

Preparation and Characterization of Polyvinyl Alcohol-Polyethylene Oxide-Carboxymethyl Cellulose Blend Membranes

Bhuvanesh Gupta,¹ Roopali Agarwal,^{1,2} M. Sarwar Alam²

¹Department of Textile Technology, Bioengineering Laboratory, Indian Institute of Technology, New Delhi 110016, India

²Department of Chemistry, Jamia Hamdard, Hamdard Nagar, New Delhi 110062, India

Correspondence to: B. Gupta (E-mail: bgupta@textile.iitd.ernet.in)

ABSTRACT: In this study, blends of poly(vinyl alcohol) (PVA) and poly(ethylene oxide) (PEO) were prepared by solution casting method to develop membranes. The addition of carboxymethyl cellulose (CMC) led to the stabilization of PVA and PEO blend system. PVA/PEO/CMC membranes of three compositions 90/10/5, 90/10/10, and 90/10/20 were prepared and were characterized by X-ray diffraction (XRD), thermogravimetric analysis, differential scanning calorimetry (DSC), and attenuated total reflectance-Fourier transform infra-red. It was found that the addition of CMC to PVA/PEO blend leads to significant visible changes in the miscibility of these two components. Swelling of blend membranes increased with the increase in concentration of CMC. The thermal stability and mechanical strength of the blended samples increased with increasing CMC content when compared with pure PVA and PVA/PEO blends. XRD and DSC showed decrease in crystallinity with the increase in CMC content. © 2012 Wiley Periodicals, Inc. *J. Appl. Polym. Sci.* 000: 000–000, 2012

KEYWORDS: polyvinyl alcohol; polyethylene oxide; carboxymethyl cellulose; miscibility; hydrogels

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INTRODUCTION

Hydrogels belong to one of the most interesting group of polymeric materials due to their distinctive properties such as swellability, hydrophilicity, biocompatibility, and lack of toxicity. These are used for many biomedical applications such as wound dressings, artificial skin, artificial tendon materials, artificial kidney membranes, and drug delivery.¹ These can be prepared by freeze–thawing, irradiation, chemical methods, or blending process. The blending of polymers is an interesting means for obtaining materials having required mechanical properties when compared with the pure components and offers simple route to develop materials having various shapes.^{2,3}

Poly(vinyl alcohol) (PVA) is a water-soluble semicrystalline polymer, which is used in several biomedical applications because of its favorable properties such as nontoxicity, biocompatibility, hydrophilicity, strength, chemical resistance, and good film and fiber forming ability.^{1,4–9} The chemical structure of PVA favors the formation of intramolecular hydrogen bonding; thus, it is used in the preparation of membranes and hydrogels. The films of PVA in combination with natural polymers such as chitosan, sodium alginate (SA), xylan, gelatin, and synthetic polymers, such as poly(ethylene oxide) (PEO), polyvinyl pyrroli-

done (PVP) have been investigated for several biomedical applications.^{7–13}

Yoshii et al.⁷ prepared PVA-PEO hydrogel wound dressing by electron beam irradiation and found that the material provides moist environment to wound and showed quicker healing in comparison with the gauze dressing. PVA and SA hydrogel matrix-based wound dressing systems containing nitrofurazone was synthesized by Kim et al.⁹ using freeze–thaw method and observed better healing effect. In one of the studies, crosslinked hydrogel films containing drug were prepared with PVA and sodium carboxymethyl cellulose (Na-CMC) using freeze–thaw procedure and found that it had given an enough level of humidity on the wound region.^{14,15} The physically crosslinked PVA hydrogel has been used as drug delivery vehicles as well.¹⁶ Hong et al.¹⁷ observed that the heat-treated electrospun PVA/silver nitrate fiber web was an excellent material for wound dressings as it had tremendous antimicrobial ability.

PEO is a hydrophilic semicrystalline polyether that exhibits biocompatibility, nontoxicity, nonpolarity, nonantigenicity, and nonimmunogenicity.¹⁸ For these reasons, PEO hydrogels are used as wound dressings, hemodialysis membrane, and drug delivery vehicles.^{7,19,20} CMC is a ether derivative of cellulose in

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which H atoms of hydroxyl groups are replaced by carboxymethyl groups ($-\text{CH}_2\text{COOH}$).²¹ It is often used as its sodium salt, Na-CMC, and exhibits pH sensitivity.²² It is used in various biomedical applications primarily due to its easy availability, high viscosity, good water solubility, nontoxicity, low price, and biocompatibility.²¹ It is expected that ether groups of PEO will form hydrogen bonds or interact with the hydroxyl groups of PVA. However, it is found that PVA/PEO blend solution shows phase separation in aqueous medium and form immiscible blends.^{23–25} It has been found that PVA and PEO are immiscible systems that do not have a tendency for extensive mutual solubility. Sawatari et al.²⁶ also reported that PVA having only secondary hydroxyl groups cannot interact with the skeletal oxygen on PEO. Therefore, to prepare miscible blends of PVA and PEO, a cellulose derivative can be used as a compatibilizer; this idea is also supported from studies that a cellulose derivative form miscible or partially miscible blends with both crystalline synthetic polymers PVA and PEO at the molecular level.^{27–29} The miscibility between PVA and CMC presumed to be due to the capability of the two polymers, having abundant hydroxyl groups, to interact through hydrogen bonding.³⁰ It is also reported that cellulose is miscible with both PVA and PEO.^{30–32} Kondo et al.²⁸ proposed the mechanism for the development of interaction in the cellulose/PEO blend and showed that the hydrogen bonding between the hydroxyls of C6 position of cellulose and ether oxygen in PEO is more favorable. Thus, it may also be deduced that these hydrogen bonding interaction between PVA/CMC and PEO/CMC contributes to the enhancement of miscibility between the present blend systems. So, the system of interest here is the influence of CMC on the miscibility in blends of PVA and PEO.

This study is confined to the preparation of membranes of PVA/PEO/CMC by solution casting method and to study the influence of CMC on the miscibility of blends of PVA/PEO by attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and X-ray diffraction (XRD). The mechanical strength, water vapor transmission, swelling behavior, and swelling kinetics of the blend membranes are also presented in this study.

EXPERIMENTAL

Materials

PVA (degree of polymerization 1700–1800 and molecular weight 1,15,000) and CMC sodium salt of high viscosity were received from Loba Chemie Pvt. Ltd., Mumbai, India. Poly(ethylene oxide) (PEO) of molecular weight 3,00,000 was supplied by Sigma Aldrich India. Deionized water was used for all experiments.

Preparation of PVA/PEO Blend Membranes

PVA was dissolved in deionized water under constant stirring at 70°C to achieve homogeneous solution. PVA solution was brought to the room temperature and then casted on a Petri dish. The drying was carried out at room temperature, and the membrane was dislodged carefully and then kept for further drying in vacuum oven for 2 h at 80°C.

Blend solutions having PVA/PEO in the ratio 90 : 10 (w/w) and different concentrations of CMC were prepared using deionized water as solvent. CMC was added in different amounts to the PVA/PEO solution using magnetic stirrer for 8 h at 70°C. The total polymer concentration was maintained to be 5% by weight. After complete dissolution, the blend solutions were used to prepare blend membranes by casting on Petri dish as followed for pure PVA membrane preparation.

Miscibility Studies

The transparency of pure polymer solutions and blend solutions having different concentrations of CMC was measured by UV-Vis spectrophotometer (Perkin Elmer Lambda 35 UV-Vis Spectrophotometer). The percentage transmittance of solutions was measured in the range of 300–900 nm. The surface morphology of the blend membranes was observed by light microscopy using a Nikon Eclipse E200 microscope and analyzed.

Attenuated Total Reflectance-Fourier Transform Infra Red Spectroscopy

ATR-FTIR spectroscopy of thin membranes of samples was recorded on a Perkin-Elmer spectrophotometer in the wave number range of 650–4000/cm in a transmittance mode.

Density Measurements

Density of the samples was measured by taking into account the thickness of membranes of exact size by thickness tester and by measuring the weight of the sample on an analytical balance. The density was obtained by the following expression.³³

$$\text{Density} = \frac{\text{Weight(g)}}{\text{Volume(cm}^3\text{)}} \quad (1)$$

Differential Scanning Calorimetry

The DSC studies on the samples were carried out on a Perkin-Elmer DSC-7 system. Vacuum-dried samples were loaded, and the thermograms were run in the -50°C to 350°C range under nitrogen atmosphere at a heating rate of $10^\circ\text{C}/\text{min}$. The melting temperature was obtained as the peak of the thermogram. The heat of fusion (ΔH_f) was obtained from the area under melting thermograms. The crystallinity of samples is obtained by the following expression.³⁴

$$\text{Crystallinity(\%)} = \frac{\Delta H_f}{\Delta H_{f(\text{cryst})}} \times 100 \quad (2)$$

where ΔH_f is the heat of fusion of the sample and $\Delta H_{f(\text{cryst})}$ is the heat of fusion of 100% crystalline PVA, i.e., 156 J/g ³⁵ and PEO, i.e., 197 J/g .³⁶

In high-temperature DSC, all samples were heated at a range of 50 – 150°C at a heating rate of $10^\circ\text{C}/\text{min}$, kept 5 min at 150°C , cooled to 50°C at the same rate, and kept for 5 min at 50°C . Then, the samples were reheated from 50 to 350°C . The first heating scan, which was carried to remove the residual water and the second scan, was carried out to see the transition. In low-temperature DSC, samples were heated from 30 to 120°C at a heating rate of $10^\circ\text{C}/\text{min}$, kept 5 min at 150°C , cooled to -50°C at the same rate, and kept 5 min at -50°C . Then, samples were re-heated from -50 to 230°C at the same rate.

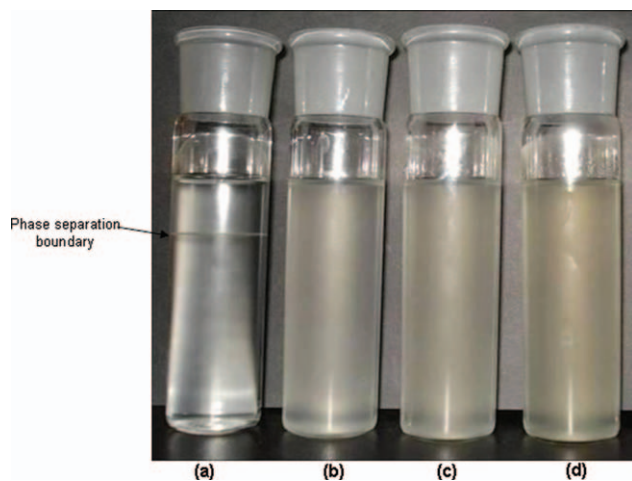


Figure 1. Solutions of PVA : PEO in ratio 90 : 10 and variable amount of CMC. (a) No CMC, (b) 5% CMC, (c) 10% CMC, and (d) 20% CMC.

X-ray Diffraction

XRD patterns of the samples were recorded in the 2θ range of $5\text{--}40^\circ$ on a Phillips X-ray diffractometer equipped with a scintillation counter. $\text{CuK}\alpha$ radiation (wavelength, 1.54 \AA ; filament current, 30 mA; voltage, 40 kV) is used for the generation of X-rays. The degree of crystallinity of samples was assessed from the X-ray diffraction pattern by separating the amorphous and crystalline parts under the diffraction pattern using following expression.³⁴

$$\text{Degree of Crystallinity} = \frac{A_{\text{cr}}}{A_{\text{cr}} + A_{\text{am}}} \times 100 \quad (3)$$

where A_{cr} is the area under crystalline peak and A_{am} is the area under amorphous portion.

Thermogravimetric Analysis

The thermal stability of the samples was evaluated by TGA performed on a Perkin-Elmer TGA-7, using a nitrogen stream as purge gas, at a heating rate of $10^\circ\text{C}/\text{min}$ in the range of $50\text{--}600^\circ\text{C}$.

Mechanical Properties

The tensile strength of membranes was determined using a tensile test machine (Tinius Olson tester). The samples for the tensile test were prepared by drying them at 80°C in a vacuum oven for 4 h. The membranes with different concentrations of CMC were carefully cut into specific shape (40-mm long and 6-mm wide). The mechanical analysis was performed by mounting the samples on mechanical gripping units leaving a gauge length of 25 mm at a stretching rate of 15 mm/min to determine the maximum load for each matrix. The thickness of each individual sample was also measured. Five samples were tested for each condition.

Swelling Measurements

A parameter for hydrogel swelling is percentage equilibrium solvent content (ESC%), which can be calculated from following equation.³⁷

$$\text{ESC}(\%) = \frac{W_s - W_o}{W_s} \times 100 \quad (4)$$

where W_o and W_s are the weight of dry sample and swollen sample, respectively.

The dynamic swelling measurement of sample having PVA : PEO : CMC in ratio 90 : 10 : 20 was carried out by weighing the dried sample and swollen sample at different time intervals before and after immersing in phosphate buffer (PBS) of pH 7.4 at 37°C . The swelling was calculated using following equation.³⁷

$$\text{Swelling } \% = \frac{W_s - W_d}{W_d} \times 100 \quad (5)$$

where W_d and W_s are the weight of dry and swollen membranes, respectively.

RESULTS AND DISCUSSION

The PVA/PEO blended membranes were prepared by mixing these two polymers in aqueous medium. It is observed that the blends of PVA with PEO result in the formation of opaque solution that subsequently leads to the phase separation [Figure 1(a)]. This shows intrinsic incompatibility of the two polymers. However, addition of CMC follows significant visible changes in the miscibility of these two components, in the form of single-phase system. The compatibility in the blend increased as the CMC concentration increased from 5 to 20%. Xiao et al.²⁷ also observed that CMC and PVA form homogeneous solution, but CMC and PEO mixing showed microphase separation. Therefore, it can be stated that CMC addition leads to some interaction between two polymers and makes solution more miscible. This miscibility between polymers may be due to the formation of hydrogen bonds between the hydroxyl groups of CMC with ether groups of PEO and hydroxyl groups of PVA.

It can be clearly seen in Figure 2 that PVA solution possessed high diaphaneity, and the percentage transmittance was approximately 100% at 900 nm. The addition of CMC from 5 to 20%

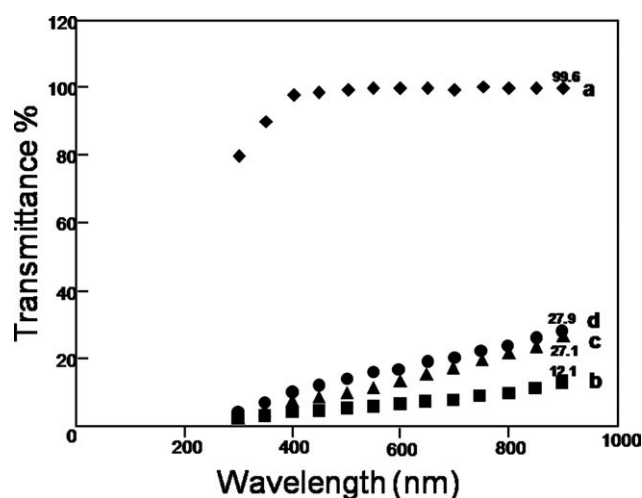


Figure 2. Transmittance percent of (a) pure PVA and blend solutions having PVA : PEO : CMC in ratios (b) 90 : 10 : 5, (c) 90 : 10 : 10, and (d) 90 : 10 : 20.

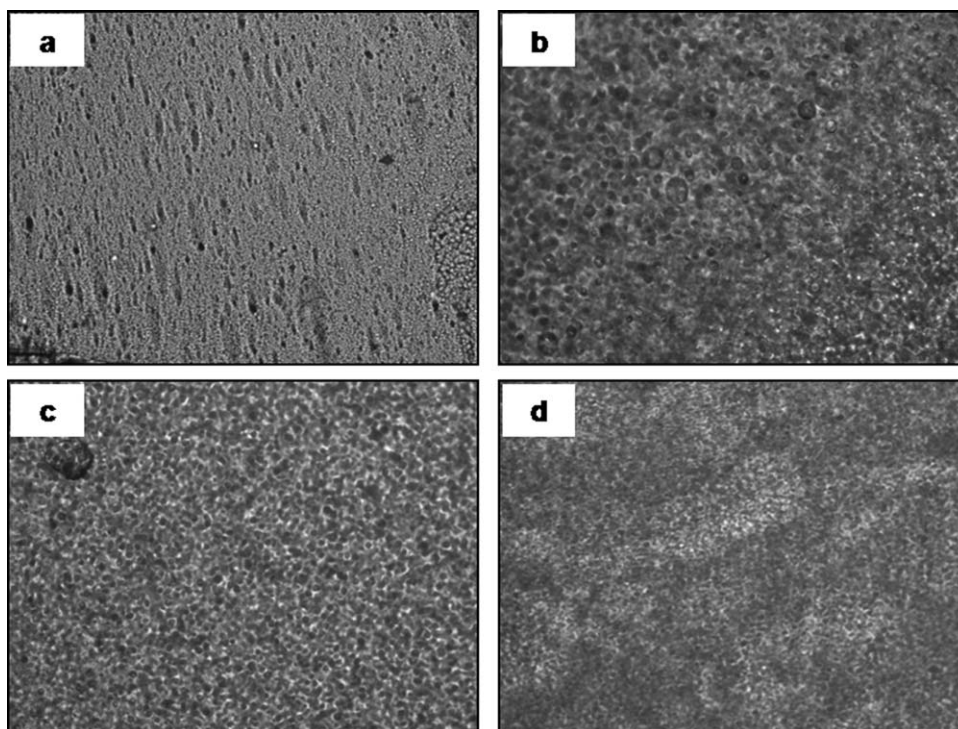


Figure 3. Optical micrographs of samples having PVA : PEO in ratio 90 : 10 and variable amount of CMC (a) no CMC, (b) 5% CMC, (c) 10% CMC, and (d) 20% CMC (magnification 40X).

to PVA : PEO (90 : 10) blend improves the transmittance value from 12 to 28%. Thus, it can be concluded from Figure 2 that CMC addition led to some interaction between the pure polymers and make the blend solution more miscible. This miscibility between polymers that lead to higher transmittance % may be due to the formation of hydrogen bonds between the hydroxyl groups of CMC with ether groups of PEO and hydroxyl groups of PVA. It is also observed from the optical micrographs in Figure 3 that PEO addition induces phase separation in PVA membrane due to restricted interaction between PVA and PEO components, which is reflected in the porosity development as well. The CMC addition to PVA/PEO makes significant alteration in the surface morphology of these membranes. It is interesting to see that PVA/PEO membrane exhibited elongated porous structures [Figure 3(a)], while the pores in PVA/PEO/CMC membranes turn more toward spherical morphology [Figure 3(b–d)]. The higher the CMC content, the denser is the membrane. This suggests that CMC acts as compatibilizer for PVA/PEO. It may be proposed that CMC interacts with PVA in a different fashion than the PEO interaction.^{28,30} CMC forms strong hydrogen bonding with PVA, while the interaction of CMC with PEO is limited. As a result, the phase separation of PEO within PVA/PEO matrix, which was earlier there, is reduced, and the system becomes more compatible and leads to the pores morphology changes from elongated to spherical.

The ATR-FTIR spectrum of PVA, PEO, CMC, and the blend membrane with 20% CMC have been presented in Figure 4. PVA shows peak at 2933/cm for C–H alkyl stretching band. A broad peak at 3287/cm corresponds to the hydrogen bonded

hydroxyl groups. A peak at 1140/cm is due to crystallinity of PVA and is associated to carboxyl stretching band (C–O).³ The peaks at 1706 and at 1087/cm may be attributed to the stretching vibration of C=O and C–O of the remaining nonhydrolyzed vinyl acetate group of the PVA,³⁸ rocking vibration peaks of –CH₂ appeared at 913 and 843/cm.³⁹ The spectrum of pure PEO shows the stretching of ether groups from 1057 to 1143/

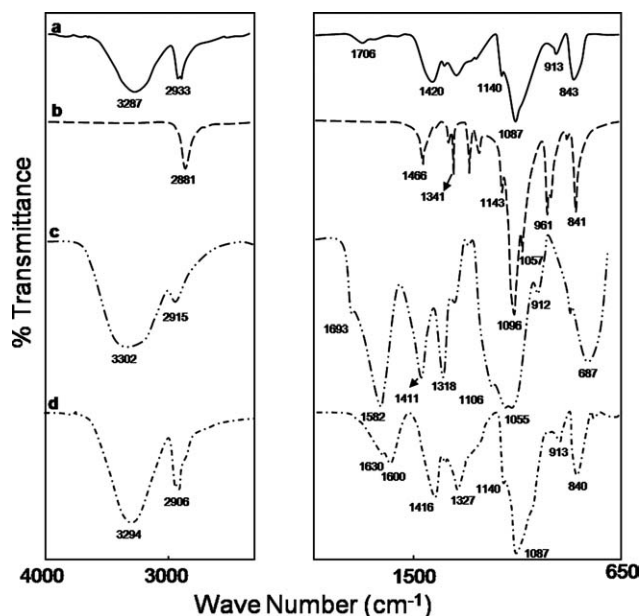


Figure 4. ATR-FTIR of (a) PVA, (b) PEO, (c) CMC, and (d) blend sample having PVA : PEO in ratio 90 : 10 and 20% CMC.

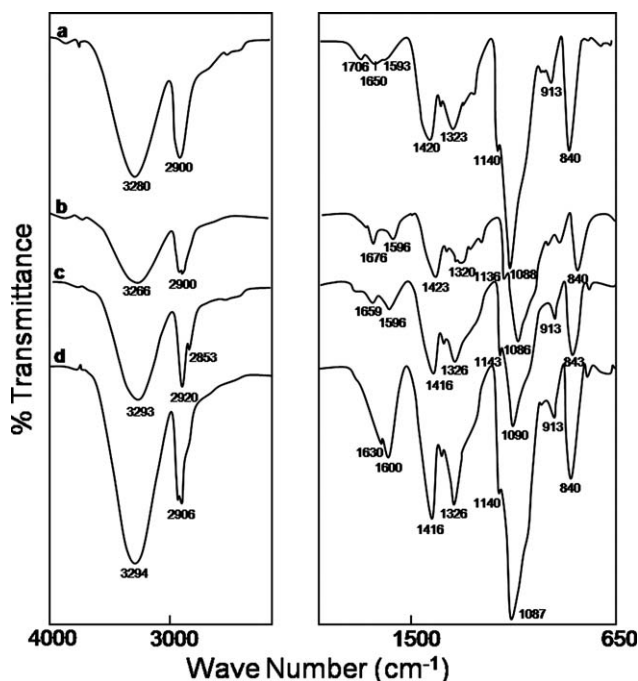


Figure 5. ATR-FTIR of samples having PVA : PEO in ratio 90 : 10 and variable amount of CMC (a) no CMC, (b) 5% CMC, (c) 10% CMC, and (d) 20% CMC.

cm. It also shows the characteristic C—H alkyl stretching peak at 2881/cm, thus showing the major peaks related with PEO.⁴⁰ In the FTIR spectra of PVA-PEO blend (Figure 5), the little shift in —OH absorption band peak from 3287 to 3280/cm due to intermolecular or intramolecular hydrogen bonding were attributed to hydrogen bonding interaction between PVA and PEO.

CMC shows a broad absorption peak at 3302/cm due to the stretching frequency of the —OH group. The presence of a strong absorption peak at 1582/cm confirms the presence of carboxylate (COO^-) ion.⁴¹ The peak at 1693/cm is associated with vibration of the C—O vibration bond. The peak at 1055/cm is due to C—O—C stretching. IR peak ranges that are of interest in spectrum of sample having PVA : PEO : CMC in ratio 90 : 10 : 20 [Figure 4(d)] are C—O—C asymmetric stretch at 1080–1095/cm, i.e., 1087/cm, —OH broad peak in the range of 3260–3295/cm, i.e., 3294/cm and —CH stretching vibration in

the range of 2900–2920/cm, i.e., 2906/cm. It is interesting to note that these peaks in the spectrum of blend membrane shift a little. It seems that the interaction between the polymers is very weak and does not interfere much with the absorption in the specified range.

The IR spectra of blends in Figure 5 showed absorption bands at 3260–3295/cm, which is due to —OH stretching vibrations of CMC and PVA and additional band at 1415–1425/cm¹ (CH_2 stretch). This additional band was also present in the IR spectra of pure PVA. Bands at 3260–3295/cm in the spectra of blends showed increased intensity with increase in the CMC composition. This may be ascribed to more and more hydrogen bonding between polymers. Bands at 1630–1680/cm were attributed to the characteristic absorptions of asymmetrical stretching vibration of COO^- of CMC. The absorption band at 1693/cm of CMC shifted to lower wavelengths 1676/cm in 5% CMC, 1659/cm in 10% CMC and 1630/cm in 20% CMC. Based on these results, it seems that the COO^- and —OH groups of CMC participate in intermolecular hydrogen bonds with the —OH groups of PVA, respectively. In addition to that, all the characteristic bands of PEO can be observed in the spectra of blend membranes.

The density of air-dried membranes at varying CMC concentration is presented in Table I. The density tends to increase as the CMC content in the membrane increases upto 10% beyond which it stays constant. Density was found to be 0.90 g/cm³ for membrane without CMC and 1.2 g/cm³ for membrane with 20% CMC content. The increase in density may be ascribed to the interaction between hydroxyl groups of CMC and the functional groups of PVA and PEO. As a result, the system becomes more interacting and compact and the blend become denser. These data are also supported by the morphology of the blend membranes shown in Figure 3.

DSC thermograms of PVA, PEO, and blends with various concentrations of CMC are presented in Figure 6. The pure PVA sample gives a relatively large melting endotherm with a peak maximum (T_m) at 225.4°C. The melting point of PEO, on the other hand, was found to be 65.5°C. The addition of CMC to the blends shows significant variation in the melting temperature (Figure 6). The shape of thermograms under the melting peak of pure PVA remains almost identical for all membranes. However, the endothermic curve of PEO became less prominent

Table I. Influence of Concentration of CMC on the Density, Crystallinity, and Equilibrium Solvent Content (ESC%) of Blends Membranes Having Different Compositions

| Composition (PVA : PEO : CMC) | Density (g/cm ³) | Crystallinity (%) by XRD | Crystallinity (%) by DSC wrt PVA | Crystallinity (%) by DSC wrt PEO | ESC% |
|-------------------------------|------------------------------|--------------------------|----------------------------------|----------------------------------|------------|
| 100 : 0 : 0 | — | — | 32.4 | — | 78.8 ± 4 |
| 0 : 100 : 0 | — | — | — | 83.6 | — |
| 90 : 10 : 0 | 0.90 | — | — | — | 79.8 ± 2.4 |
| 90 : 10 : 5 | 1.10 | 48.6 | 24.3 | 6.8 | 86.2 ± 1.5 |
| 90 : 10 : 10 | 1.20 | 47.7 | 24.2 | 5.8 | 87.6 ± 0.2 |
| 90 : 10 : 20 | 1.20 | 42.5 | 19.6 | 3.7 | 89.4 ± 0.3 |

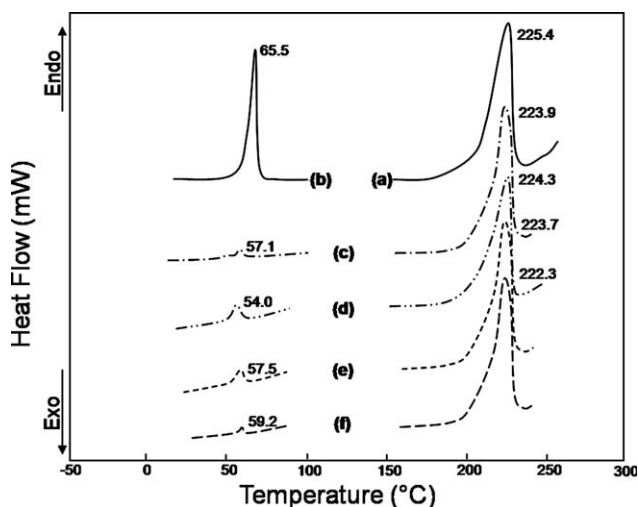


Figure 6. DSC curves showing the melting peaks of (a) PVA, (b) PEO and samples having PVA : PEO in ratio 90 : 10 and variable amount of CMC: (c) no CMC, (d) 5% CMC, (e) 10% CMC, and (f) 20% CMC.

and shifted toward much lower temperature. The depression of melting temperature indicates that the addition of CMC hinders the crystallization process of the two polymers due to interactions between the functional groups of polymers. The crystallinity of membranes with respect to PVA and PEO as a function of CMC concentration is reported in Table I. It is difficult to observe the T_g of PEO by DSC due to the high crystallinity of PEO. Also the T_g of PVA is close to the melting temperature of PEO, therefore, T_g of PVA might overlap with the melting peak of PEO in the DSC thermogram of blends and not visible in DSC.³⁶

XRD patterns of the blends and the pure components are presented in Figure 7. The diffraction peaks for the pure PVA appeared at 2θ 14.1°, 16.9°, and 19.0° characteristic of the PVA.⁴² PEO, on the other hand, has two sharp characteristic reflections at 18.9° and 23.2°.²³ CMC, however, does not show any crystalline peak and shows a very low degree of crystallinity even in the pure form. The blend having PVA : PEO in 90 : 10 ratio without CMC shows only one reflection at 2θ 19.7°, which is due to the little interactions between PVA and PEO [Figure 7(d)]. It can also be seen from the Figure 7 that as CMC is added to the blend of PVA and PEO, all the crystalline peaks of pure PVA and PEO get merged and show only one single diffraction at around 19.5°, which is near to the characteristic sharp reflection of PEO. Therefore, it can be concluded that CMC has strong interaction with PVA, but very little interaction with PEO. As a result of which, the regularity of pure polymers was destroyed in different fashion. The crystallinity of blend membranes decreases with the addition of more CMC from 48.6 to 42.5% (Table I), which can be attributed to the more and more hydrogen bonding between PVA and CMC, thus destroying the regularity of PVA.

The TGA thermograms of various membranes are presented in Figure 8. Two stages of thermal degradation were observed for pure PVA. The weight loss in the first stage from 50 to 150°C was due to the elimination of water molecules present in the

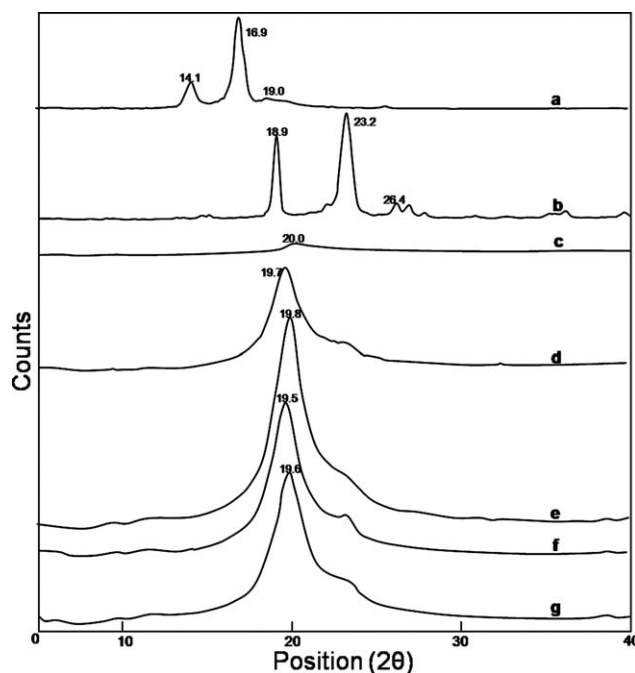


Figure 7. XRD patterns of (a) PVA, (b) PEO, (c) CMC and samples having PVA : PEO in ratio 90 : 10 and variable amount of CMC: (d) no CMC, (e) 5% CMC, (f) 10% CMC, and (g) 20% CMC.

membranes. The second stage was due to the main chain degradation between 200 and 600°C.⁴³ On the other hand, PEO undergoes one step degradation in the thermogram.⁴⁴ Pure CMC showed a two-step thermogram. The initial weight loss is due to the presence of moisture in the sample. The second loss is due to decarboxylation from the polysaccharide chain. TGA of PVA : PEO : CMC blend of 90 : 10 : 20 ratio showed three-step degradation. The first region of weight loss at about 50–150°C was due to the dehydration, second region at about 200–300°C was attributed to thermal degradation of the side groups,

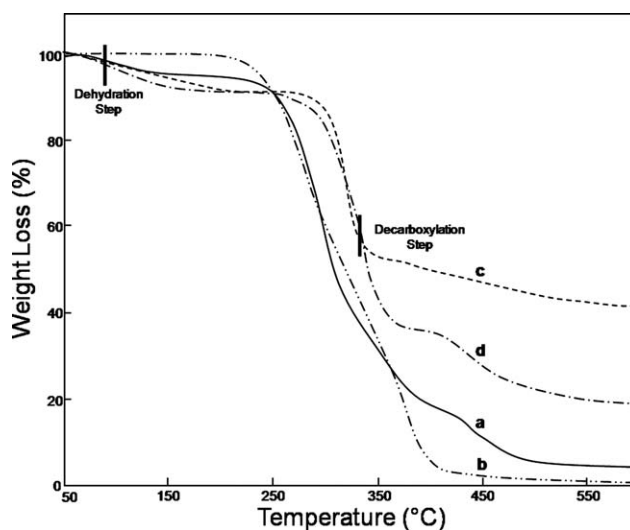


Figure 8. TGA of (a) PVA, (b) PEO, (c) CMC and blend sample (d) having PVA : PEO in ratio 90 : 10 and 20% CMC.

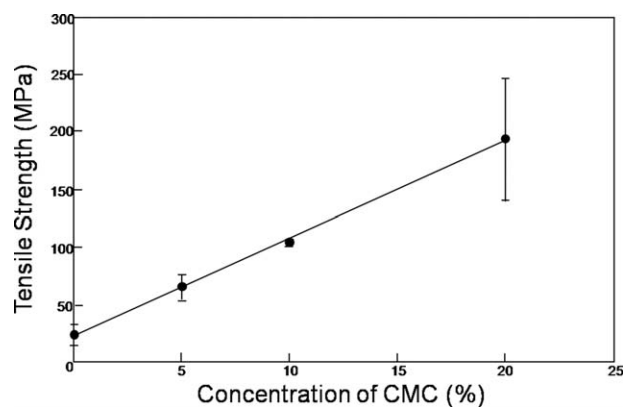


Figure 9. Influence of concentration of CMC on the tensile strength of the blends having PVA : PEO in ratio 90 : 10 and variable amount of CMC.

and the third region at about 350–400°C was associated with major weight loss equal to 80%. This weight loss was attributed to thermal degradation of the main chain C—C— bonds of the blend components. Furthermore, the influence of CMC on the thermal stability of PVA/PEO can also be observed from Figure 8. It is obvious that the blend sample having 20% CMC is thermally more stable when compared to pure PVA and PEO.

The tensile strength of membranes with different CMC concentration is presented in Figure 9. The thickness of membranes of different compositions is presented in Table II. It may be seen from the results that as CMC content increases, the tensile strength also increases. There is about eightfold increase in tensile strength of the blend membranes by the addition of CMC from 0 to 20% of total polymer. The strength of PVA/PEO membrane was 24 MPa. This strength is subsequently enhanced to 193 MPa for 20% CMC in blend membranes. For the blend membranes, the tensile strength depends on the composition indicating some interaction between the components. It leads to the conclusion that CMC increases the compatibility between PVA and PEO.

The effect of concentration of CMC on ESC of blends in PBS (pH 7.4) at 37°C is presented in Table I. It shows that as the concentration of CMC increases from 0 to 20% in the blends of PVA/PEO/CMC, the ESC of blends increases. The results can be explained by the fact that increasing the ratio of hydrophilic polymer in the blend increases the affinity for solvent and thus resulting in increased value of ESC. All the values of ESC of the hydrogels were greater than the percent water content values of the body about 60%. It may be mentioned that due to high hydrophilicity, the membrane reached swelling equilibrium in 45 min. The swelling increased sharply at the beginning and leveled off with time.

Table II. Thickness of Blend Membranes Having Different Compositions

| Composition (PVA : PEO : CMC) | Thickness (mm) |
|-------------------------------|----------------|
| 100 : 0 : 0 | 0.16 ± 0.09 |
| 90 : 10 : 5 | 0.18 ± 0.03 |
| 90 : 10 : 10 | 0.14 ± 0.03 |
| 90 : 10 : 20 | 0.24 ± 0.05 |

CONCLUSION

The blends of PVA and PEO have been prepared by incorporating CMC as the compatibilizer by solution casting technique. Their miscibility was assessed by XRD, ATR-FTIR, and DSC techniques. It is found from the results obtained from different characterization techniques that as the concentration of CMC increases in blends of PVA/PEO, the compatibility increases. From the morphology of blend membranes, it is observed that there are some interactions among CMC, PVA, and PEO. As a result, the system becomes more interacting and compact, and the blend becomes denser. This miscibility between polymers may be due to the formation of hydrogen bonds between the hydroxyl groups of CMC with ether groups of PEO and hydroxyl groups of PVA. The higher the CMC content, the denser is the membrane as suggested from density data. From TGA, it is obvious that the blend sample having 20% CMC is thermally more stable when compared to pure polymers. This higher stability in blend sample was also attributed to the hydrogen bonding interaction between the polymers. DSC also indicated that PVA, PEO, and CMC in the blend membranes displayed miscibility between pure polymers. Tensile results showed the blend membrane having 20% CMC shows good mechanical strength as compared to membranes having 0, 5, and 10% CMC. XRD and DSC data showed decrease in crystallinity as CMC concentration increases, which may be due to the destruction of regularity of pure polymers in different fashion. FTIR of all the blends show characteristic peaks of all the components present with a little shift. Equilibrium swelling behavior of the blends in PBS (pH 7.4) increases on increasing CMC concentration.

The membranes with PVA : PEO : CMC in ratio 90 : 10 : 20 have high transmittance % value when compared to other compositions, maximum mechanical strength, and swelling and offers interesting matrix for subsequent dressing fabrication. As a result of remarkable swelling of 20% CMC, these can absorb lot of exudates that will come out of the wound and as exudates absorption is an important criterion for an ideal wound dressing, so 20% CMC concentration in the blend of PVA/PEO may be taken as the optimized concentration for further studies.

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