

Mechanical and Morphological Properties of Polyacrylamide and Methylcellulose Hydrogels

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Abstract – This paper describes the mechanical and morphological characterization of polyacrylamide and methylcellulose (PAAm-MC) hydrogels synthesized with different formulations by the free radical polymerization method. Results showed that these properties can be controlled by varying the acrylamide (AAm) and methylcellulose (MC) concentration. Increase of AAm concentration causes a pronounced decrease in porosity, and an increase in mechanical properties (maximum load and modulus of elasticity). Furthermore, increasing the MC concentration caused an increase in porosity, but decrease in maximum load and elasticity modulus because of the increase in the hydrogel hydrophilicity due to incorporation of hydroxyl groups from MC chains.

Polyacrylamide (PAAm) has been used successfully as a basic material for the preparation of hydrogel [1] with good mechanical properties and high swelling degree. Methylcellulose (MC), a water-soluble polysaccharide, can be chemically crosslinked with dialdehyde in the presence of a strong acid to generate a hydrogel [2]. However, hydrogels based on MC have poor mechanical properties that limit their applications. The synthesis of MC hydrogels within a matrix with good mechanical properties, for example PAAm matrix, is a good alternative to minimize this limitation.

In this report, we prepare hydrogels based on PAAm and MC by the free radical polymerization method using *N,N,N',N'*-tetramethylethylene-diamine as catalyst agent and sodium persulfate as initiator. The copolymerization crosslinking reactions of acrylamide (AAm) monomer and *N,N'*-methylene-bis-acrylamide (MBAAm) crosslinker (% molar concentration fixed in relation to AAm) were carried out in aqueous solutions containing MC.

From Figure 1 it was possible to observe that the mechanical property maximum load (σ_{max}) of the PAAm-MC hydrogels can be controlled by varying the AAm and MC content where σ_{max} increased when the AAm concentration was increased or when MC content was decreased. This trend is attributed to the increase of network rigidity, where the flexibility of a hydrogel network is directly related with the amount of total water absorbed by the hydrogel. The Elasticity modulus (E) presented the same dependence; therefore their results were not shown. Three-dimensional network porous structures were analyzed using scanning electron microscopy (SEM). The open spaces (pores) among the polymer network decreased when high polymer concentration was used for the hydrogel preparation. Hydrogels with large pores (Figure 2a) have a greater interaction with water molecules that result in large water-uptake, but lower mechanical properties. In contrast, as shown in Figure 2b, hydrogels with high AAm concentration have a tighter structure with smaller pore sizes. In this condition, the pores area in contact with water molecules is smaller, which contributes to decreasing water-uptake capacity and increasing the mechanical properties.

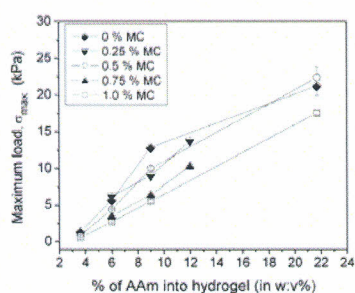


Figure 1: Dependence of maximum load as a function of AAm concentration of different PAAm-MC hydrogels formulations.

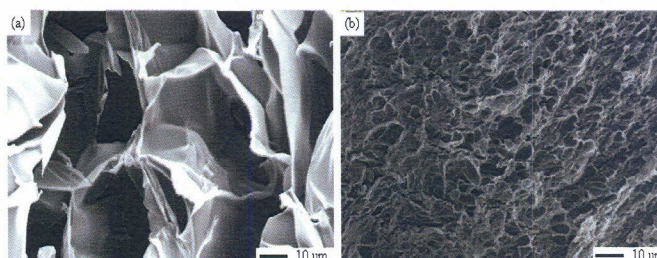


Figure 2: SEM micrographs of hydrogels: (a) AAm = 3.6 % AAm (w:v%), $\sigma_{max} = 1.35 \pm 0.14$ kPa and $E = 1.85 \pm 0.08$ kPa, (b) AAm = 21.7 % AAm (w:v%), $\sigma_{max} = 21.25 \pm 1.32$ kPa, and $E = 27.50 \pm 1.11$ kPa. Micrographs were obtained at 1,000 X magnification.

References

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