

Electrochemical Reduction of Carbon Dioxide on Pt Modified Cu Electrodes Prepared by Exchange Plating Method

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Introduction

In this paper, we will describe the electrochemical reduction of CO₂ at Pt modified Cu electrodes. Because Cu is known to effective electrodes for reduction of CO₂, and Pt is one of the most popular and active catalyst for various reactions. Here, we prepare Pt modified Cu electrode by dipping a Cu plate into H₂PtCl₆ solution.

Experimental

Electrochemical reduction of CO₂ was performed in a home-made high pressure cell. A Pt/Cu electrode was prepared by dipping a Cu electrode into 1mM H₂PtCl₆ solution. The amount of Pt at Cu electrode was controlled by the dipping time. Fig.1 shows schematic representation for the preparation of Pt modified Cu electrode. Pt plate and Ag/AgCl electrodes were used as counter and reference electrodes, respectively. Electrochemical reduction of CO₂ was performed at a pressure of 2 MPa. Gaseous products obtained during electrochemical reduction were collected in a gas collector and were analyzed by gas chromatography. Products soluble in the catholyte were analyzed using HPLC.

Result

Table 1 shows the partial current efficiencies for CO₂ reduced at a constant potential -2.5 V under 2 MPa of CO₂ at various electrodes. As shown in Table 1, the major products were formic acid and CH₄. Current efficiencies of formic acid and CH₄ on Cu/Pt (1) were the best among all electrodes used. At Pt/Cu (3), CO was detected with the current efficiency of 12.7 %. Current efficiencies of products depended on the composition of Pt modified Cu electrode. XPS was used to investigate the surface state of Pt modified Cu electrodes. Fig. 2 shows XPS spectra of Pt modified Cu electrodes. As shown in Fig. 2, the bands at 77 and 74.8 eV correspond to Pt⁴⁺ and Pt²⁺ respectively, and the band at 71 eV to Pt⁰. The bands of Pt⁴⁺ and Pt²⁺ were observed in all the Pt modified Cu electrode, however, The band of Pt⁰ was not observed in Pt /Cu (1). The ratio of Pt metal and Pt ion may play an important role for CO₂ reduction.

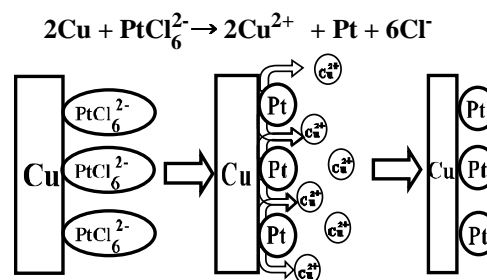


Fig. 1 Schematic representation of preparation of Pt/Cu electrode

Table 1 Electrochemical reduction of CO₂ under a pressure of 2 MPa on Cu and modified electrodes in 0.1 mol dm⁻³ KHCO₃

Electrode	Electrolysis potential (E/V vs. Ag/AgCl)	Current efficiencies(%)		
		CH ₄	CO	HCOOH
Cu	-2.5	11.8	—	6.9
Pt	-2.5	—	—	5.0
*Pt/Cu(1)	-2.5	17.6	—	37.0
*Pt/Cu(2)	-2.5	7.4	—	25.8
*Pt/Cu(3)	-2.5	—	12.7	30.3

*Dipping time a 1 mM H₂PtCl₆ solution : (1) 10 sec, (2) 30 sec, (3) 5min

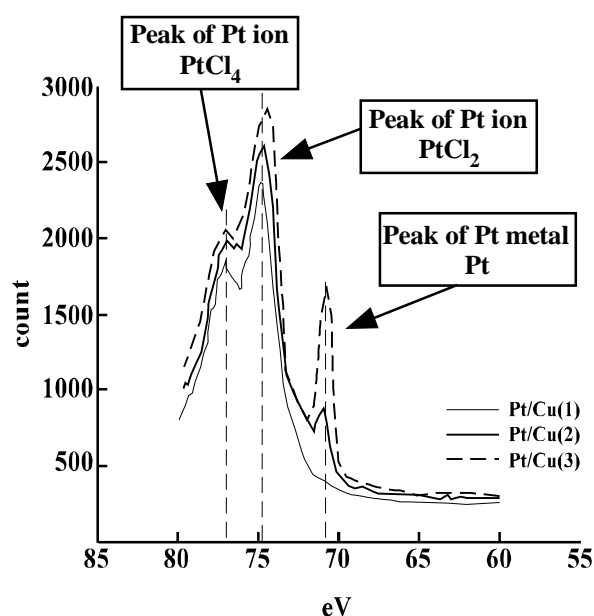


Fig. 2 XPS Pt 4f spectra obtained from Pt modified Cu electrodes