

CO electrochemical reduction in a CO/(Pt/Ru) | PBI (H₃PO₄) | Pt/H₂ membrane cell at 150°C

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Introduction

This poster presents the results of a study of CO electrochemical reduction obtained in a CO/(Pt/Ru) | PBI (H₃PO₄) | Pt/H₂ electrolysis cell system. The development of our understanding of the system as well as the products produced is presented.

The most commonly seen electrochemical promotion cells consist of an ion conductor-electrode assembly placed in a tightly closed container filled with reactant gas mixture.

Therefore, at zero polarization of the working electrode, the potential difference between the working and counter electrodes is zero and there is no ion flow between the electrodes.

In our fuel cell, the gas composition is different at the working and counter electrodes. the potential difference between the working and counter electrodes is not zero. In order to study the effect of the ion flow, the cell voltage, V_{WR} , should first be changed to $V_{WR} = 0$.

Experimental

The results of the electrochemical reduction of CO in the CO/ (Pt/Ru) | PBI (H₃PO₄) | Pt/H₂ electrolysis cell is studied, the same cell has been used in previous studies by our group^[1]. The experimental setup is shown in figure 1.

All experiments were performed at 150°C, using Ar as carrier gas on the working side. Outlet gas composition was studied using mass spectrometry.

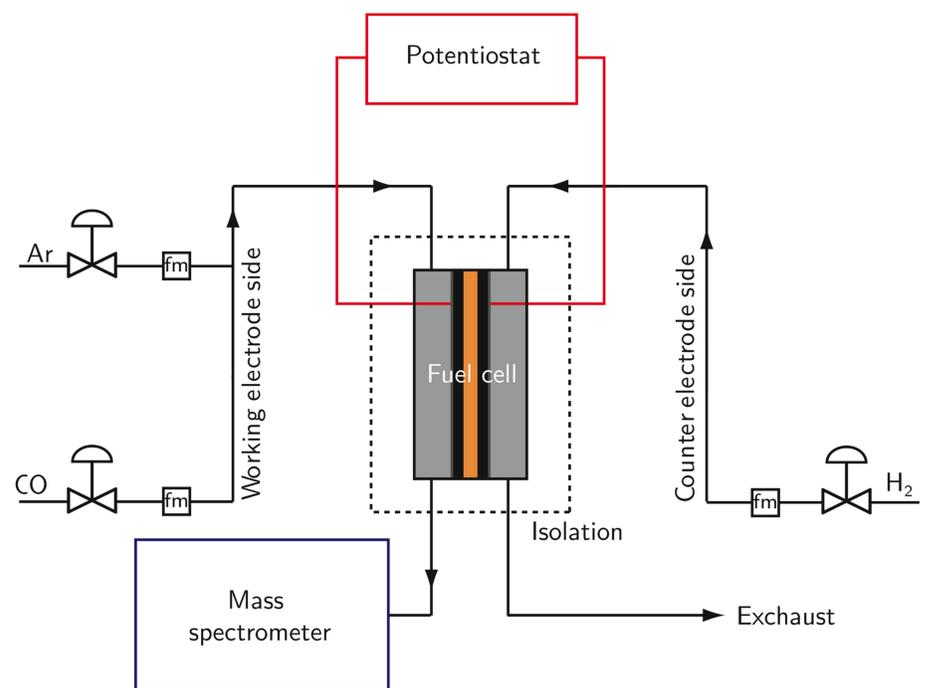


Figure 1: The experimental set-up, for the (CO, Ar), Pt/Ru | polybenzimidazole (PBI)-H₃PO₄ | Pt, (H₂) fuel cell.

Results

CO reduction with hydrogen

The results of the carbon monoxide reduction in a CO, Ar (CO/Ar = 5/195 mL/min) / Pt/Ru/C | polybenzimidazole (PBI) – H₃PO₄ | Pt/C/H₂ cell obtained at 150°C are given in Fig. 2

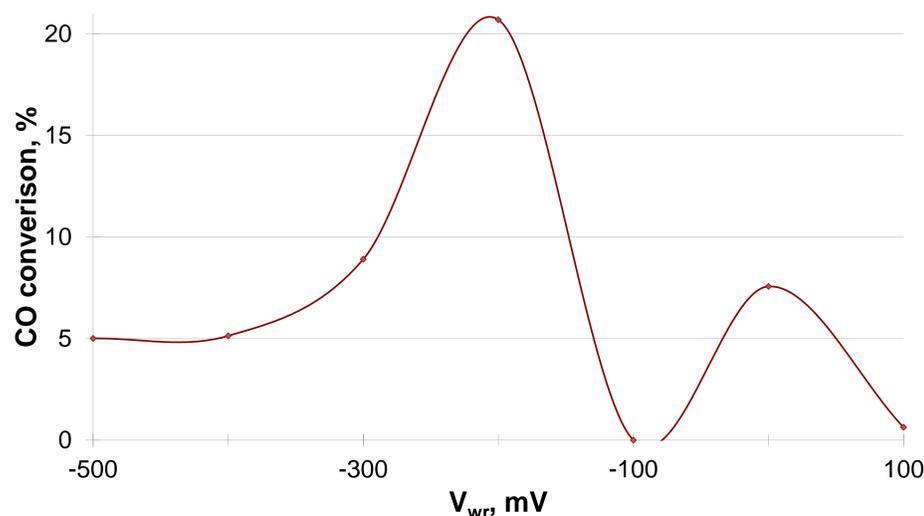


Figure 2: CO conversion vs. V_{WR} obtained at 150°C and atmospheric pressure. In the (CO,Ar), Pt/Ru | polybenzimidazole (PBI)-H₃PO₄ | Pt, (H₂) fuel cell.

It can be seen from Fig. 2, that the maximum CO conversion, 20.6% was obtained at -200 mV. Steady state voltammetry for the reaction is seen in Fig. 3.

Methane was defined as the product of the CO reduction by mass spectrometry and verified by gas chromatography.

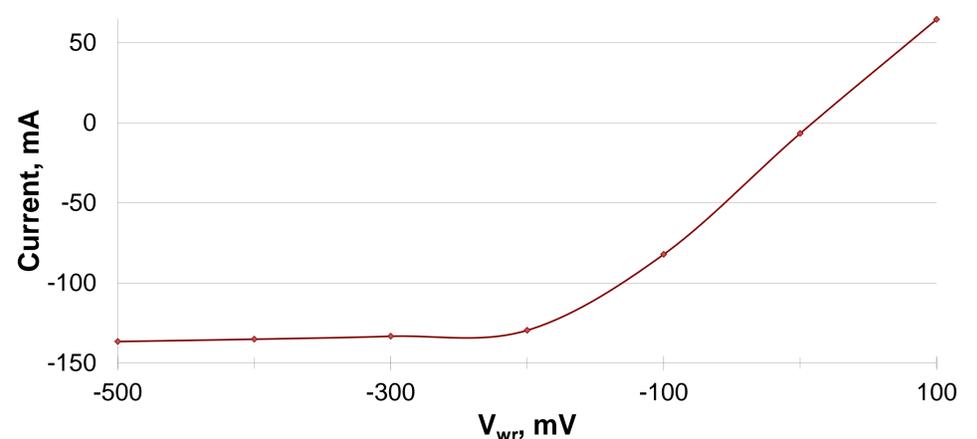
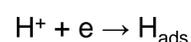


Figure 3: Steady state voltammetric curve obtained at 150°C in the (CO,Ar), Pt/Ru | polybenzimidazole (PBI)-H₃PO₄ | Pt, (H₂) fuel cell.

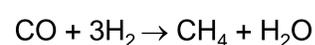
Discussion

As seen from the steady state voltammetric curve (Fig. 3) there is a cathodic voltammetric wave at the voltage range of the maximum CO conversion. This wave has a limiting current of 136 mA. It was proved in^[2] that the electrochemical reduction of hydrogen from protons



takes place in the same cell voltage region.

We can thus assume that the electrochemical reduction of protons to hydrogen is taking place. This hydrogen then reduces CO to methane through the reaction:



From the data the electrochemically reduced CO (with methane as a product) should have a maximum reduction rate of 1.43×10^{-5} mol/min. Maximum CO conversion calculated from the data in Fig. 2, is 3.04×10^{-5} mol/min. This can be explained by the assumption that simultaneous electrochemical CO reduction to carbon is taking place, which cannot be detected by the mass spectrometer, since C is deposited in the fuel cell:



Conclusions

It has been shown that CO can be electrochemically reduced in the studied fuel cell. The main product of the CO electrochemical reduction was methane, the other probable product of the CO reduction was carbon. Maximum CO conversion reached 20% at the potential of the fuel cell working electrode equal to -200 mV.

References

1. I. M. Petrushina, N. J. Bjerrum, V. A. Bandur, and L. N. Cleemann, *Topics in Catalysis*, 2007, 44, 427-434
2. I. M. Petrushina, L.N. Cleemann, R. H. Refshauge N. J. Bjerrum, and V. A. Bandur, *J. Electrochem. Soc.*, 2007, 154 E84-E90.