

## Plasma Modification of Catalysts Using a Dielectric Barrier Discharge

David T. Lundie<sup>1\*</sup> and J.A.Rees<sup>1</sup>

Hidden Analytical Ltd. 420 Europa Boulevard,  
Warrington, WA5 7UN, (UK)  
dlundie@hidden.co.uk

### Introduction

The combination of plasmas and catalysis under moderate temperatures is an emerging area [1]. The techniques are commonly combined in one of two ways. In the first of these the catalyst is introduced into the plasma, in plasma catalysis (IPC) while in the second, the catalyst is placed down-stream of the discharge zone, post plasma catalysis (PPC). The introduction of a plasma to a catalysis system may produce a change in the distribution or type of reactive species available for reaction or a change of catalyst properties, such as an increase in dispersion or a change in catalyst structure.

In the present work, a micro-reactor has been constructed that allows the study of catalysis using traditional temperature-programmed techniques. The reactor also allows a dielectric barrier discharge (DBD) to be generated over the whole length of the catalyst region or to precede it. The DBD produces a cool plasma at atmospheric pressure and generates surface modifications of the catalyst and is a source of ions and radicals for reaction processes. Test reactions have been studied to show differences in reaction product distributions and activation temperatures when compared with the catalyst alone.

The reactor has also allowed catalysts to be held in the plasma in order to attempt to modify the catalyst surface before testing them in a more conventional microreactor system.

### Materials and Methods

A microreactor based on the Hidden CATLAB was constructed to allow a catalyst to be heated under controllable temperature and gas flow conditions. The microreactor was connected to the Hidden QIC-20 capillary inlet mass spectrometer system. In addition to the standard furnace arrangement a dielectric barrier discharge (DBD) could also be generated over the length of the catalyst or in an area before the catalyst. The DBD consisted of an inner coaxial tungsten wire electrode of 1.0 mm diameter and an outer cylindrical metallic electrode wrapped around a quartz tube and connected to ground. The tungsten electrode is connected to the open-circuit end of the secondary winding of a high voltage transformer operated at 50 kHz.

Initial reactions were performed using 1% Pd/Al<sub>2</sub>O<sub>3</sub> catalyst. The test reaction used was the oxidation of CO to form CO<sub>2</sub>. Plasma modified catalysts were also investigated using the partial oxidation of methane over Ni / Al<sub>2</sub>O<sub>3</sub> catalysts as the test reaction.

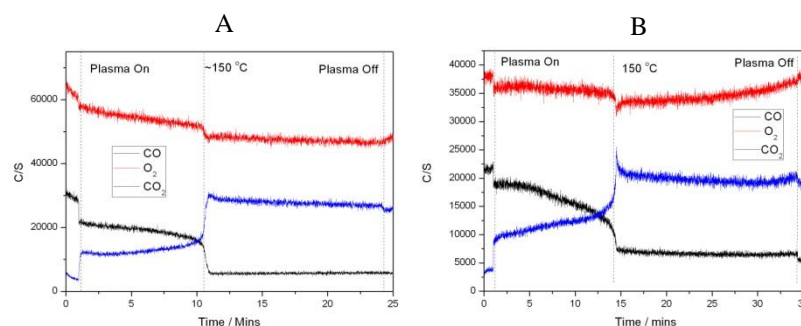
### Results and Discussion

The combination of plasma and heat over the length of the catalyst (IPC) showed that a low level of reaction commenced when the plasma was switched on, Figure 1A. Upon heating it can be seen that complete conversion of CO to CO<sub>2</sub> occurs at 150 °C, 100 °C below the temperature at which reaction occurs with the catalyst and temperature alone.

When the plasma was generated in a region before the catalyst bed (PPC), before heating, the plasma was switched on and showed the same level of reaction as seen in the IPC experiment, Figure 1B. Upon heating it can be seen that there is complete conversion of CO to CO<sub>2</sub> at 150 °C. This is similar to the result of the experiment with the plasma generated over the length of the catalyst. This suggests that the decrease in reaction temperature is due to the ionised gas species created in the plasma being more reactive over the catalyst and not due to any modification to the catalyst surface by the plasma being responsible for the decrease in reaction temperature.

### Significance

The combination of a plasma and catalyst shows potential for altering reaction conditions to produce more efficient processes. Modification of catalyst surfaces using plasmas is also an area of potential interest.



**Figure 1.** A, CO oxidation reaction using IPC + Heat. B, CO oxidation reaction using PPC + Heat

### References

1. J. Van Durme, J. Dewulf, C. Leys, H. Van Langenhove, Appl. Catal. B Environ. 78 (2008) 324-333.