

Electropolymerization of Pyrrole onto Gold Nano-tube Template Membrane

Tomoko Nishitani and Katsumi Yamada
Department of Photonic Information and Media
Engineering1583, Iiyama, Atsugi, Kanegawa, 243-0297
JAPAN

Abstract

Polypyrrole (PPy) nano-tubes were prepared by electrochemical polymerization with gold nano-tube membrane (Au-NTM) electrodes as the template. When the polymerization was carried out with a potential scan mode, the observed peak growth on the cyclic voltammogram was distinct from that with ordinary gold flat surface electrode. Namely, the polymer growth at the initial stage involved the pore filling process and the outer surface process.

Introduction

A number of investigators have examined the preparation of nano-materials. We have already shown and developed a simple method ("Template Synthesis") to obtain nano-tube membrane with various materials such as carbon and gold.¹⁾ Here the preparation of polypyrrole nano-tube are investigated by electro-polymerization with gold nano-tube membrane as the electrode.

Experimental

Commercially-available 'track-etched' polycarbonate (PCTE, Poretics) filter membranes are used as the templates to prepare the gold nano-tube electrode. The polycarbonate membranes used for this study had nominal pore diameters of 220 nm and the thickness is 9 μm . The electroless plating method used to deposit the gold nano-tubes within pores of these membranes has been described previously.²⁾ Pyrrole (20 mM) was dissolved in the LiClO_4 (0.1 M) aqueous solution. Gold nano-tube membrane (Au-NTM), Ag-AgCl and Pt wire were used as the working electrode, the reference electrode and counter electrode, respectively. For the electropolymerization, the potential was cycled (maximum 70 cycles) between -0.6 and +0.7 V (vs. Ag-AgCl) at 50 mV/s. Cyclic voltammetry was carried out to evaluate the electrochemical activity of the resulting PPy.

Results and Discussion

We employed a potential scanning procedure to electropolymerize pyrrole into Au-NTM. This procedure is useful to evaluate the amount or the electrochemical activity of the product on the electrode. Figure 1a shows the cyclic voltammograms during the pyrrole electropolymerization (70 cycles) with the Au-NTM electrode. On the first potential cycle, an anodic current began to generate around +0.6 V due to the oxidation of pyrrole monomer. Subsequent reaction including dimerization and polymer growth occurred on the electrode until switching the potential scanning at +0.7 V. Therefore, cathodic responses due to the reduction of the polymer were observed on the voltammogram at a potential scanning for negative direction. These responses are consisted from the redox reaction of the resulting polymer inside gold nano-tube and the outer surface. These enhancement of redox current with increasing scan number of the electro-polymerization indicate the polymer growth onto the Au-NTM electrode. Therefore, the thickness of the polymer on the electrode

could be controlled by the scan number. When the polymerization was carried out by 70 cycles of potential scanning, the current enhancement continued until around 30 cycles. And then, the redox current would be gradually smaller (Fig.1b). It is supposed that there is no serious influence of the overoxidation of PPy in the present polymerization condition with the switch potential at +0.7 V (vs. Ag-AgCl). Therefore, we believe that the continuous polymer growth occurs at over 30 cycles. In the present report, the relationship between the peak current and the polymer growth on the Au-NTM is discussed by SEM observation and electrochemical measurements.

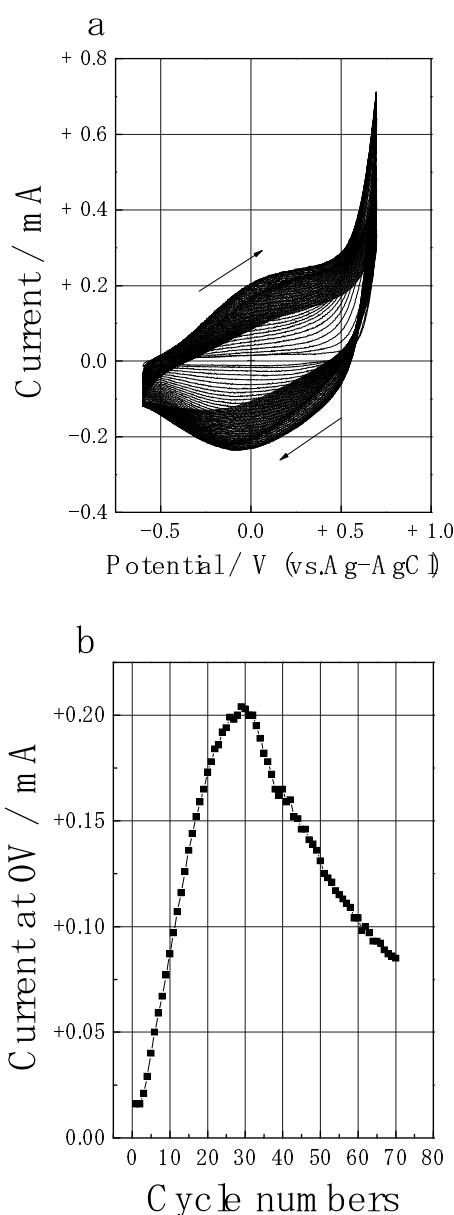


Figure 1 Cyclic voltammograms during the electropolymerization of pyrrole (20 mM) with the Au-NTM in the LiClO_4 (0.1 M) aqueous solution under nitrogen atmosphere. Scan rate is 50 mV/s (a), relationship between the cycle numbers for the electropolymerization and the recorded values of the oxidative current at 0 V (b).

References

- 1) C. R. Martin, Science 266, 1961 (1994)
- 2) V.P.Menon and C.R.Martin, Anal.Chem., **67**, 1920 (1995).