

Superabsorbent conducting hydrogel from poly(acrylamide-aniline) with thermo-sensitivity and release properties

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Abstract

Interpenetrating networks (IPN) poly(acrylamide-aniline) polymer was synthesized by a two-steps aqueous polymerization method, which aniline monomer was absorbed in the network of polyacrylamide and followed by a polymerization reaction between aniline monomers. The poly(acrylamide-aniline) hydrogel possessed a conductivity of 25.28 mS cm^{-1} . An interpenetrating network structure model with a three-dimensional network of polyacrylamide and a one-dimensional chain of polyaniline for poly(acrylamide-aniline) conducting hydrogel was proposed, and a conduction mechanism with charge carriers (protons) hopping along the polyaniline chain was suggested. The poly(acrylamide-aniline) hydrogels have predominant thermo-sensitivity. Poly(acrylamide-aniline) hydrogels possess loading and releasing properties, an anomalous release mechanism is found.

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Keywords: Poly(acrylamide-aniline); Conducting hydrogel; Interpenetrating network; Thermo-sensitive; Release property

1. Introduction

Superabsorbent polymers have a network structure with a suitable degree of crosslinking (Buchholz & Graham, 1997). Not only it is able to absorb a large amount of water to form a stable hydrogel, but also the absorbed water is hardly removed under some pressure. About three decades ago (Fanta, Baker, Burr, Doane, & Russell, 1977; Fanta & Doane, 1986), superabsorbent polymers were introduced into the agriculture and diaper industries, and then their applications were extended to other industries where an excellent water holding property was of prime importance. Recently, many researchers focus their attentions on the superabsorbent polymer for developing new applications, such as conducting materials, biomaterials, sensors and release materials, wave-absorbing materials (Abd El-Rehim, 2005; Dispenza, Lo Presti, Belfiore, Spadaro, &

Piazza, 2006; Ito and Chuang, 2003; Lee & Chen, 2005; Li, Guo, Wei, MacDiarmid, & Lelkes, 2006; Omidian, Rocca, & Park, 2005; Richter, Howitz, & Kuckling, 2004; Siddhanta & Gangopadhyay, 2005; Wada, Nohara, & Iwakura, 2004; Wu, Lan, Wang, Hao, & Lin, 2006a; Wu et al., 2006b; Wu, Wei, Lin, & Lin, 2003), and so on, it is expected to prepare a multifunctional superabsorbent material to meet applications requirement by modifying, grafting, copolymerizing and other methods.

However, the researches on conducting polymer (or hydrogel) based on the superabsorbent polymer is still few to see. A conducting hydrogel could be used in fuel cells, supercapacitor, dye sensitive solar cell and rechargeable lithium batteries (Lan et al., 2006; Lewandowski, Zajder, Frackowiak, & Beguin, 2001; Pissis & Kyritsis, 1997; Shinji et al., 2003; Sun, Liu, Xie, Han, & Kerr, 2004; Wu et al., 2006a, 2006b), due to its better conductivity property, colloid stability, low cost and simple preparation.

Polyaniline is a higher conductivity polymer, by integrating with polyacrylamide superabsorbent polymer, it should form a novel conducting hydrogel. In this paper,

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poly(acrylamide-aniline) polymer was synthesized by two-steps aqueous polymerization based on our previous work (Tang, Lin, Wu, Zhang, & Hao, 2007). An interpenetrating networks structure model with a three-dimensional network of polyacrylamide and a one-dimensional chain of polyaniline for poly(acrylamide-aniline) conducting hydrogel is proposed. Meanwhile, the release property for poly(acrylamide-aniline) hydrogel was investigated.

2. Experiment part

2.1. Materials

Acrylamide and aniline monomer was distilled under reduced pressure prior to use. Potassium persulfate (KPS) as a radical initiator for the synthetic reaction of polyacrylamide and polyaniline, was purified by recrystallization from 66 wt% ethanol/water solution. *N,N'*-methylene bisacrylamide was a crosslinker for preparation of polyacrylamide. Methylrosaniline chloride was used as a drug target with solution concentration of 1 wt%.

2.2. Preparation of polyacrylamide superabsorbent polymer

Polyacrylamide superabsorbent polymer was prepared by modifying the procedure from reference (Huang & Wan, 1999; Lin, Wu, Yang, & Pu, 2001; Wu, Lin, Li, & Wei, 2001). A mixed solution of acrylamide, crosslinker was made by agitating acrylamide monomer (15 g), crosslinker (*N,N'*-methylene bisacrylamide, 0.006 g) and distilled water (15 ml) at ambient temperature. Under a nitrogen atmosphere, the mixture solution was stirred and heated to 80 °C in a water bath for 15 min, and then the initiator (0.15 g) was added, the reaction mixture was stirred for a few minutes until polymerization reaction completed. A jell-like intermediate product was filtered through Whatman filter paper No. 54 and then immersed in excess distilled water to remove any impurities. After dried under vacuum at 80 °C for more than 3 h to constant weight and milled using a 40-mesh screen, a powdered products polyacrylamide superabsorbent polymer thus was obtained.

2.3. Preparation of poly(acrylamide-aniline) polymer

On the basis of the polyacrylamide superabsorbent polymer, a poly(acrylamide-aniline) polymer was prepared according to following procedure. Under vigorous agitating, 5 g powdered polyacrylamide superabsorbent polymer was immersed in a predetermined amount aniline aqueous solution at ambient temperature for 30 min, which resulted in the absorption of aniline monomer inside of the polyacrylamide network and the formation of a swollen sample. The swollen sample was dispersed in a solution of 100 ml containing a suitable amount of initiator potassium persulfate, which caused an in situ polymerization between aniline monomers and formed polyaniline inside the network

of polyacrylamide. The polymerization reaction took place at room temperature. After that, similar to the preparation of polyacrylamide superabsorbent polymer, the intermediate product was filtrated, washed, dried milled and sifted, finally a jade-green powdered poly(acrylamide-aniline) conducting polymer thus was obtained.

2.4. The measurement of swelling ratio

The swelling ratio is the criterion of describing water absorption capacity. The measurement of the swelling ratio of poly(acrylamide-aniline) polymer was conducted by a tea-bag method, and using distilled water as liquids to be absorbed. The tea bags used in the method was made of 40 meshes nylon net. The weight of the wet nylon net was measured and marked as W_n . The weight of dry poly(acrylamide-aniline) polymer was marked as W_d . The test sample of poly(acrylamide-aniline) polymer, after weighed, was placed into the tea bag and then the tea bag with sample inside was suspended and fully immersed into liquids to be absorbed in the range of 5–45 °C. After 24 h, the tea bag was hung in the air for 15 min, and then the weight of the tea bag including swollen resin was measured and marked as W_t . The swelling ratio poly(acrylamide-aniline) polymer was calculated as:

$$\text{Swelling ratio(SR)}(\text{g/g}) = \frac{W_t - W_d - W_n}{W_d} \quad (1)$$

2.5. Measurement of conductivity of poly(acrylamide-aniline) hydrogel

The powdered conducting polymer of 3 g was immersed in distilled water of 500 ml at room temperature for at least 3 h to reach swelling equilibrium, which resulted in the absorption of water inside of the network of the poly(acrylamide-aniline) conducting polymer and the formation of a conducting hydrogel. The unadsorbed water was removed by filtrating over a 40-mesh stainless steel screen and hanging up for 25 min. The electrical conductivity of the hydrogel washed for three times was measured by inserting a Pocket Conductivity Meter (HANNA8733) in a cylinder containing a swollen sample of 30 g. The conductivities of initial filtrate were also measured by the Conductivity Meter.

2.6. Release experiments

The drug loaded and released properties were evaluated by using methylrosaniline chloride as drug target. Poly(acrylamide-aniline) dried samples were immersed in the drug target aqueous solution with different concentrations (0.03, 0.06 and 0.10 mg/ml) for 12 h at room temperature. The loaded and released amount were determined spectrophotometrically ($\lambda = 270 \pm 1$ nm) with a UV-3100 UV-vis-IR spectrophotometer (Shimadzu Corporation, Japan). The regression equation of methylrosaniline chlo-

ride solution working curve was $A = 45.45c - 0.022$, $r = .9994$.

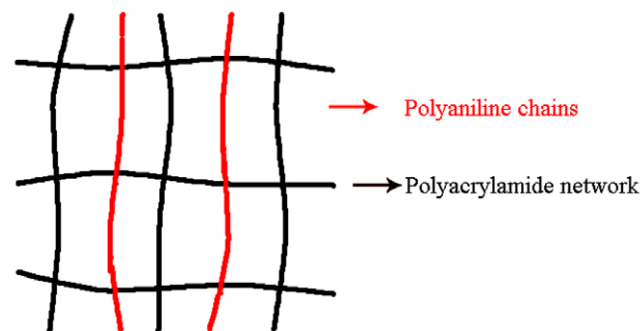
2.7. Characterizations

The morphology of poly(acrylamide-aniline) sample was examined using a scanning electron microscope (Hitachi S-5200, Japan). Poly(acrylamide-aniline) sample was grounded into powder, and mounted on metal stub, and coated with gold, subsequently, its surface was observed and photographed by SEM (scanning electron microscope). The sample was identified by IR spectroscopy on a Nicolet Impact 410 FTIR spectrophotometer using KBr pellets. Powder X-ray diffraction studies were performed using D8 ADVANCE X-ray diffractometer of Germany BRUKER Co., Cu K α with wavelength 0.15406 nm, running at 40 kV and 30 mA, scanning from 2° to 40° at 5°·min⁻¹.

3. Results and discussion

3.1. SEM photographs of the hydrogel

The SEM photographs of polyacrylamide and poly(acrylamide-aniline) hydrogels are shown in Fig. 1. It can be seen that the surface of polyacrylamide is glossy and no impurity accretes (Fig. 1a), while for poly(acrylamide-aniline) hydrogel, coarse and network-like structure (Fig. 1b) is formed in the polymer. According to the SEM and the preparation process for poly(acrylamide-aniline) polymer, an interpenetrating network structure model is proposed, and the sketch figure is shown in Fig. 2. As we known that a polyacrylamide three-dimensional network is formed after the first polymerization reaction (Lin et al., 2001; Wu et al., 2001). Since aniline monomer is absorbed inside of the polyacrylamide network, the polyaniline chain is formed inside of the polyacrylamide network during the second polymerization process. Due to the bifunctional groups for aniline monomer, the polyaniline exist only in one-dimensional chain instead of three-dimensional network structure. Additional, the polyacrylamide network



Structure of poly(acrylamide-aniline) hydrogel

Fig. 2. Interpenetrating networks structure model of poly(acrylamide-aniline) hydrogel.

and polyaniline chain may integrate by physical or chemical combination, owing to $-\text{CONH}_2$ group on the polyacrylamide network and $-\text{NH}_2$ group on the polyaniline chain. Once the second chain of polyaniline is formed, whole system becomes an interpenetrating network structure, and a polyaniline chain electrical conductive channel is formed.

3.2. FTIR spectrum of poly(acrylamide-aniline) polymer

In Fig. 3, the absorption peak at 3170 cm^{-1} is belonged to the N—H bending, 3006 cm^{-1} is for the $-\text{CH}_2-$ stretching, 1667 cm^{-1} is for the C=O bending for polyacrylamide, respectively. The absorption peak at 1586 cm^{-1} is belonged to a quinoid ring stretching, 1498 cm^{-1} is attributed to benzene ring stretching, 1297 cm^{-1} is N—H stretching in connecting between benzene ring and quinoid ring, 1112 and 762 cm^{-1} are absorption peaks for single replaced benzene ring of polyaniline, respectively. And two absorption peaks at 1030 and 674 cm^{-1} are the same to reference (Huang & Wan, 1999) on the whole.

3.3. XRD analysis of poly(acrylamide-aniline) hydrogels

Crystallinity and orientation of conducting polymer have been of interest, because more highly ordered system

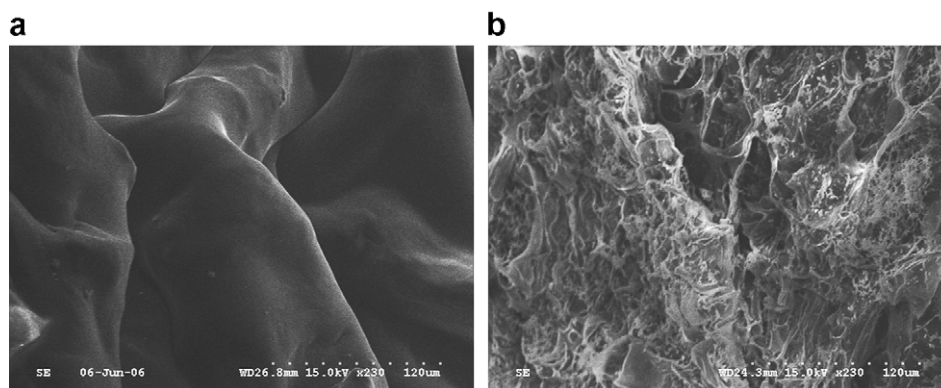


Fig. 1. SEM photographs of (a) polyacrylamide and (b) poly(acrylamide-aniline) hydrogel.

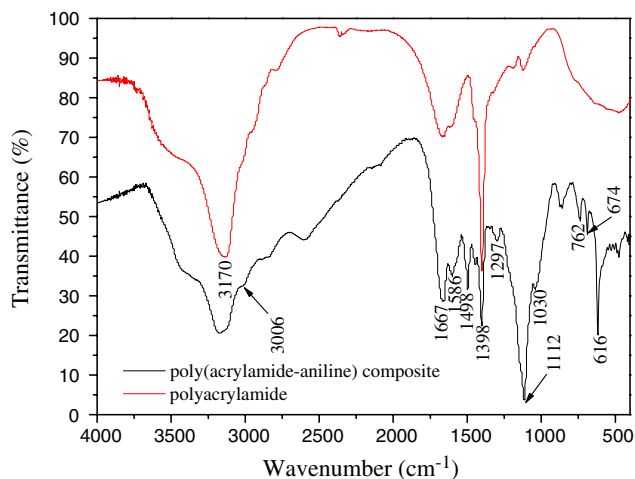


Fig. 3. FTIR spectrum of poly(acrylamide-aniline) polymer (mass ratio of polyacrylamide to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, reaction temperature 20 °C and time 6 h).

could display a metal-like conducting state (Li, Cruz, & Philips, 1993). XRD patterns of poly(acrylamide-aniline) hydrogels were carried out as a function of temperature and pH. Fig. 4 shows the XRD profiles for bulk hydrogels prepared at pHs and temperature. The X-ray pattern for doped polyaniline in bulk hydrogels (Fig. 5) exhibits sharp diffraction peaks at $2\theta = 6.2^\circ$, 17.1° , 20.3° , 24.1° and 28.6° , which are attributed to (001), (010), (100), (110) and (28.6) planes, respectively. The peak centered at $2\theta = 20.3^\circ$ is ascribed to periodicity parallel to the polyaniline chain, while the peak at $2\theta = 24.1^\circ$ due to the periodicity perpendicular to the polyaniline chain (Moon, Cao, Smith, & Heeger, 1989). The peak at $2\theta = 20.3^\circ$ also represents the characteristic distance between the ring planes of benzene rings in adjacent chains or the close contact inter-chain distance. The sharp diffraction peaks of poly(acrylamide-aniline) conducting hydrogels prepared at pH of 1.5 and

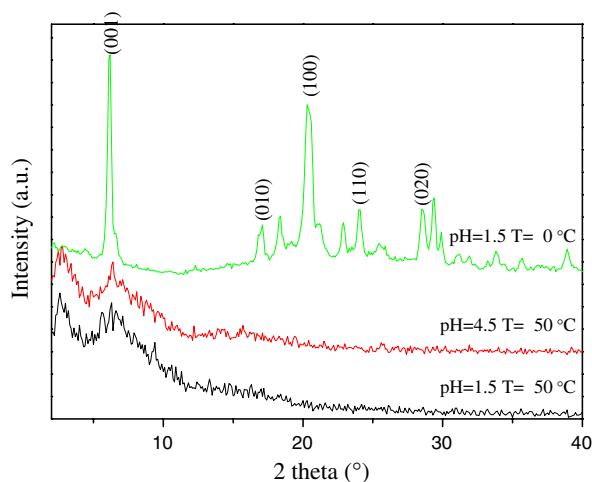


Fig. 4. XRD patterns of poly(acrylamide-aniline) bulk conducting hydrogels as a function of pH and temperature (mass ratio of polyacrylamide to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, and reaction time 6 h).



Fig. 5. Morphology of poly(acrylamide-aniline) bulk conducting hydrogel.

temperature of 0 °C reveal that the polyaniline owns visible crystalline. While for the conducting hydrogels prepared at high temperature and pHs, the diffraction peaks disappear except $2\theta = 6.2^\circ$. The disappearance of sharp diffraction peaks indicates lower crystalline order owing to the formation of larger fraction of polyaniline.

3.4. Influence of KPS on conductivity of the hydrogel

The conductivity of the conducting hydrogel depends on polyaniline chain, and the formation of the polyaniline chain is initiated by potassium persulfate (KPS), so the amount of initiator KPS affects the conductivity of the hydrogel. As are shown in Fig. 6, the electrical conductivity of the hydrogel increases with the increase of the mass ratio of KPS to aniline monomer in the range of 0.4–1.0, beyond a mass ratio of 1.0, the conductivity decreases. Clearly, a lower amount of KPS does not produce enough crosslink

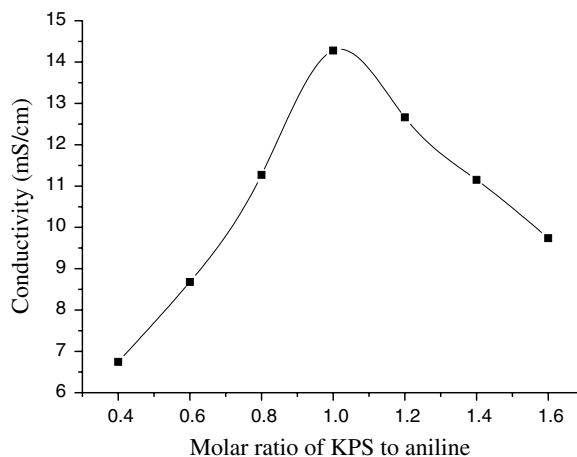
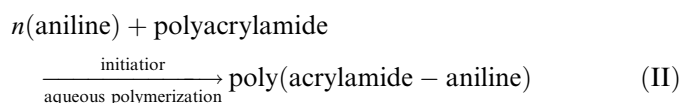
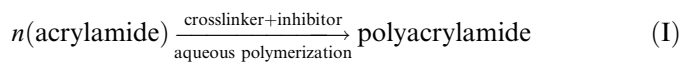


Fig. 6. Variation of molar ratio of KPS to aniline in conducting hydrogel under preparation of mass ratio of PAM to aniline 7.84, aniline concentration 1.25%, reaction temperature 20 °C and time 6 h.

points to construct a polyaniline chain and a conducting channel, and results in the decline of the conductivity of the hydrogel. On the other hand, KPS is not only an initiator, but also an oxidizer, excessive KPS causes a side reaction for oxidizing polyaniline, which results in the devastation of the polyaniline chain to some extent, a conducting channel cannot run through the material effectively, therefore, the conductivity of the hydrogel decreases. According to Fig. 6, the mass ratio of KPS to aniline monomer 1.0 is the better.

3.5. Influence of aniline concentration on conductivity of the hydrogel

The polyaniline chain is formed inside of the polyacrylamide network in aqueous solution system based on the polymerization reaction (reaction I and II). The concentration of aniline affects the reaction (II) and the conductivity of hydrogel. From Fig. 7, it can be seen that the increase of aniline concentration from 0.83 to 1.1 wt% causes the increase of conductivity of the system, beyond the concentration of 1.1 wt%, the conductivity decrease.



According to mass law, a lower aniline concentration causes a slower velocity for the polymerization reaction between aniline monomers, a lower polyaniline yield, and a lower conductivity. On the other hand, due to the osmosis character of aniline monomers and polyacrylamide network, only part aniline monomers penetrate into polyacrylamide network and polymerize to form polyaniline.

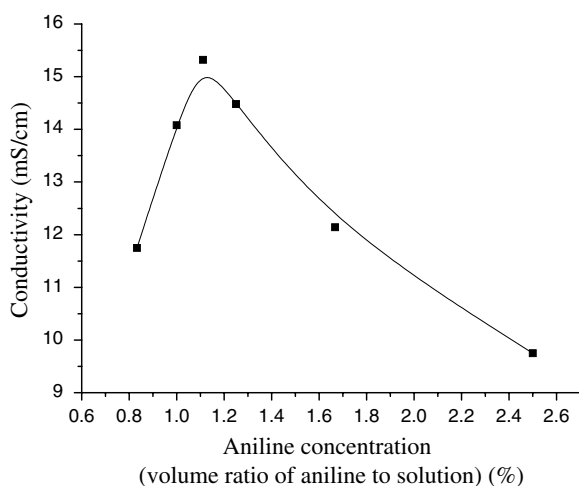


Fig. 7. Variation of aniline concentration in polyacrylamide/polyaniline conducting hydrogel under preparation of mass ratio of PAM to aniline 7.84, molar ratio of KPS to aniline 1.0, reaction temperature 20 °C and time 6 h.

line chain. Under a higher aniline concentration, mostly aniline monomers and oligomer exist outside of polyacrylamide network, and are washed out in the preparation process. Consequently, higher aniline concentrations do not produce a higher polyaniline chain density in the network of polyacrylamide and a higher conductivity. In our experiment conditions with the aniline monomer concentration of 1.1 wt%, the hydrogel possesses the highest conductivity.

3.6. Influence of polyacrylamide on conductivity of the hydrogel

The conductivity of hydrogel depends on the amount of polyacrylamide in the conducting polymer. As is shown in Fig. 8, with the increase of mass ratio of PAM to aniline, the conductivity of the hydrogel increases gradually, and then decreases after reaching a highest conductivity of 17.65 mS cm⁻¹ with mass ratio of PAM to aniline amount of 9.8. As is known, an interpenetrating network is formed by integrating a polyaniline network and a polyacrylamide network. A suitable mass ratio of polyacrylamide to aniline is significant. Obviously, a higher mass ratio of PAM to aniline means lower concentration of aniline which causes the weakening for polyaniline network. A lower mass ratio of PAM to aniline also can not absorb enough aniline monomer inside of polyacrylamide network to construct a suited polyaniline network, due to the osmosis character of aniline monomer and polyacrylamide network. Above two cases can not form an interpenetrating network to conduct electrons and bring to the decrease of conductivity of the hydrogel.

3.7. Influence of reaction temperature and time on conductivity of the hydrogel

The reaction temperature and time is another factor affecting the structure and conductivity of hydrogel. From

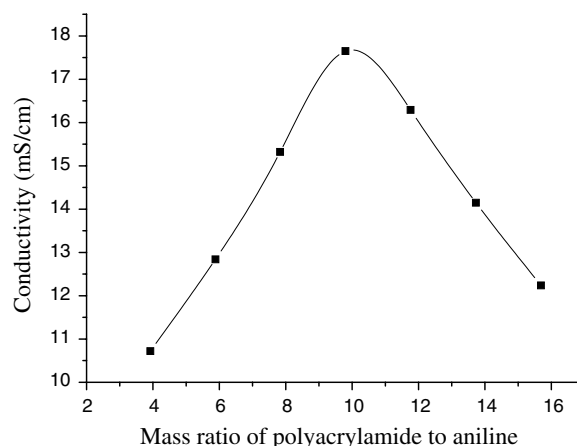


Fig. 8. Variation of PAM amount in conducting hydrogel under preparation of molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, reaction temperature 20 °C and time 6 h.

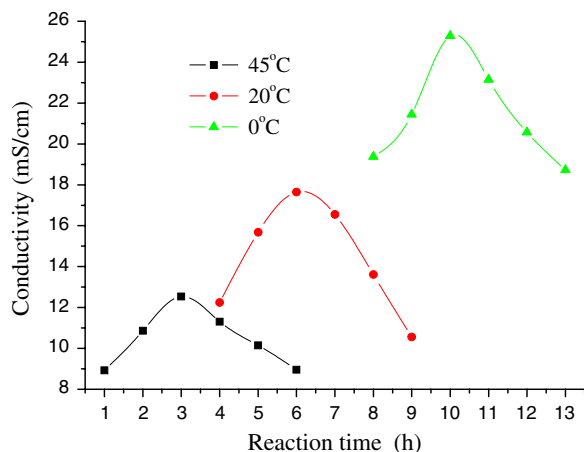


Fig. 9. Variation of reaction temperature and time in conducting hydrogel under preparation of mass ratio of PAM to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%.

Fig. 9, it is obvious to see that the conductivity of the hydrogel increases and then decreases with the reaction time prolonging for three temperature curves, and the higher temperature, the shorter reaction time for reaching the highest conductivity is. Higher reaction temperature resulting in shorter reaction time is accorded with the general rule of polymerization reaction II. High reaction temperature results in the reaction equilibrium move to the left, and occurrence of polyaniline with low molecular weight, short conducting chains i.e., which is the reason of higher conductivities in lower reaction temperature. A longer reaction time brings a side reaction for oxidizing polyaniline, which results in the breakage of the polyaniline conducting network in some extent and decline of the conductivity of the materials.

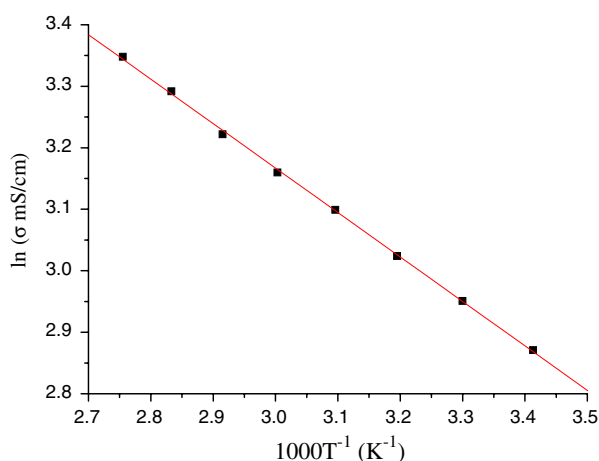


Fig. 10. Variation of temperature in conducting hydrogel under preparation of mass ratio of PAM to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, reaction temperature 20 °C and time 6 h.

3.8. Influence of temperature on the conductivity of hydrogel

The dependence of temperature on the conductivity of hydrogel shows that the conductivity of hydrogel rises with the increase of temperature (Fig. 10). Obviously, this is due to that the electrons move faster under higher temperature than under lower temperature. The conductivity-temperature behavior of the conductive hydrogel can be described by Arrhenius equation.

$$\sigma(T) = A \exp \left[\frac{-E_a}{RT} \right] \quad (1)$$

where E_a is the activation energy, R is the molar gas constant, A is a constant, and T is absolute temperature. According to the experimental data, the E_a is calculated as $6.01 \text{ kJ} \cdot \text{mol}^{-1}$ and the A is 29.22. In our conditions, the reaction is easy to occur for lower activation energy.

3.9. Swelling behaviors responding to temperature

It is well known that the hydrogels with suitable hydrophilic–hydrophobic balance may exhibit thermo-sensitivity, i.e. sharp decrease in volume in aqueous environment with high temperature. Fig. 11 shows the temperature-dependent swelling of poly(acrylamide-aniline) hydrogels when the temperature of the aqueous media increased from 5 to 45 °C. It can be seen that the swelling ratio decreased with the increasing temperature in the region of 30–45 °C. Volume-phase transition of the hydrogel depended on temperature is ascribed to the intramolecular hydrophobic interaction, the H-bonding with water (Dergunov, Nam, Doldina, Nurkeeva, & Shaikhutdinov, 2004), and the porosity (Mahdavinia, Pourjavadi, Hosseinzadeh, & Zohuriaan, 2004) of the hydrogel.

From the thermodynamics aspects, the ΔH that water molecules enter the networks of polymer and cause a hydrogel swelling is negative due to the formation of

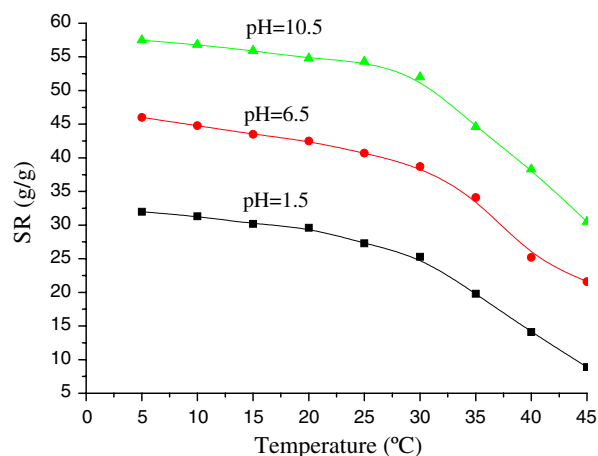


Fig. 11. Dependence of equilibrium swelling ratio of the hydrogels on environmental temperature at different pH values (under preparation of mass ratio of PAM to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, reaction temperature 20 °C and time 6 h).

hydrogen bond, and ΔS for the hydrogel swelling is also negative for the formation of cage structures (Zeng, Liu, & Tong, 1997) and enhancement of the ordered degree of water molecules. According to $\Delta G = \Delta H - T\Delta S$, increasing temperature is disadvantageous for the swelling of hydrogel. If $T = T_C$, $\Delta G = 0$; $T > T_C$, $\Delta G > 0$, which results in a deswelling and a decrease of the hydrogel volume.

3.10. Methylrosaniline chloride loading and release

The poly(acrylamide-aniline) possesses porous-like structure (Fig. 2b) and the property of semipermeable film, which is possible to be used in drug release. Using methylrosaniline chloride with different concentrations as targets, the cumulative release of methylrosaniline chloride at different loading amount were measured and shown in Fig. 12.

Modeling of the controlled release from polymeric devices has been the subject of considerable research over the past 25 years (Stephens, Li, Robinson, Chen, & Chang, 2000). Most of the models have been based on solutions of the Fickian diffusion published in the classic book of Crank (1975). Higuchi derived a simple relationship that described drug release from a matrix as a function of time (Eq. (2)) (Higuchi, 1963).

$$\frac{M_t}{M_\infty} = kt^{1/2} \quad (2)$$

where M_t and M_∞ are the masses of drug released at time equals t and ∞ , respectively. It can be considered that the relative release of the drug is linear with the square root of time.

Peppas extended the Higuchi model to a more generalized form:

$$\frac{M_t}{M_\infty} = kt^n \quad (3)$$

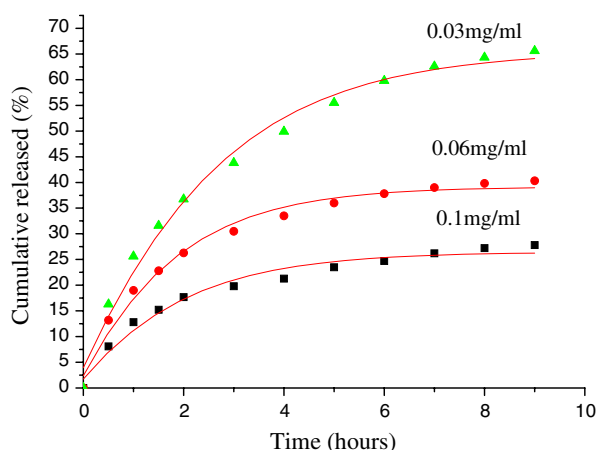


Fig. 12. Effect of methylrosaniline chloride concentration absorbed by the hydrogel on MC release at 25 °C and pH 6.5 (under preparation of mass ratio of PAM to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, reaction temperature 20 °C and time 6 h).

where n is the diffusional exponent. Information about the release mechanism can be gained by fitting the release data (for the first 60% dissolved) and comparing the values of n to the semi-empirical values for various geometries reported by Peppas and Ritger (1987a, 1987b). For a cylindrical geometry, values of n of 0.45 (or less) correspond to a purely Fickian diffusion mechanism. Values of n greater than 0.89 indicate a relaxation controlled-release mechanism, and n values between 0.45 and 0.89 indicate an anomalous release mechanism. Despite the approximations, it has been found that these relationships can be applied to release data, indicating that the diffusion-based models of Higuchi and Peppas describe drug release from a polymeric system quite well.

According to Eq. (3) and Fig. 12, the relationship between $\ln(M_t/M_\infty)$ on $\ln t$ was made and the result is shown in Fig. 13. The diffusional exponent n value for 0.10, 0.06 and 0.03 mg/ml is 0.52, 0.48 and 0.46, respectively. Diffusional exponent n values for poly(acrylamide-aniline) hydrogel with different loading amount between 0.45 and 0.89 indicate an anomalous release mechanism, which may be the cooperate effect results including the methylrosaniline chloride concentration difference between the exterior and the interior of poly(acrylamide-aniline) hydrogel, and the interaction between methylrosaniline chloride and poly(acrylamide-aniline) matrix. The higher n value for higher methylrosaniline chloride concentration indicates that the interaction is enhanced further.

The influence of temperature on drug release was shown in Fig. 14, it can be seen that with the increase of temperature, the cumulative release amount and release velocity increase. This is due to that a higher temperature makes a higher kinetic energy of methylrosaniline chloride molecule and weakens the interaction between matrix and methylrosaniline chloride molecules.

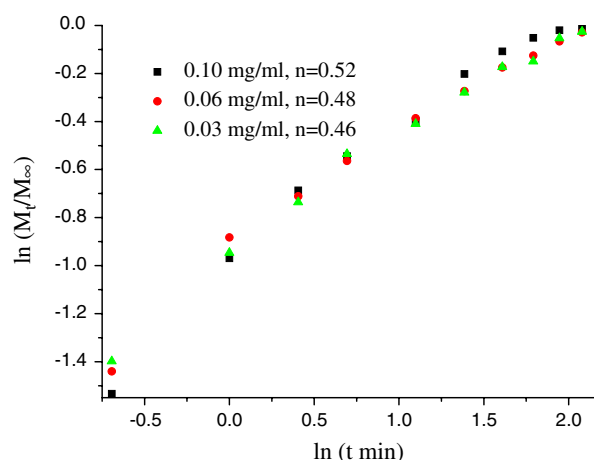


Fig. 13. The relationship of $\ln(M_t/M_\infty)$ – $\ln t$ for poly(acrylamide-aniline) hydrogel with different loading amount.

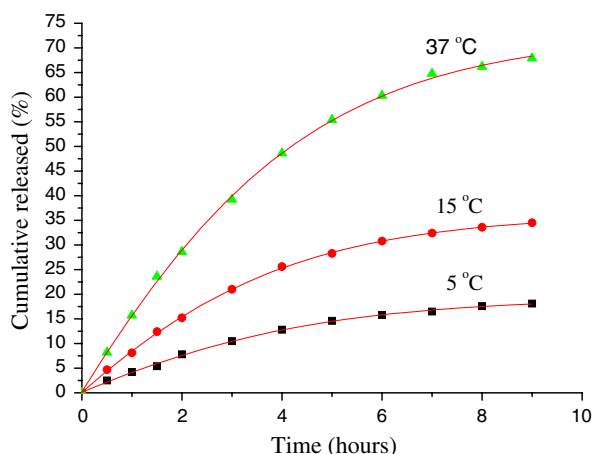


Fig. 14. Effect of different temperatures on MC release at pH of 6.5 and concentration of MC 0.06 mg/ml (under preparation of mass ratio of PAM to aniline 9.8, molar ratio of KPS to aniline 1.0, aniline concentration 1.1%, reaction temperature 20 °C and time 6 h).

4. Conclusions

Poly(acrylamide-aniline) conducting polymer was prepared by a two-steps aqueous polymerization. Firstly, the polyacrylamide superabsorbent polymer was synthesized by a routine aqueous polymerization. Secondly, aniline monomers were absorbed inside of polyacrylamide network followed by a polymerization to form a poly(acrylamide-aniline) polymer. When immersed the polymer in distilled water, a hydrogel with a conductivity of 25.28 mS cm^{-1} was obtained.

An interpenetrating networks structure model with a three-dimensional network of polyacrylamide and a one-dimensional chain of polyaniline for poly(acrylamide-aniline) conducting hydrogel was proposed. The Arrhenius behavior of conductivity for the hydrogels suggested that the conduction was due to charge carriers (protons) hopping along the polyaniline chain.

Based on the porous-like structure, poly(acrylamide-aniline) hydrogels possess loading and releasing properties. Diffusional exponent n values for poly(acrylamide-aniline) hydrogel between 0.45 and 0.89 indicate an anomalous release mechanism, which may be due to the concentration difference between the exterior and the interior of poly(acrylamide-aniline) hydrogel, and the interaction between methylrosaniline chloride and poly(acrylamide-aniline) matrix.

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