

論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Electric Field-Driven Electrosynthesis of Conducting Polymers and Modification of Electrode Surfaces Based on Bipolar Electrochemistry
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

系・コース： 応用化学 Department of Graduate major in エネルギー	系 コース	申請学位 (専攻分野) : 博士 Academic Degree Requested Doctor of (工学)
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

This dissertation titled "Electric Field-Driven Electrosynthesis of Conducting Polymers and Modification of Electrode Surfaces Based on Bipolar Electrochemistry" focuses on preparation of functional one-dimensional (1D) conducting polymers (CPs) with and without templates and personalized modification of electrode surfaces using various organic compounds in a facile way.

Chapter 1 "General Introduction" introduces the fundamentals of bipolar electrochemistry including principles, common electrolytic setups and advantages. Additionally, interesting applications on bipolar electrochemistry from materials science to electroanalysis and motion generation are described.

Chapter 2 "Template-free Vertical Growth of Poly(3,4-ethylenedioxythiophene) Fiber Arrays by Alternating Current-Bipolar Electrolysis" demonstrates the successful growth of perpendicular CP fiber arrays on the electrode surface using a cylindrical electrochemical apparatus, benefiting from synergetic electrolysis and electrophoresis effects in a bipolar electrochemical system. This study is of significance to practical applications due to the fact that anisotropic CPs usually have an excellent electron transfer efficiency. Plausible growth mechanism that several micrometer-sized islands initially form during an induction period and trigger the subsequent growth is proposed. Besides, the author carried out thorough investigations on influence factors of the PEDOT fibers growth, including electrolytic setups, electrolytic parameters, electrodes substrates and so on. The applied voltage and the gap between the cylinder and the BPE determined the successful growth of CP fiber arrays. Diameter of the cylinder, solvent and supporting electrolyte affected morphologies of CP fibers. In addition, the CP fiber array could grow not only on flat ITO surface, but also on other substrates, even for the glassy carbon beads-decorated electrode surface. The facile method is possible to have a wide applicability to satisfy various demands.

Chapter 3 "Fabrication of Polymer Nanowires by Templated Bipolar Electropolymerization Assisted by Electrophoretic Effect" shows enhanced electrophoretic migration of charged monomers into a template to fabricate robust CP nanowires, benefiting from synergetic electrolysis and electrophoresis effects under bipolar electrochemical conditions. Electrodeposition of electroactive monomers with the help of the template is one of popular methods to prepare CP-based nanomaterials because of its simplicity and

controllability. A commercially available hard template, such as the anodic aluminum oxide (AAO) membrane is commonly employed for decoration of the electrode surface to regulate the size and the shape of nanostructures. However, the nanopores of the template have a high aspect ratio, thus highly limited the diffusion of monomers into the narrow space; therefore, the electropolymerized CPs tend to perform a hollow tubular structure with a low mechanical strength. Here, electrodeposition of monomers was carried out under bipolar electrochemical conditions. Actuated by an external electric field, the migration of charged monomers into the template was effectively improved due to the electrophoresis effect, resulting in densely packed CP nanowires. Positively charged ruthenium-containing monomer was used for reductive electropolymerization, while negatively charged 3-thiophenetrifluoroborate monomer was employed for oxidative polymerization. These obtained polymer nanowires possessed a good mechanical property to keep 1D perpendicular structures, even after removing the template. This work proves the inherently high synergy of electrolysis and electrophoresis in a bipolar electrochemical system.

Chapter 4 "Fabrication of Gradient and Patterned Organic Thin Films by Means of Bipolar Electrolytic Micelle Disruption Method Using Redox-active Surfactants" establishes a bipolar electrolytic micelle disruption (BEMD) method to prepare gradient and patterned films on BPE surfaces. In the BEMD approach, an electrolytic micelle disruption process is well integrated with bipolar electrolytic technology. The micelles composed of electroactive surfactants can carry various organic compounds. When these surfactants were oxidized, various organic compounds incorporated into micelles were released and deposited on the electrode surface. A U-shaped bipolar electrolytic setup generated a sigmoidal potential distribution on the BPE, while a cylindrical bipolar electrolytic setup provided a site-selective potential feature on the BPE. Therefore, the disruption of micelles could selectively proceed on the BPE surface, following the potential distribution. Finally, a variety of gradient and patterned organic thin films were formed on the BPE surface. These organic compounds as film-forming materials can be a polymerizable monomer, an organic dye or luminescent aggregation-induced emission molecules. Such a general BEMD approach takes full advantage of bipolar electrochemistry, opening a long-term perspective for electrode surface modifications.

Chapter 5 "General Conclusion" summarizes and reviews the results of this study that the electrosynthesis of 1D CPs and the selective modification of electrode surfaces were achieved by bipolar electrochemistry. These achievements offer general approaches on the preparation of materials and greatly extend the application scopes of bipolar electrochemistry. Therefore, it is recognized that this dissertation is of sufficient value as a doctoral thesis.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note: Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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