Synthesis of Self-Healing Polymer with High Ion Conductivity

Name: Catherine Laurent
Student ID No.: B10835008
Major: IATP Chemical Engineering field
Advisor: 邱昱誠 Yu-Cheng Chiu

2022 01 17

Synthesis of Self-Healing Polymer with High Ion Conductivity

Abstract

Polymer with high ion conductivity is known for its widespread application and it is still a challenge to improve the self-healing properties while still maintaining its high ion conductivity. Herein, a p(AMPS-*co*-BA), self-healing polymer with high ion conductivity, is created by copolymerization of 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS) and n-Butyl acrylate (BA) in methanol. Followed by membrane dialysis and evaporation of the solvent. Synthesis of p(AMPS) and p(BA) are also done in the same manner. The result shows that a p(AMPS-*co*-BA), p(AMPS), and p(BA) are polymerized successfully.

Introduction

Self-healing polymers with high ion conductivity are gaining massive attention in recent years due to their wide potential in electronic devices. As the electrolyte is one of the key components in electronic devices, such as in a lithium-ion battery, it is bound to go through deformations that will eventually affect the effectiveness of the device. By adding self-healing property, it would matter immensely on its endurance.

As shown in figure 1, p(AMPS-*co*-BA) is prepared by free radical polymerization between AMPS and BA with azobisdisobutyronitrile (AIBN) as the initiator (Figure 2). AMPS is highly ionic conductive and has remarkable self-healing ability. While BA is flexible and has a great chain mobility.

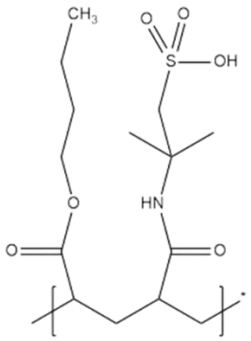
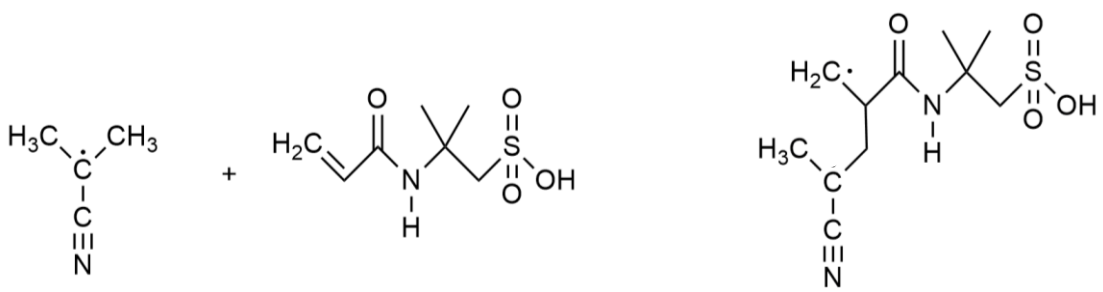


Figure 1 p(AMPS-*co*-BA) structure.

a.



b.

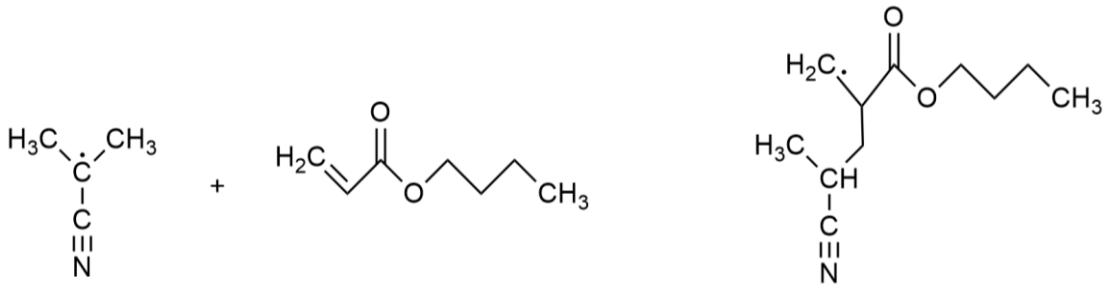


Figure 2(a) Free radical polymerization of AMPS and AIBN. (b) Free radical polymerization of BA and AIBN.

Due to the hydrogen bonding between AMPS (Figure 3), p(AMPS-co-BA) will have a self-healing ability. Aside from that, AMPS has strong sulfonic and amide groups which are conducive to the dissociation of lithium salts and can absorb large volumes of anions through hydrogen bonding. This will affect greatly the conductivity of the polymer.

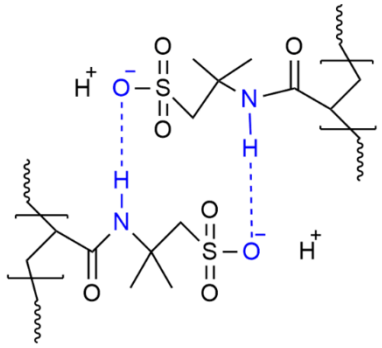


Figure 3 Hydrogen bonding between AMPS.

Motivation

To successfully synthesis self-healing polymer with high ion conductivity p(AMPS-*co*-BA), p(AMPS), and p(BA).

Description of Research Work

Free Radical Polymerization of p(AMPS-*co*-BA) are done by these steps:

1. Weigh AMPS and BA with the ratio of 4:6
2. Pour BA and methanol (solvent) into round bottomed flask. Then input argon gas and

heat the liquid component.

3. Put AMPS and AIBN (initiator) into Schlenk flask. Then in input argon gas and vacuum solid components alternatingly for 45 minutes.
4. Mix together solid and liquid components then heat to 65°C and stir for 24 hours.
5. Purify in membrane (membrane dialysis) for 3 days. Change the solvent every 12 to 24 hours.
6. Evaporate to remove most of the solvent and store polymer

Free Radical Polymerization of p(AMPS) are done by these steps:

1. Weigh AMPS with desired weight.
2. Pour methanol (solvent) into round bottomed flask. Then input argon gas and heat the liquid component.
3. Put AMPS and AIBN (initiator) into Schlenk flask. Then in input argon gas and vacuum solid components alternatingly for 45 minutes.
4. Mix together solid and liquid components then heat to 65°C and stir for 24 hours.
5. Purify in membrane (membrane dialysis) for 3 days. Change the solvent every 12 to 24 hours.
6. Evaporate to remove most of the solvent and store polymer

Free Radical Polymerization of p(BA) are done by these steps:

1. Weigh BA with desired weight.
2. Pour BA and methanol (solvent) into round bottomed flask. Then input argon gas and heat the liquid component.
3. Put AIBN (initiator) into Schlenk flask. Then in input argon gas and vacuum solid components alternatingly for 45 minutes.
4. Mix together solid and liquid components then heat to 65°C and stir for 24 hours.
5. Purify in membrane (membrane dialysis) for 3 days. Change the solvent every 12 to 24 hours.
6. Evaporate to remove most of the solvent and store polymer.

Conclusion

Synthesis of p(AMPS-*co*-BA) and p(AMPS) can be done in the same solvents, initiator, and other conditions. While p(BA) cannot be polymerized under the same conditions with p(AMPS-*co*-BA) and p(AMPS) since it will form two immiscible layers due its hydrophobic

properties even though the polymers are formed successfully. Further experiment must be done in order to produce a miscible p(BA).

Reference

Diao, W., Wu, L., Ma, X., Wang, L., Bu, X., Ni, W., Yang, X. and Fang, Y., 2021. *Reversibly highly stretchable and self-healable zwitterion-containing polyelectrolyte hydrogel with high ionic conductivity for high-performance flexible and cold-resistant supercapacitor*. [online] Available at: <https://onlinelibrary.wiley.com/doi/10.1002/app.48995> [Accessed 1 November 2021].

Zheng, Y., Xu, D., Tian, S. *et al. Polar poly(n-butyl acrylate)-g-polyacrylonitrile elastomer with high temperature elasticity and healability as flexible electronic substrate*. *Fash Text* **8,** 4 (2021). https://doi.org/10.1186/s40691-020-00235-4

Han-Fang Wen, Hung-Chin Wu, Junko Aimi, Chih-Chien Hung, Yun-Chi Chiang, Chi-Ching Kuo, & Wen-Chang Chen. (n.d.). *Soft Poly(butyl acrylate) Side Chains toward Intrinsically Stretchable Polymeric Semiconductors for Field-Effect Transistor Applications*. Retrieved November 1, 2021, from https://pubs.acs.org/doi/pdf/10.1021/acs.macromol.7b00860.

Guoping Yang, Haopeng Cai, Xiangyu Li, Mengjun Wu, Xue Yin, Haining Zhang, & Haolin Tang. (2020, January 30). *Enhancement of the electrochemical performance of lithium-ion batteries by SIO 2 @poly(2-acrylamido-2-methylpropanesulfonic acid) nanosphere addition into a polypropylene membrane*. RSC Advances. Retrieved December 5, 2021, from https://pubs.rsc.org/en/content/articlehtml/2020/ra/c9ra08273e.

Azonitriles. (n.d.). Polymer Properties Database. Retrieved November 10, 2021, from https://polymerdatabase.com/polymer%20chemistry/AIBN.html#:%7E:text=When%20AIBN%20decomposes%2C%20it%20forms,thereby%20creating%20growing%20polymer%20chains.