

論文 / 著書情報
Article / Book Information

題目(和文)	多孔質基材を用いた機能膜開発のための新規プラズマグラフト重合法
Title(English)	Novel plasma-induced graft polymerization for fabricating functional membrane materials from porous substrates
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第9646号, 授与年月日:2014年9月25日, 学位の種別:課程博士, 審査員:山口 猛央,小坂田 耕太郎,山元 公寿,西山 伸宏,田巻 孝敬
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第9646号, Conferred date:2014/9/25, Degree Type:Course doctor, Examiner:,,,,
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

(博士課程)
Doctoral Program

論文要旨

THESIS SUMMARY

専攻 : Department of	化学環境学	専攻	申請学位 (専攻分野) : 博士 (工学)
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

Plasma-induced graft polymerization (PIGP) is one of the most efficient grafting methods explored for fabricating functional materials on porous substrates, due to its superior efficiency in forming grafted layers inside the nano-sized pores while maintaining the bulk property of the substrate. It has been successfully used to prepare materials with superior functional properties, such as drastic response gating membranes and high selectivity pervaporation membranes. At the same time, some prevailing challenges act as barriers for the wide-scale application of PIGP. One of the major problems is the limited number of monomers that can be employed with this technique. This problem is basically associated with the lack of understanding about the grafting mechanism inside the pores, since only few research attempts have been conducted with special consideration on the effect associated with the porous structure of the substrate. Being aware of these important issues, the present study is devoted to investigate the mechanism of grafting inside pores, with the goal of exploring larger application prospects for PIGP. A novel PIGP approach applicable to monomers of low PIGP reactivity is proposed and subsequently investigated its mechanism along with the polymer growth features with sufficient consideration given to the porous structure of the substrate used for grafting. The dissertation is composed of 6 chapters described as follows.

Chapter 1 "Introduction" introduces the characteristics of PIGP technique, and explains the advantages of PIGP over other "grafting from" techniques. The previous studies describing the mechanism and the influencing factors of grafting are also reviewed. Furthermore, by evaluating the gap between the application prospects and the current research state, the challenging issues of PIGP and the necessity for deeper understanding on the grafting mechanism inside pores are pointed out.

Chapter 2 "Plasma-induced graft polymerization of a sulfonic monomer" describes a novel PIGP approach based on a sulfonic monomer 2-acrylamide-2-methylpropane sulfonic acid (AMPS) and a porous substrate composed of high density polyethylene. AMPS, having low reactivity in the conventional PIGP, underwent smoothly graft polymerization with the assistance of the surfactant sodium dodecyl sulfate (SDS). A key feature of the present PIGP approach is that it prefers a lower grafting temperature range than the conventional PIGP does. Furthermore, desirable grafting degree can be achieved by simply adjusting the reaction conditions such as grafting time and monomer/additive concentration.

Chapter 3 "Mechanism study of the proposed plasma-induced graft polymerization" investigates the

mechanism of the proposed PIGP approach focusing on two questions derived from its features, “the role of the additive SDS” and “the cause for the low grafting temperature range”. The main role of SDS was found to be helping monomer solution to infiltrate into the pores which is extremely important for the grafting inside pores of porous substrate. The low grafting temperature was found to be associated with the acidic condition which decreased the working temperature of the peroxide initiator produced by plasma-irradiation and subsequent air exposure.

Chapter 4 “Applicability of the proposed plasma-induced graft polymerization to other monomers” applies the present PIGP approach to four other monomers, *N*-isopropylacrylamide (NIPAM), (3-methacrylamidopropyl)trimethylammonium chloride, vinylbenzyltrimethylammonium chloride and sodium 4-vinylbenzenesulfonate. The grafting of each monomer was succeeded at a low temperature 40 °C by applying acidic condition and ensuring the infiltration of monomer solution into the pores of the porous substrate. Additionally, monomer of different structure exhibited different pH dependent grafting behavior, which indicates that the structure of monomer may also affect the initiation process of the graft polymerization.

Chapter 5 “Analysis of the grafted polymers fabricated by the proposed plasma-induced graft polymerization” investigates the structure of grafted polymers inside pores and its effect on the membrane performance based on the thermal-responsive gating membrane fabricated by grafting the thermal responsive NIPAM polymers onto the pore surface of the decomposable porous polycarbonate substrate. It was found that the molecular weight and density of grafted polymer chains can be adjusted by controlling the grafting temperature. The higher grafting temperature led to smaller molecular weight and higher density of the grafted chains, which consequently resulted in more drastic response to the temperature stimulus.

Chapter 6 “Conclusion and prospect” summarizes the achievements of the present study and forecasts the application prospect of PIGP.

Throughout the dissertation, the mechanism of grafting of different monomers on porous substrates is carefully studied with sufficient consideration on the influence of the porous structure, and a novel PIGP approach is proposed. The proposed approach enables direct grafting of several strong ionic monomers, and the lower grafting temperature allows the utilization of thermally labile monomers. This expansion in the available range of monomers diversifies the achievable compositions of the grafted polymers, thus enabling direct preparation of materials such as electrolyte membranes and polyampholyte membranes. Furthermore, the findings on the effect of grafted polymer structure on the membrane performance provide a valuable guideline for graft-material design and their performance optimization. Hence, the achievements in this study are expected to contribute on promoting the emergence of novel high-functional materials.

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).