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Polyvinyl Alcohol/Egg White/Na-Montmorillonite Nanocomposite Hydrogels

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Abstract
A series of nanocomposite hydrogels based on egg white and polyvinyl alcohol containing 0, 5, 10 and 15 wt % of Na-montmorillonite nanoclay were prepared by freezing- thawing method. The morphology, gel fraction, swelling ability and dynamic mechanical properties of the prepared nanocomposite hydrogels were investigated. The results showed that the prepared nanocomposite hydrogel have an exfoliated morphology. It was shown that by increasing the Na-MMT loading level, the gel fraction and the storage modulus of nanocomposite hydrogels are increased while their swelling capability decreased.

Keywords: Nanocomposite Hydrogel- Polyvinyl Alcohol- Egg White- Montmorillonite.

Introduction
In recent years, several investigations have been done to improve the properties of polymeric hydrogels by adding nanoparticles such as clays to reach the nanocomposite hydrogels with improved physical, chemical and mechanical properties [1]. Nanocomposite hydrogels are three dimensional networks consisting of matrix phase and at least one nanometric reinforcing phase [2,3]. Due to the non-biocompatibility of some nanocomposite hydrogels, special attentions have been recently paid on production of nanocomposite hydrogels using the biocompatible materials. In this work, nanocomposite hydrogels on the basis of polyvinyl alcohol (PVA) and egg white were prepared using Na-Montmorillonite (Na-MMT) as crosslinker. The morphology, swelling behavior, gel fraction and dynamical properties of the prepared nanocomposite hydrogels were investigated.

Experimental
The clay suspensions were prepared by well mixing of Na-MMT in double distilled water. Then adequate amounts of egg white were added to the suspensions and mixed at room temperature for four hours. The PVA solutions were separately prepared with mixing PVA granules in double distilled water for four hours at 90 °C. Subsequently, the egg white-clay suspensions were mixed with PVA solutions at room temperature for one hour. The prepared solutions poured in plastic molds and placed at -20 °C for 24 hours to induce gel formation. After freezing, the sample placed at room temperature for 24 hours. The freezing- thawing cycle was repeated three times for each sample. All final samples had 10 wt% of PVA, 37 wt% (based on the mass of wet hydrogel) of egg white and different loading levels of Na-MMT, i.e. 0, 5, 10 and 15 wt% (based on the mass of completely dried hydrogel).
The morphology of prepared nanocomposite hydrogels was examined with X- ray diffractometry (XRD). In order to determine the effect of Na-MMT on the crosslinking of the hydrogels, the gel fraction test was performed. The swelling capabilities of the prepared nanocomposite hydrogels were investigated by measuring the swelling kinetics at 37 °C. Dynamic mechanical-thermal analysis (DMTA) was carried out using a Rheometrics dynamic mechanical analysis. The analysis was performed at a scan rate of 5 °C/min, in the temperature range from -50 to 150 °C at a frequency of 1 Hz.

Results and discussion
The XRD profiles of Na-MMT and two typical nanocomposite hydrogels containing 5 and 15 wt% of Na-MMT (EV5 and EV15) have been shown in Fig. 1. A characteristic diffraction peak around 7.6° is observed for Na-MMT powder. As shown in Fig. 1 this peak has been disappeared in VE5 and VE15 nanocomposite hydrogels. Therefore, the prepared nanocomposite hydrogels has an exfoliated morphology.

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Figure 2 shows that the nanocomposite hydrogels have higher gel fraction values compared with the pure PVA/egg white hydrogel and the gel fraction value increases by increasing the amount of Na-MMT. This infers the development of interactions between Na-MMT layers and egg white/PVA matrix and shows the role of Na-MMT layers as crosslinker in the structure of nanocomposite hydrogels.

The swelling ratio curves versus time are shown in Fig. 3. Swelling ratios of all hydrogels were increased with prolonged time. It is also observed that an increase in Na-MMT content causes a decrease of the swelling ratio of nanocomposite hydrogels.

The DMTA curves have been demonstrated in Fig. 4. It can be seen that both in glassy and rubbery states, nanocomposite hydrogel (EV15) has higher modulus compared with the pure PVA/egg white hydrogel (EV0), which reveals of the reinforcing effect of Na-MMT in the PVA/egg white/Na-MMT nanocomposite hydrogels.

Conclusion

In this study, nanocomposite hydrogels on the basis of PVA/egg white and Na-MMT nanoclay were prepared. XRD results showed an exfoliated morphology for prepared nanocomposite hydrogels. The gel fraction and swelling tests revealed the interaction development among the egg white/PVA matrix and Na-MMT layers which shows the creation of crosslinked sites in the nanocomposite hydrogels. DMTA experiment demonstrated the reinforcing effect of Na-MMT in the matrix of nanocomposite hydrogels.

References

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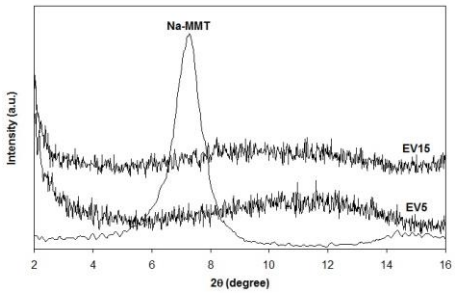

Fig. 1. XRD Profiles of Na-MMT and two typical nanocomposite hydrogels, EV5 and EV15.

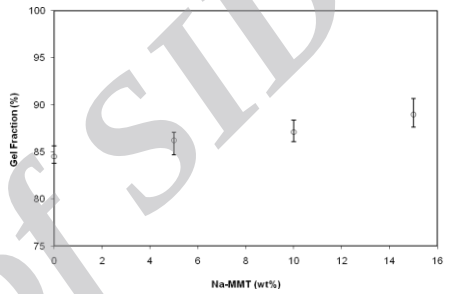

Fig. 2. The effect of Na-MMT loading on the gel fraction values of hydrogels.

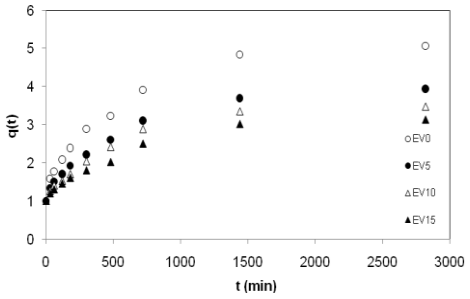

Fig. 3. Swelling ratio (q) curves of hydrogels vs time at swelling temperatures of 37 °C.

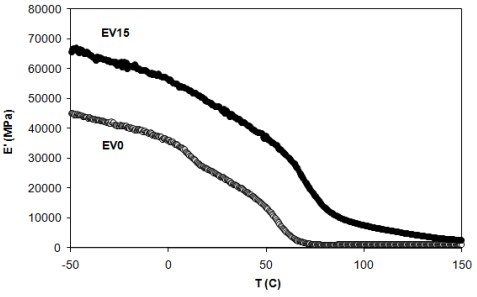

Fig. 4. Storage modulus curves of EV0 and EV15 samples.