

Characteristics of Conductivity-improved Polypyrrole Deposited on Roughened Gold Substrate

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As shown in the literature, many factors can influence the physical and spectroscopic properties of PPy. These include the nature of solvent,^{1,2} polymerization method and rate,^{3,4} deposition time,^{5,6} pH in solution,^{7,8} monomer and electrolyte concentrations in polymerization.⁹ Furthermore, some reports^{10,11} suggested that higher conjugation structures and doping levels in the polymers backbones are accompanied by higher molecular weights of PPy films, which can be prepared at a lower polymerization rate. Recently, surface-enhanced Raman scattering (SERS) in principle provides a powerful means of obtaining vibrational information of organic compounds, presenting at very low levels in a system, on the adsorbate-substrate interface in view of its unique sensitivity and excellent frequency resolution. However, the chemical mechanism of this enhancement is poorly understood compared to the electromagnetic mechanism. The utility to explore catalytic electrooxidation pathways by means of extending the concept of SERS is thus limited. This work reports a new electrochemical method to improve the conductivity of electrochemically prepared PPy deposited on a roughened gold (Au) substrate. Meanwhile, the characteristics of the modified PPy were examined via X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy.

1000 mC/cm² PPy was electrochemically polymerized at a constant anodic potential of 0.8 V vs. Ag/AgCl in a deoxygenated aqueous solution containing 0.1 M pyrrole and 0.1 M LiClO₄ (called pure PPy). PPy (called PPy deposited on roughened Au) was also prepared on a roughened Au substrate with a pretreatment of oxidation-reduction cycles (ORC) for 50 times. The result indicates that the conductivity of PPy increases significantly by 3.5-fold, just depositing PPy on a roughened Au substrate.

From the cyclic voltammetry (CV) experiments, they indicated that 0.7 and 0.8 V vs. Ag/AgCl were the onset potentials of PPy deposited on Au substrates with and without roughening treatment, respectively. It clearly explicates that the roughened Au substrate demonstrates a catalytic electrooxidation pathway. Therefore, at the same applied anodic potentials, the higher polymerization overpotential takes the advantage of a higher oxidation

level, contributing for owning a high level of conductivity. On the other hand, the higher doping level may be also ascribed to an electron transfer from PPy to AuCl₄⁻, forming on the Au substrate during roughening. From the Raman spectra showing the C-H in-plane deformation of PPy, it reveals obviously that PPy deposited on roughened Au owns a higher relative intensity of the double peaks at about 1083 cm⁻¹ in the range of 1000~1150 cm⁻¹ which is assigned to be the C-H in plane deformation of oxidized PPy.

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References

1. Dhanalakshmi, K.; Saraswathi, R.; Srinivasan, C. *Synth. Met.* **1996**, 82, 237.
2. Lim, J. Y.; Paik, W. K.; Yeo, I. H. *Synth. Met.* **1995**, 69, 451.
3. Hwang, B. J.; Lee, K. L. *Thin Solid Films* **1996**, 279, 236.
4. Valerir, F. A. J.; Gottesfeld, S. *Synth. Met.* **1993**, 55, 3760.
5. Tourillon, G.; Dartyge, E.; Dexpert, G.; Fontaine, A.; Jucha, A. *J. Electroanal. Chem.* **1984**, 178, 366.
6. Neoh, K. G.; Kang, E. T.; Tan, K. L. *J. Phys. Chem. B* **1997**, 101, 726.
7. Neoh, K. G.; Young, T. T.; Kang, E. T.; Tan, K. L. *J. Appl. Polym. Sci.* **1997**, 64, 519.
8. Sixou, B.; Vautrin, M.; Attias, A. J.; Travers, K. P. *Synth. Met.* **1997**, 84, 835.
9. Brie, M.; Turcu, R.; Mihut, A. *Mater. Chem. Phys.* **1997**, 49, 174.
10. Kudoh, Y.; Fukuyama, M.; Yoshimura, S. *Synth. Met.* **1994**, 66, 157.
11. Sun, B.; Jones, J. J.; Burford, R. P.; Kazaoos, M. S. *J. Mater. Sci.* **1989**, 24, 4024.