Fabrication of Strong and Stretchable Thin Film Hydrogel

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1. Introduction

Hydrogel is defined as a crosslinked three-dimensional polymeric network structure, which can absorb and retain considerable amounts of water. Hydrogels have been received special attention due to their promising properties such as biocompatibility and environmental friendliness, responsiveness to external stimuli, adhesion, and biodegradability [1]. They have many applications in various fields such as sensors, actuators, and biomedical so there are overwhelming researches to develop their mechanical properties [2].

Fig.1 Hydrogel Applications

In this research, we developed a new monomer: 5-(N-acryloylamino) isophthalic acid (MHOF) for making strong and stretchable thin film hydrogels. The hydrogels had water contents more than 50% with high Young's modulus (~47 MPa) and tensile strength (~3MPa).

2. Synthetic procedure

We develop a monomer to fabricate strong and stretchable thin film hydrogels. The target monomer is MHOF and there are two steps of synthesis.

In first step, 5-aminoisophthalic acid (6g) and sodium hydroxide (3.96g) were added to water (66ml) and the mixture was cooled to 0°C in an ice bath. Acryloyl chloride (3.72ml) was added slowly to the rapidly stirred suspension and wait for 12h. After that reaction mixture was acidified by the dropwise addition of 20ml Conc. hydrochloric acid. The compound was collected by filtration, washed with a sufficient amount of water and dried to get the pure compound.

In second step, acryloyloxy isophthalic acid (1g) and 4-Dimethylaminopyridine (0.125g) dissolved in dimethyl formamide (10ml) in a round bottom flask and cooled to room temperature under nitrogen atmosphere (N2 atm) and then add 1-ethyl-3-(3-dimethylaminopropyl-carbodimide hydrochloride (1.3g) under N2 atm and kept for 45 minutes, after that add phenol (0.88g) and stirred at room temperature for an additional 24h under N2 atm. The resulting mixture was put into water and extracted with ethyl acetate. The organic part washed twice with brine and pass through sodium sulfate and dried under vacuum. After that purification with column.

3. Fabrication and characterizations

Our method includes three steps. Firstly, MHOF and acrylamide (AAm) monomer were dissolved in dimethyl sulfoxide (DMSO) solvent. After that, the solutions were polymerized at high temperature (120°C) in 10 minutes with ammonium persulfate initiator then slowly cooling down to room temperature. Finally, the organogels were immersed in water in 24 hours for exchanging DMSO – water process.

4. Results and discussion

In this research, we determined effect of MHOF concentration and cooling speed to mechanical properties.

To determine the effect of MHOF concentration, we made three types of hydrogel: (MHOF-AAm): (25-100)mg, (50-100)mg and (75-100)mg – (MHOF-AAm). The results showed that concentration (MHOF-AAm):(75-100)mg got the best results. The maximum Young's modulus, tensile strength and work of extension of 6PL hydrogel were 18.03 MPa, 4.3 MPa and 11.85 MJ m^{-3}. The water contents were around 51.1 %.

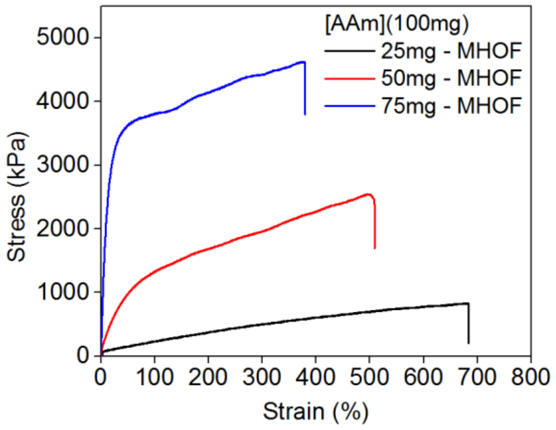

Fig.2 The effect of MHOF concentration to mechanical properties

For determine the effect cooling speed to mechanical properties, two condition were tested. After polymerization 10 minutes in high temperature 120°C, the organogels were cooling down slowly in temperature and cooling down rapidly in fridge. The results showed that the slowly cooling down showed better results. The maximum Young's modulus, tensile strength and work of extension of 6PL hydrogel were 18.03 MPa, 4.3 MPa and 11.85 MJ m^{-3}. The water contents were around 51.1 %. For the cooling down rapidly, the Young's modulus, tensile strength and work of extension of hydrogels were 10.09 MPa, 3.19 MPa and 12.08 MJ m^{-3}. The water contents were around 52.7 %.

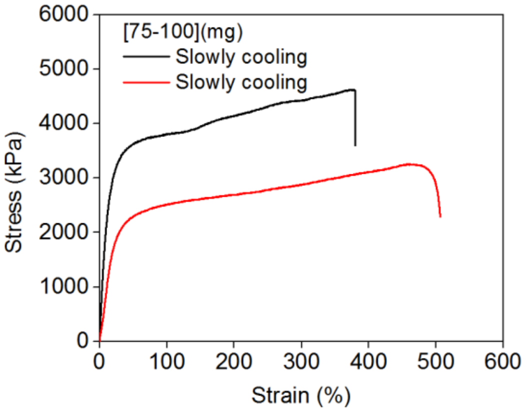

Fig.3 The effect of cooling speed to mechanical properties

5. Conclusions

In summary, we have successfully developed strong and stretchable thin film hydrogels. With their good mechanical properties, this hydrogel can be used for many different applications in the future.

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