Fabrication of Metal-Supported Diamond Electrodes for Direct Formic Acid Fuel Cells

Kohei Shibano
Michio Murata, Yasuaki Einaga
Department of Chemistry, Keio University, 3-14-1 Hiyoshi, Yokohama-shi 223-8522, Japan.
kohei.s1223@keio.jp

In recent years, direct formic acid fuel cells (DFAFCs) have attracted growing attention [1]. However, their development remains in progress. In particular, the optimization of anode materials for the oxidation of formic acid is pivotal to achieve high performance in DFAFCs. In this context, we focused on boron-doped diamond (BDD), which has high physical and chemical durability, as a catalyst support and aimed to fabricate an electrode with high activity for formic acid oxidation.

Firstly, platinum was electrodeposited on a bare BDD support (Pt/BDD) from aqueous solution containing 1 mM H_2PtCl_6 + 0.5 M H_2SO_4 by applying a constant potential. Subsequently, palladium was electrodeposited on the Pt/BDD electrode (PtPd/BDD) from aqueous solution containing 1 mM $PdCl_2$ + 0.5 M H_2SO_4 in a similar manner. The catalytic activity towards formic acid oxidation was measured in aqueous solution containing 1 M HCOOH + 0.5 M H_2SO_4 by linear sweep voltammetry at a scan rate of 100 mV s^{-1}.

No redox peaks were observed at the bare BDD electrode, while two oxidation peaks appeared at the Pt/BDD electrode (**Figure**). The first peak at 0.3 V vs. Ag|AgCl is assigned to the direct oxidation of formic acid on platinum sites blocked by adsorbed CO (CO_{ads}) produced by dehydration of formic acid. The second peak at 0.8 V vs. Ag|AgCl corresponds to the oxidation of CO_{ads} [2, 3]. On the other hand, with the PtPd/BDD electrode, the current density of the direct oxidation peak increased by 109 times, and the CO_{ads} oxidation peak disappeared. Furthermore, the onset potential for formic acid oxidation shifted negatively, indicating a reduction in overpotential due to suppression of CO poisoning. These results show that palladium significantly enhances the catalytic activity. In addition, when applied as the anode in a DFAFC, the PtPd/BDD electrode achieved the highest power density among all tested electrodes.

References

[1] C. Rice, S. Ha, R. I. Masel, P. Waszczuk, A. Wieckowski, T. Barnard, *J. Power Sources*, 111 (2002) 83.
[2] A. Capon, R. Parsons, *J. Electroanal. Chem.*, 45 (1973) 205.
[3] B. Beden, A. Bewick, C. Lamy, *J. Electroanal. Chem.*, 148 (1983) 147; 150 (1983) 505.

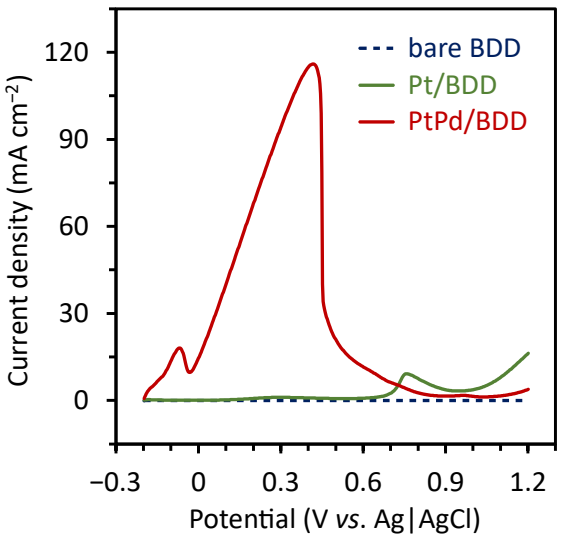

Figure: Linear sweep voltammograms for bare BDD, Pt/BDD, and PtPd/BDD electrodes recorded in 1 M HCOOH + 0.5 M H_2SO_4.