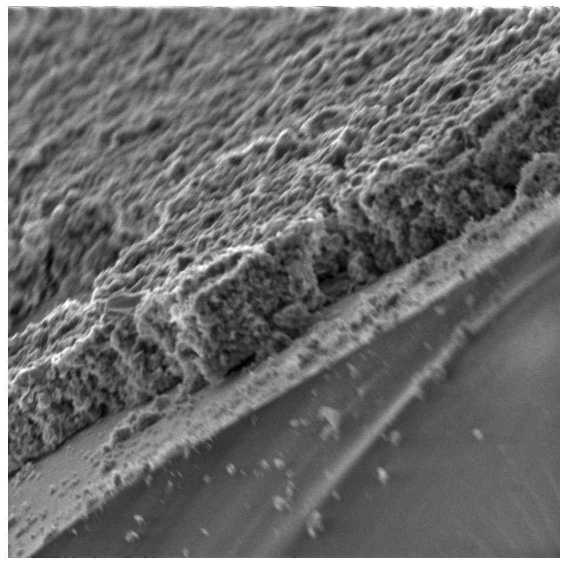

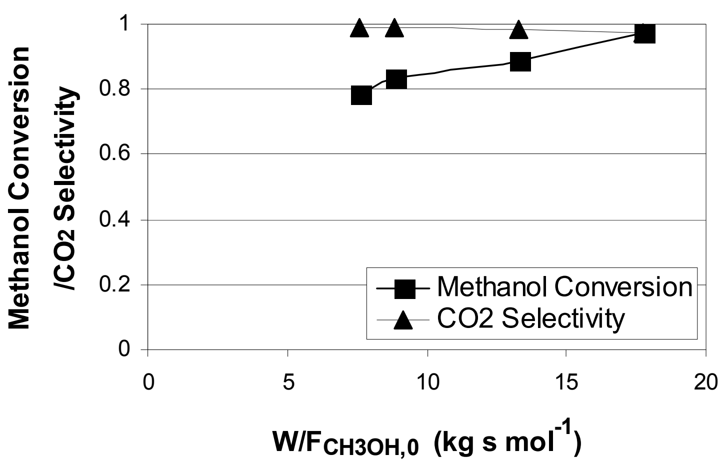

Figure 1. Methanol Conversion and CO_2 Selectivity versus $W/F_{CH3OH,0}$ at 230 ±C, Water/Methanol molar ratio of 1.1:1

[1] Lee F. Brown, International Journal of Hydrogen Energy 26 (2001) 381-397

[2] Brant A. Pepply, John C. Amphlett, Lyn M. Kearns, Ronald F. Mann, Applied Catalysis A: General 179 (1999) 31-49