

## Fabrication and Properties of Needle Type Glucose Sensors Using Electropolymerization Procedure

M. Yasuzawa, T. Yamada, H. Takaoka  
A. Kunugi and S. Imai\*

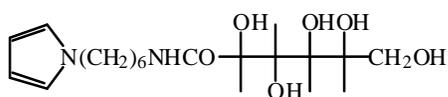
Department of Chemical Science and Technology,  
The University of Tokushima, 2-1 Minamijosanjima,  
Tokushima, 770-8506 JAPAN

\*Toyo Precision Parts MFG. Co., Ltd.

97-1 Higashinaka, Yamatotakada, Nara 635-0066 JAPAN

### Introduction

Among the various techniques for enzyme immobilization, the electropolymerization method is interesting for its simple preparation, miniaturization, and the precise localization of enzymes. Umaña et al. reported that glucose oxidase (GOD) immobilized electrodes were successfully prepared by the electropolymerization of pyrrole in the presence of the enzyme, however, the lifetime of the observed electrode in the biological environment was not adequate, due to a release of enzyme from the electrode surface<sup>1,2</sup>. Therefore, variety of attempts, such as introduction of functional substituent to pyrrole, has been performed to enclose the enzyme tightly on the electrode. Since the compounds containing saccharide group are known to combine considerably stable with the enzyme by hydrogen bonding, the authors recently synthesized pyrrole containing saccharide units, 1-(6-D-gluconamidoheptyl) pyrrole (GHP) and applied for enzyme immobilized electrode preparation<sup>3</sup>. The obtained electrode presented excellent long-term stability of more than 4 month from the day of fabrication. Moreover, the response current of the obtained electrode was approximately not influenced by the addition of ascorbic acid, urea, D-(-)-fructose and acetaminophen, while that of uric acid was not negligible. In this study, needle type glucose sensors were prepared by the electropolymerization of GHP in order to investigate the utility of the obtained electrode for in vitro and in vivo measurement.



GHP

### Experimental

GOD-immobilized electrode was prepared by electrooxidizing deaerated 0.1 mol dm<sup>-3</sup> phosphate buffer solutions (pH 7.4) containing GHP (0.1 mol dm<sup>-3</sup>), GOD (1 mg cm<sup>-3</sup>) and LiClO<sub>4</sub> (0.1 mol dm<sup>-3</sup>) on iridium-platinum (10% Ir-90% Pt, diameter 0.178 mm) electrode at 4 °C. A constant potential of 1.2 V (vs. Ag/AgCl), was applied for the electropolymerization and the amount of deposition charge passed was 0.2 C cm<sup>-2</sup>. The dip coating of polyurethane film was performed on some electrodes. The platinum-black plating was also modified on some electrodes.

Amperometric responses of the prepared electrodes to glucose were examined in a 0.1 mol dm<sup>-3</sup> phosphate buffer solution of pH 7.4 by measuring the electrooxidation current at a potential of 0.55 V (for hydrogen peroxide detection). The calibration of the sensor was carried out by adding increasing amounts of glucose to the stirred phosphate buffer solution (pH 7.4) and bovine serum (containing 6.16 mmol dm<sup>-3</sup> glucose) at 40 °C. The current was measured at the plateau (steady-state response) and was

related to the concentration of the analyte.

### Results and Discussion

The electrode stability of prepared GOD-immobilized electrodes was investigated in 5.6 mmol dm<sup>-3</sup> glucose. The electrodes were stored in phosphate buffer when not in use. The response current of the electrode with polyurethane outer film showed unchanged response for 30 days, while that without polyurethane film showed unstable response. The relationship between the glucose concentration and the response current was measured in phosphate buffer solution (pH 7.4) and bovine serum at 40 °C. The response of the electrode with platinum-black plating showed four times higher response than that without plating. The response current of both electrodes in bovine serum increased linearly with the addition of glucose up to 33.6 mmol dm<sup>-3</sup>. In vivo measurement was performed using rats, while no clear response current corresponding to the glucose level was obtained.

### References

1. M. Umana and J. Waller, *Anal. Chem.*, **58**, 2979 (1986)
2. N. C. Foulds and C. R. Lowe, *J. Chem. Soc., Faraday Trans. I*, **82**, 143 (1986)
3. M. Yasuzawa, S. Fujii, A. Kunugi, T. Nakaya, *Anal. Sciences*, **15**, 12, 1175 (1999).