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Swelling Characterization of Nanocomposite Hydrogels of Poly (acrylamide-N-vinylimidazole)

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Abstract

In this study, a hydrogel composed of acrylamide (AAm) with N-vinylimidazole (NVI) as co-monomer, with a cross-linker such as N, N` Methylenebisacrylamide and potassium peroxodisulfate as an initiator solution was prepared. Poly (AAm/NVI) hydrogels were synthesized by free radical solution polymerization. Swelling experiments were performed in water at 25°C, gravimetrically. Here, it was of interest to increase the water absorption capacity of AAm hydrogels with add VI. AAm is a highly hydrophilic monomer, and VI monomer is neutral. The one purpose of this study is to combine both monomers in one polymer. In this respect, a series of hydrogels was synthesized by changing the content of AAm and VI. Then, some swelling of these hydrogels was studied in water.

Keywords: *Swelling, Hydrogel, Acrylamide, N-vinylimidazole.*

Introduction

Hydrogels are cross-linked, macromolecular polymer networks immersed in a solvent, synthesized to exhibit large volumetric swelling in response to a variety of environmental stimuli. They are cross-linked polymeric structures that are able to swell in the aqueous environment. In order to keep the spatial structure, the polymer chains are usually physically or chemically cross-linked [1–7]. Hydrogels are a unique class of polymeric materials, which imbibe enormous amount of water when left in a water reservoir for long times. After intimate contact is established, the rate and duration of drug release depends on the swelling behavior of the hydrogel [1–7].

For potential release property of the hydrogels, the desired mechanical properties must be delivered. For this, the amount of crosslinking agent and the synthesis conditions could be

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investigated. The mechanical properties of hydrogels may be improved by preparing polymer networks, when the hydrogel network is prepared in the presence of a previously made polymer, such polyacrylamide, poly (vinylpyrrolidone), etc. [1, 8-10].

In this study, it was of interest to increase the water absorption capacity of AAm hydrogels with vinyl functional groups containing chemical reagents such as NVI via free radical solution polymerization method. It was reported that some groups has been synthesized NVI based cross-linked polymers, or copolymers and some sorption studies of it [11-13]. Here, in this work we investigated the incorporation of a vinyl chemical such as NVI into AAm hydrogel during free radical solution polymerization synthesis by using different a 3 series of nanocomposite poly (AAm-VI) hydrogels was synthesized with 3 compositions different; 25:75, 50:50, 75:25 of AAm: VI.

AAm is a highly hydrophilic monomer, and NVI monomer is neutral [14-16]. The main purpose of this study is to combine both monomers in one polymer. In this respect, a series of copolymeric hydrogels was synthesized by changing the content of NVI. Then, some swelling, properties of these hydrogels were studied in water by dynamic swelling studies for swelling characterization.

Materials and methods

Highly swollen poly (acrylamide (AAm)/N-vinylimidazole (NVI)) hydrogels; (Aldrich, Steinheim, Germany) were prepared by free radical solution polymerization in aqueous solution of AAm monomer (Merck, Darmstadt, Germany) with NVI (Fluka, Steinheim, Germany) as comonomer and a multifunctional crosslinker such N,N`-Methylenebisacrylamide (Aldrich, Chemical Co. Milwaukee, USA). The initiator, potassium peroxodisulfate were also supplied by Merck. To prepare highly swollen poly (AAm/NVI) hydrogel systems, AAm weighing 1 g was dissolved in 1 ml aqueous solutions containing 0, 20, 40, 60, and 80 mg NVI. AAm weighing 1 g was dissolved in 1 ml aqueous solutions containing 60 mg NVI. Poly (AAm/NVI) hydrogels were accurately weighted and transferred into water. Water uptake with respect to time was obtained by periodically removing the samples from water; and reweighing. The measurements were conducted at 25 °C in water.

For the swilling test, each of the synthesized samples of poly (AAm) and poly (VI) hydrogels and nanocomposite poly (AAm-VI) were accurately weighted than transferred into distilled water. Swelling a period time was obtained. The measurements carried out in at constant temperature (25◦C). The sample, were taken out from the water, and weighed. It was observed that swelling increase with time up to certain level, then reaching a weight balance, then it will not increase weight samples.

Results and discussion

Equilibrium swelling studies a fundamental relationship exists between the swelling of a polymer in a solvent and the nature of the polymer and the solvent. The swelling, (S) of the hydrogels in distilled water was calculated from the following relation (Peppas, 1986):

$$S= \frac{W_t-W_0}{W_0}$$

Where W_t is the mass of the swollen gel at time *t* and W_0 is the mass of the dry gel at time 0. Diffusion characteristics, kinetic parameters, etc. were calculated by using swelling data. The water intake of initially dry hydrogels was followed for a period of time, gravimetrically. Swelling isotherms of poly (AAm/NVI) hydrogels were constructed and representative swelling curve is shown in Figure 1.

Figure 1 shows that swelling increases with time up to certain level, then levels off. This value of swelling may be called as the equilibrium swelling (Seq). Hydrophilicity of poly (AAm/NVI) copolymers becomes greater than that of AAm, so, the swelling of poly (AAm/NVI) copolymers is greater than the swelling of AAm hydrogels. The swelling capacity (S) of the hydrogels in distilled water was calculated from the following relation:

$$S= \frac{W_t-W_0}{W_0}$$

Where W_t is the mass of the swollen sample at time *t* and W_0 is the mass of the dry sample at time 0. Swelling isotherms of poly (AAm) and poly (VI) hydrogels and poly (AAm-VI) nanocompositewere constructed and representative swelling curve is shown in Figure1. Figure 1 shows that swelling increases with time up to certain level, then levels off. In this work we investigated: that poly (AAm) is a highly swelling capacity than of poly (VI). Also nanocompositepoly (AAm-VI) showed large extents of swelling in water. Swelling and hydrophilicity of poly (AAm-VI) with composition 75:25 of AAm:VI nanocomposite is greater than the swelling of AAm hydrogeles. Swelling capacity of nanocomposite being highly dependent on chemical composition, and increases swelling capacity of nanocomposite by increases the amount of acrylamide in the samples.

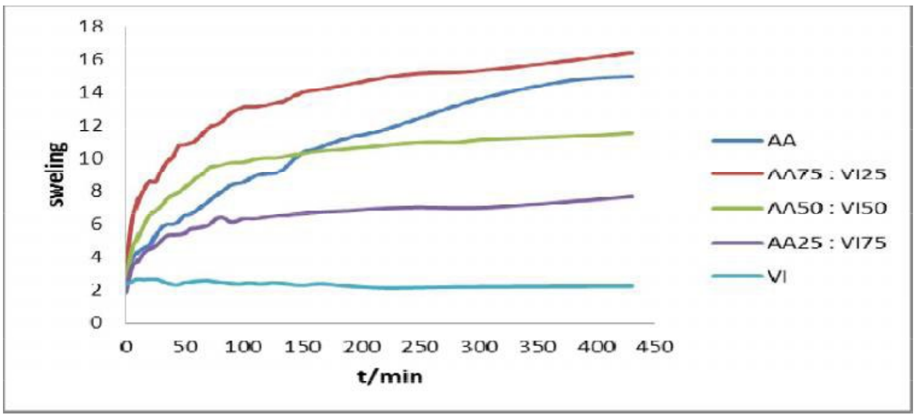

Figure 1. Swelling isotherms of poly (AAm-VI) hydrogels.

Conclusions

The present work has given the quantitative information on the swelling characteristic of poly (AAm/NVI) hydrogel. Incorporation of hydrophilic group containing chemical such as NVI and a poly AAm hydrogels has been obtained successively by free radical solution polymerization method. The hydrogels showed high water absorbency. It was seen that swelling of poly (AAm/NVI) hydrogel increased with the increasing of content of NVI. The results of swelling kinetics characterization are behaved as the parallel to the results of swelling characterization. Especially, Seq (theoretical) or Seq is increased with NVI content.

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