

論文 / 著書情報
Article / Book Information

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Title(English)	Nanostructured and Functionalized Poly(3,4-ethylenedioxythiophene)-based Interfaces: Syntheses, Fabrications and Dynamic Switches
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学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

専攻 : Department of	electronic chemistry	専攻	申請学位 (専攻分野) : Academic Degree Requested	博士 Doctor of	(science)
学籍番号 : Student ID Number			指導教員 (主) : Academic Advisor(main)		Hsiao-hua Yu
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

In this thesis, several functionalized 3,4-ethylenedioxythiophene (EDOT) monomers were synthesized and those EDOTs building blocks were electropolymerized as thin film or one-dimensional nanostructures on conductive substrates as polymer interfaces for different studies.

In chapter 1, a brief introduction on discovery and syntheses of conducting polymers is described. Besides, fabrication methods of nanostructured conducting polymers are also introduced in this chapter. Subsequently, recent advances of conducting polymers on anti-wetting surfaces and bioengineering applications are summarized.

In chapter 2, detailed experiment procedures in this thesis are summarized, including the monomer syntheses, electrochemical measurements, surface characterizations and cellular experiments.

In chapter 3, a hard-template based approach to modify conducting substrates as well-defined nanorod arrays is demonstrated. A variety of functionalized PEDOTs are utilized for understanding molecular and nanstructure effects on surface wettability. Anodic alumium oxide (AAO) templates are fabricated directly onto the conductive substrates and functionalized EDOT monomers are assembled inside the pores of these AAO templates by applying pulsed voltage to initiate electropolymerization and deposition. It is noticed that hydrophilic monomers (unfunctionalized EDOT and EDOT-OH) formed tubes inside the pores. On the other hand, alkyl and perfluoro-functionalized PEDOTs are assembled as rods with almost identical nanostructures. These ordered nanorod arrays allow us to differentiate the contribution of molecular architecture and micro/nanoscale structure on the surface properties of our materials. In the water/air interface, the contact angles of water droplet (CA_{water}) for the smooth alkyl functionalized PEDOT films increase when alkyl chains become longer. At the same time, the contact angle reaches saturation at 130° with alkyl chain longer than C2 in assembled nanorod arrays. Moreover, the perfluoro-functionalized PEDOT with identical nanostructures also shows contact angle around 130° . In the oil/water interface, the contact angle of oil droplet ($CA_{\text{oil in water}}$) on films or nanorod arrays of alkyl- and perfluoro-functionalized PEDOTs decreases with longer alkyl chains. The contact angle reaches saturation in both of the nanorod arrays and the smith films when the chain is longer than C8. This result shows that the molecular effect dominates the surface wettability on the

oil/water interface. It is also noticeable that PEDOT-C2 nanorod arrays displays superoleophobicity in water. This material shows potential applied as underwater self-cleaning material.

In chapter 4, we have developed a dynamic polymer interface based on EDOT monomer with electrochemically responsive hydroquinone (EDOT-HQ). PEDOT-HQ interface shows highly reversible hydroquinone-benzoquinone switch in aqueous solution. We utilized formation and cleavage of oxime linkage to manipulate conjugation and release of the aminoxy functionalized ligands on PEDOT-HQ films. Furthermore, PEDOT-HQ interface undergoes site-selective immobilization and release of fluorescence dyes when it is deposited on interdigitated microelectrode arrays. This dynamic PEDOT interface has great potential as a new material for bioelectronic devices and organic implants.

In chapter 5, We have developed a dynamic polymer interface based on the hydroquinone EDOT (EDOT-HQ) and the zwitterionic phosphorylcholine EDOT (EDOT-PC) for releasing nerve cells and fibroblasts after long term interfacing and stimulating. EDOT-PC is introduced into the dynamic polymer interface because of its' excellent cell-resistant properties. For the construction of dynamic polymer interface, an inverse emulsion electro-copolymerization method was utilized to assemble the EDOT-PC and EDOT-HQ into a polymer film with tunable composition. Upon finely-tuned density of EDOT-PC, the dynamic polymer interface exhibits cell-resistant properties. For example, NIH 3T3 fibroblasts cannot seed on the dynamic polymer interfaces when polymer films containing over 85% EDOT-PC, the cells can only bind these polymer films when RGD ligands are conjugated on the surfaces. Besides, releasing immobilized NIH 3T3 cells from the dynamic polymer interface is also achieved when the cells lost the specific binding with the polymer. The released NIH 3T3 cells present like a cell sheet and remain good viability as high as 94%. The dynamic polymer interface also demonstrates excellent compatibility with PC12 nerve cells. PC12 cells can attach, proliferate and differentiate very well. Moreover, by applying a programmed pulse voltage onto the polymer interface not only demonstrates its capability for electrically tuning the cell differentiation, but also for controlled release of the cells. The differentiated PC12 cells sprout longer neurite with electrical stimulation than the control without electrical stimulation. Following stimulation, PC12 cells are released from the polymer and the released cells displayed viability as high as 93% examined. Besides, the released PC12 cells are dispersed in culture medium and seeded on the culture dish. The PC12 cells spread well on the culture dish and still remain long neurite after seeding for 1day. Once this dynamic polymer is used as interface for implantable bioelectronic devices and tissue engineering, we plausibly ensure that the polymer interface intimately interacts with targeted cells with resistance to non-specific binding, efficient electrical signal delivery and reduced damage on surrounding tissues when devices are removed.

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 2 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 2 copies of 800 Words (English).