Electrocatalytic Oxidation of Sugars at Ad-metal Modified Gold Single Crystal Electrodes for Preparation of New Sugar-Air Fuel Cells

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Electrocatalytic oxidation of sugars has been examined extensively from various points of view such as wastewater treatment in food industry, blood sugar sensing for medical use, and in fuel cell business.

In the present study, effects of ad-metals on gold single crystal electrodes on electrochemical oxidation of sugars have been demonstrated and a new glucose-air fuel cell was prepared

Ag ad-layer modified Au(111) and Au(100) electrodes showed excellent catalytic behavior for oxidation of aldose type (such as glucose, maltose, galactose and xylose) sugars. At a (√3 x √3)R30˚ Ag-Au(111) electrode, 1/3 monolayer of Ag on Au(111), the catalytic oxidation of glucose was clearly seen. Similar results were also obtained at Au(111) film electrodes, prepared by vacuum-evaporation of gold on the mica surface, with large surface areas after deposition of Ag ad-layer.

The best catalytic effect was observed at a (√2 x 5√2)R45˚ Ag-Au(100) electrode, 2/5 monolayer of Ag on Au(100), where the oxidation of glucose began at –0.7 V (vs. Ag/AgCl) with a negative shift of ca. 0.2 V in oxidation potential compared to the oxidation at a bare Au(100) electrode (Fig. 1). Oxidation product was gluconate (2-electron oxidation product).

To understand the effect of ad-metals on a gold electrode, Au(111) surfaces were modified with various ad-metals by using the under-potential deposition (UPD) technique. Cu ad-atoms modified Au(111) electrodes showed a slight negative shift for a pre-peak in oxidation of glucose with a small oxidation current and a main oxidation peak appeared around -0.04 V vs. Ag/AgCl. Pd ad-atoms gave negative catalytic activity. Double layer capacitance measurements revealed the shift of the potential of zero charge (pzc) between bare Au(111) and Ag ad-atoms modified Au(111) electrodes (the pzc shifted negatively by modification of Ag) was useful in the explanation of the observed catalytic activities, where the number of AuOH sites on the Au(111) surface would be important for oxidation of glucose and gluconolactone (or gluconate).

The positive catalytic activity of Ag ad-layer modified Au electrodes, including Ag ad-layer modified Au(111) film electrodes, would be of great interest for preparation of sugar-air batteries. In fact, the combination of an Ag ad-layer modified Au (111) film electrode with a commercially available air electrode gave a excellent glucose-air battery with the open-circuit potential of ca. 0.65 V, the short-circuit current of ca. 0.77 mA cm^{-2} and the maximum power of ca. 0.2 $mWcm^{-2}$ at the cell voltage of ca. 0.3 V.

References

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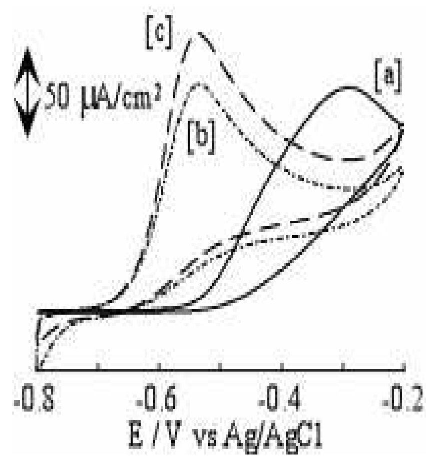

Fig. 1. Cyclic voltammograms of 1 mM glucose in a 0.1 M NaOH solution at [a] bare Au(100), [b] (1x1)Ag-Au(100) and [c] (√2 x 5√2)R45˚ Ag-Au(100) electrodes. Scan rate: 50 mV/s