Phosphotungstic acid loaded mixed matrix membranes of sodium alginate karayagum for dehydration of aqueous-organic mixtures

Yeggada Maruthi[1], Palla Kumara Babu[1], M C S Subha[2] & Kashayi Chowdoji Rao*,[1]

[1]Department of Polymer Science & Tech, Sri Krishnadevaraya University, Anantapuramu 515 003, AP, India.

[2]Department of Chemistry, Sri Krishnadevaraya University, Anantapuramu 515 003, AP, India.

E-mail: chowdojirao@gmail.com

Novel mixed matrix blend membranes of sodium alginate (SA) / karayagum (KG) have been prepared using solution casting method by incorporating 0, 5, 10, and 15 wt. % of Phosphotungstic acid (PWA) particles and crosslinked by glutaraldehyde. These membranes have been characterized by FTIR, DSC, SEM, X-RD and used for pervaporation (PV) dehydration of isopropyl alcohol (IPA) at 30°C. The phosphotungstic acid, with its hydrophilic nature as well as its molecular sieving effect and its favourable interaction with hydrophilic SA and KG, is responsible to enhance the PV dehydration of aqueous isopropanol in terms of selectivity (α), flux (J), and pervaporation separation index (PSI). The pervaporation performance has been evaluated by varying experimental parameters such as feed composition, different polymer compositions and found to be promising membrane for separation of water- isopropanol mixtures. The results pertaining to the 15 wt% PWA loaded blend membrane SA/PW-15% had the highest selectivity 5525 which is attributed to the combined effect of molecular adhesion between PWA and SA-KG blend matrix as well as hydrophilicity. A significant improvement in PV performance is observed for PWA particles loaded membrane compared to pristine blend membrane.

Keywords: Blend, Sodium alginate (SA), Karayagum (KG), Pervaporation, Flux, Selectivity.

Pervaporation, a potential industrial method for the separation of liquid mixtures, is considered to be a promising alternative to conventional energy intensive technologies, like extractive or azeotropic distillation in liquid mixture separation for being economical, safe and eco-friendly. Pervaporation separation is based on the differences in sorption and diffusion properties[1,2] of the permeating compounds and is useful particularly for the separation of azeotropes and close boiling mixtures, isomers, besides heat sensitive and hazardous compounds[3,4]. In general pristine polymers show low transport parameters selectivity and productivity and mechanical strength. To overcome this problem and to improve transport properties, variety of zeolites have been used as fillers[5,6].

Sodium alginate is a salt of alginic acid, which has the capacity to crosslink with other natural or synthetic polymers when it comes in contact with divalent or trivalent cations and the method is called as ionic gelation method. Alginate is a natural carbohydrate polymer commonly used in the film formation and drug delivery systems because they are biodegradable, biocompatible and non toxic. Alginate belongs to a family of linear polysaccharides, produced by brown algae, which contain varying amounts of 1, 4-linked β-D-mannuronic acid and α-L-guluronic acid residues. Sodium alginate has been commercially applied and investigated due to its low cost and minimal processing requirement. Alginate gelation takes place when divalent or trivalent cations (usually Ca^{2+}) / Glutaraldhyde (GA) interacts with guluronic acid residues, resulting in formation of a threedimensional network which is usually described by egg-box model. Alginate-Ca^{2+} / or Alginate % GA has been widely investigated for oral and nasal drug controlled release applications[7].

Another natural polymer Karayagum (KG) structure has been shown to be composed of D-glucuronic acid, D-galacturonic acid, D-galactose and L-rhamnose, in proportions differing according to the quality, type of gum and origin[8-11]. The chemical composition of gum samples obtained from different Sterculia species and from different places of origin was found to be quite similar[12,13]. Commercial KG contains about 13-26% galactose and 15-30% rhamnose, which is considerably higher than the rhamnose content of other commercial exudate gums. However, the protein content of about 1% is lower than that of other

exudate gums. KG contains approximately 40% uronic acid residues and 8% of acetyl groups, from which free acetic acid is released on aging. KG is one of the least soluble of the exudates gums. Due to its acid stability, high viscosity, and suspension properties, karayagum is well suited for stabilizing low pH emulsions, such as sauces and dressings[14]. When dispersed in water, the gum particles do not dissolve but adsorb water and swell extensively to more than 60 times the original volume, producing a viscous colloidal sol. The swelling behaviour of karayagum is caused by the presence of acetyl groups in its structure[15]. Chemical deacetylation through an alkali treatment results in a water-soluble gum. Coarse gum particles give a grainy dispersion, whereas finely powdered gum hydrates more rapidly and gives a homogeneous dispersion. KG is used extensively in various totally unrelated industries because of the properties such as water absorbing / moisture absorbing, gel and film forming, adhesiveness abilities. It is highly resistance to hydrolysis by mild acids and degradation by most of the microorganisms.

Polymer blends have received a great deal of attention due to the diversity of materials prepared from various pristine polymeric components. Blend properties can be tailored from carefully selected polymer components with the desired characteristics. Thus, blending of polymer films has the potential to improve the material strength and to modulate hydrophilic / hydrophobic characteristics as well as barrier properties to liquids[16]. In order to achieve the improved separation of water-isopropanol mixtures by the PV dehydration process, in the present study the blending of SA with KG is considered to limit the excessive swelling of SA. Since SA and KG polymers are completely miscible in all proportions, due to the hydrogen-bond formation between the donor groups of SA and the acceptor groups of KG, therefore, in the blend system, it is thought that selectivity of SA to water might be enhanced thus, favouring the dehydration of isopropanol[17].

Phosphotungstic acid (PWA) has been the rarely studied filler[18,19], in developing mixed matrix membranes (MMMs). However the potential interactions between PWA and the host polymer would be responsible to achieve extraordinary separation performance of membrane. The PWA consists of Keggin unit as a primary structure, i.e., the polyanion $[PW_{12}O_{40}]^{3-}$, and a secondary structure, i.e.,

a regular three-dimensional assembly of the hetero polyanions with counter cations (protons) and additional water molecules[20]. This Keggin unit consists of a central PO_4 tetrahedron surrounded by four W_3O_{13} sets, linked together through oxygen atoms of which, four types can be distinguished; the central oxygen atom belonging to PO_4 tetrahedron is shared by three tungsten atoms, while the edge-sharing oxygen atoms bridge two tungsten atoms of the same set. The corner-sharing oxygen atoms bridge two tungsten atoms of different sets and terminal oxygen atoms are associated with a single tungsten atom. The bridging and terminal oxygen atoms are on the periphery of the structure, which are available to associate with protons or water molecules to form hydrates that are thought to enhance selectivity to water. Also, hydrogen-bonding is likely to be established between PWA and the SA/KG blend system. Due to these advantages, in continuation of our pervaporation studies[20,24] PWA-loaded SA/KG blend membrane is selected to investigate the PV separation of Isopropanol. Four membranes i.e. one unfilled blend membrane and three MMMs incorporated with 5, 10 and 15 wt.% of phosphotungstic acid (PWA) particles were fabricated. All the membranes were characterized by a variety of characterization techniques and their PV performances were evaluated for isopropanol dehydration and the results are presented here.

Experimental Section

Materials

Sodium alginate (SA), Karayagum (KG), Glutaraldehyde (GA 50 wt % aqueous solution), Concentrated (35%) Hydrochloric acid (HCl), Isopropanol (IPA) Acetone and phosphotungstic acid were purchased from S.d. fine chemicals, Mumbai, India. All the chemicals were of analytical grade samples used without further purification. Deionized water with a conductivity of 20 µS/cm was produced in the laboratory using Techno pilot plant (Vadodara, India.) through a nano filtration membrane module and used for all the experiments.

Preparation SA-KG and Phosphotungstic acid filled blend membranes

Sodium alginate (2g) and Karayagum (2g) were individually dissolved in 100 mL of deionized water in two separate conical flasks with constant stirring for about 24 h at room temperature and these solutions were then filtered and mixed thoroughly in

the ratio of 4:1. To this mixture, 0, 5, 10 and 15 wt% PWA nanoparticles with respect to weight of the blend polymer were added and the mixture was stirred for about 2 hr and then it was kept in an ultrasonic bath for 30 min at 30°C to break the aggregated crystals of phosphotungstic acid and enhance its dispersion in the polymer matrix. The resulting solution was filtered to remove suspended particles, poured on to a clean dust-free glass plate to fabricate membranes of uniform thickness, dried at 30°C and finally peeled off the glass plate. The prepared membranes were then crosslinked in a bath containing with 85 vol.%

acetone, 10 vol.% water, 2.5 vol.% of glutaraldehyde and 2.5 vol.% hydrochloric acid catalyst for a period of 7-8 hr. The nascent blend membrane was designated as SA/KG-0, while the MMMs containig 5, 10 and 15 wt. %, PWA were designated as SA/KG-5, SA/KG-10 and SA/KG-15 respectively. A model scheme of the possible interaction is shown in Scheme.1 which represents the structure of SA-KG crosslinked with glutaraldehyde.

Pervaporation experiments

Schematic pervaporation experimental setup were performed in an apparatus designed in the Dept. of
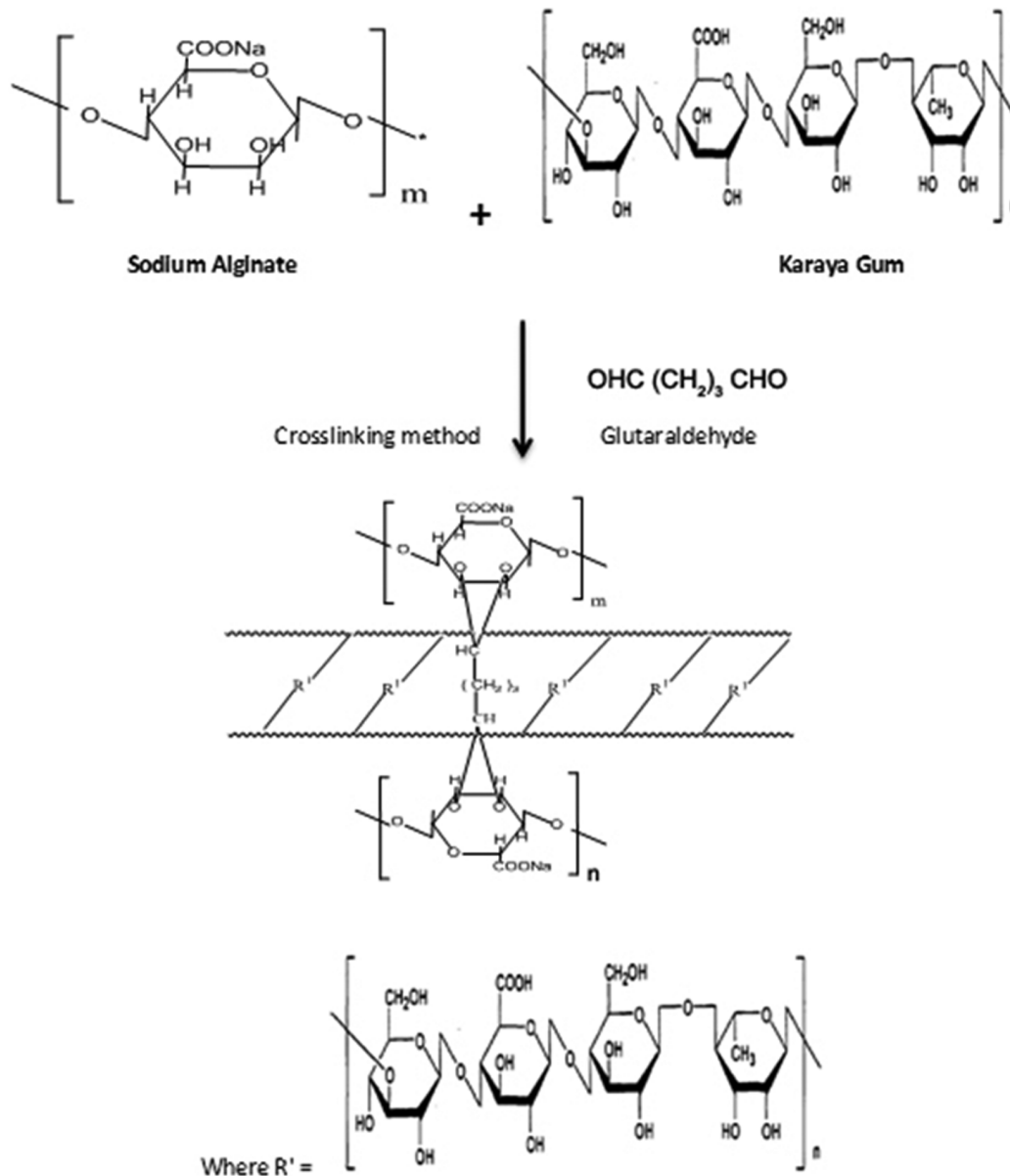
Scheme 1— Schematic representation of preparation of the SA and KG blend membrane crosslinked with glutaraldehyde.

Polymer Science & Technology, S.K.University, Ananthapur and it was used elsevier and the procedure used in pervaporation has been described earlier studies[20,21]. The pervaporation cell consist of two bell-shaped B-24 size glass column reducers/couplers clamped together with external padded flanges by means of tie rods to give a vacuum tight arrangement. The top half is used as the feed chamber. The membrane is supported by a stainless steel porous plate which is embedded with an SS mesh/screen. Teflon gaskets are fixed by means of high-vacuum silicone grease on either side of the membrane, and the sandwich is placed between the two glass column couplers and secured tightly. The effective membrane area in contact with feed is almost 20 cm^2 in all cases. The feed side pressure is maintained at atmospheric pressure and the vacuum in the downstream side at about 0.5 mm Hg using a vacuum pump (INDVAC, Model- IVP-150, Bangalore, India). The permeate was collected in liquid nitrogen cold traps for a period of 8 h followed by analyzing the compositions of the feed and permeate at 30°C using Abbe Refractometer (Atago, 3T-Japan) and comparing with standard graph of refractive index versus mixture composition. From the PV data, flux, J_i is calculated as given below:

$$Ji = \left(\frac{Wi}{At}\right) \qquad \qquad \ldots (1)$$

Here W_i represents the mass of water in permeate (kg), A is the membrane area (m^2) and t represents the permeation time (h).

Membrane selectivity, α, is the ratio of permeability coefficients of water to that of isopropanol, which is calculated from their respective concentrations in feed and permeate as given below:

$$\propto = \left(\frac{y(1-x)}{x(1-y)}\right) \qquad \qquad \ldots (2)$$

where 'y' is the mole fraction of water in feed and 'x' is its mole fraction of water in permeate. In all cases, results were obtained in triplicate but averages (3% standard error) are reported and calculated values of flux and selectivity are presented.

Sorption Experiments

The degree of swelling of phosphotungstic acid-incorporated membranes was determined in different compositions of water and isopropanol mixtures for

24 h at 30°C using an electronically controlled oven (WTB Binder, model-BD-53, Germany). The masses of the dry membranes were first determined. The dry membranes were equilibrated by soaking in different compositions of the mixture in a sealed vessel, at 30°C for 24 h and then the swollen membranes were weighed immediately after careful blotting on a single pan Adam digital microbalance (model AAA 160L, Switzerland) having a sensitivity of $\pm$ 0.01 mg. The % degree of swelling (DS) was calculated as:

$$\% \ DS = \left(\frac{Ms}{Md}\right) \times 100 \qquad \qquad \ldots (3)$$

where M_S and M_d are the mass of the swollen and dry membranes, respectively.

Measurement of refractive index (RI)

Refractive index N^D, for sodium-D line was measured using the thermostatically controlled Abbe Refractometer (Atago 3T, Japan) with an accuracy of $\pm$ 0.001. The instrument directly gives the values of N^D. Permeate composition was determined by measuring refractive index and comparing it with the established graph of refractive index versus liquid mixture composition.

Characterization Techniques

Fourier Transform Infrared (FTIR) Spectroscopic Studies

Dispersion of different amounts of phosphotungstic acid in the SA/KG matrix was confirmed by FTIR (Bomem, MB-3000, Canada) spectrophotometer. About 2 mg of the sample was grounded thoroughly with KBr, and pellets were made under a hydraulic pressure of 600 kg/cm^2. Dry membranes were characterized in the range of 4000 to 400 cm^{-1} at a scan rate of 25 cm^{-1} under N_2 atmosphere.

Differential Scanning Calorimetry (DSC) Studies

Differential scanning calorimetry (DSC) thermo grams of crosslinked SA/KG blend membranes were obtained on a differential scanning calorimeter (Model-SDT Q600, USA). Thermo grams were recorded from 30°C to 600°C at a heating rate of 10°C/min in a nitrogen atmosphere.

X-Ray Diffraction (XRD) Studies

To investigate a change in membrane structure with crosslinking density, a wide-angle X-ray diffractometer (Simens D 5000, Germany) with a scintillation counter detector using Cu Kα- radiation as a source was used. Angles (2θ) ranged from 2° to 50°. All samples were films with thickness of

11-13 μm in order to identify any changes in the crystal structure and intermolecular distances between inter segmental chains after modification.

Scanning Electron Micrograph (SEM) Studies

Scanning electron micrographs (SEM) of surface were taken for the unfilled SA/KG membrane and phosphotungstic acid filled SA/KG membranes, using software controlled digital scanning electron microscope–JEOL JSM 5410, Japan.

Results and Discussion

Fourier transform infrared spectroscopy (FTIR)

FTIR spectra of PWA, Pristine blend membrane and PWA loaded blend membranes are illustrated in Fig. 1.

From the FTIR spectra of pure PWA (Fig.1a), it is clear that the symmetric and asymmetric stretching of the different kinds of W-O bonds are observed in the following spectral regions: W-Od bonds (1080-983 cm^{-1}), W-Ob-W bridges (inter bridges between corner-sharing octahedra) (983-891 cm^{-1}), W-Oc-W bridges ("intra" bridges between edge-sharing octahedra) (891-799 cm^{-1}). Only the W-Od stretching can be considered as pure vibrations: the stretching involving Ob or Oc atoms present some bending character. In our study, the IR spectrum of the present compound exhibits the characteristic frequencies of structure in the range 3614-524 cm^{-1}. In our study, the IR spectrum of the present compounds exhibits the characteristic frequencies of structure in the range 1714-500 cm^{-1}.

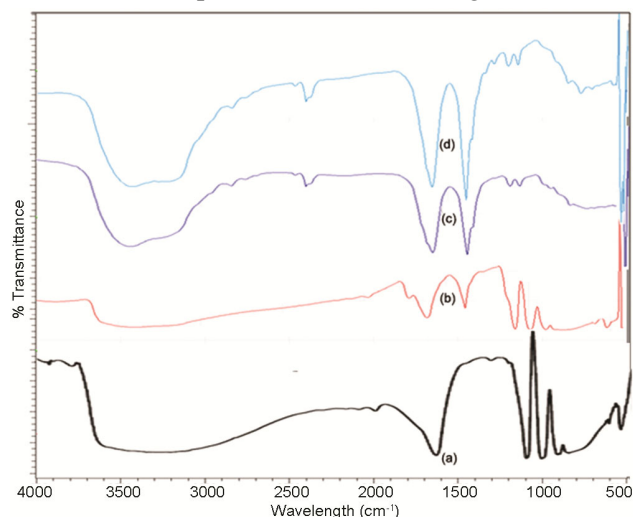A strong and broad band appearing around 3000 to 3500 cm^{-1} corresponds to O-H stretching vibrations of hydroxyl groups of PWA. The spectrum of unfilled SA/KG-0 blend membrane (b) and those of the MMMs (i.e., c & d) are also displayed in Fig. 1. The (b) membrane has characteristic peaks at 3000-3600, 2990, 1630 and 1040 cm^{-1} corresponding to peaks of -OH, C-H, C=O and C-O stretching vibrations, respectively. In case of (c & d) membranes, no characteristic bands of Keggin unit appeared, indicating homogeneous distribution of PWA particles in SA/KG blend membranes. For (d), the peak intensity corresponding to -OH around 3450 cm^{-1} shows a decrease in intensity compared to unfilled (b) membrane, indicating the interaction between PWA and blend membrane in Fig. 1. Being a high hydrophilicity inorganic material, there are a great amount of hydroxyl groups on the surface of the PWA. As a result, when the PWA was incorporated into the blend matrix, the hydrophilicity of the membrane was enhanced.

Diffential scanning calorimetry (DSC) Studies

The DSC curves of the pristine blend membrane of SA/KG-0 (a) and PWA loaded MMMs of SA/KG-5 (b), and SA/KG-15(c) are shown in Fig. 2.

We observe that the pristine blend membrane of SA/KG-0 has a Tg of 75.8^{o}C, which is shifted to higher temperatures of 86.5°C, and 90°C for (b), and (c), respectively after the addition of PWA particles. This may be due to intermolecular hydrogen-bonding interactions between SA/KG blend and PWA particles. It can be seen from Fig. 2, that the Tg curves are quite identical, suggesting the compatibility between SA/KG blend and PWA filler particles. However at higher loading as in case of (c) (SA/KG-15), the Tg was shifted to higher value due to micro-phase separation between the organic and

Fig. 1 — FTIR spectra of Pure PWA (a), pristine blend membrane (b) and PWA loaded SA+KG blend membranes (c & d)
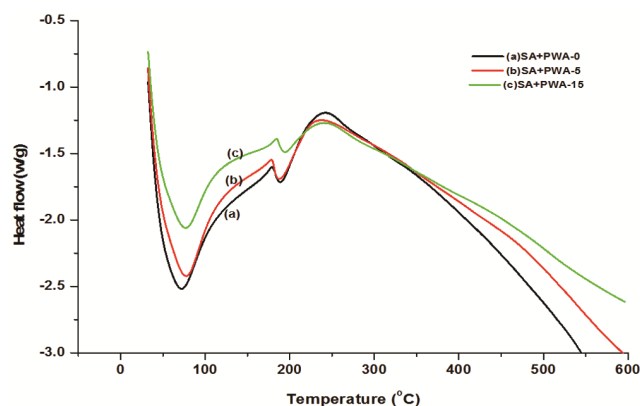

Fig. 2 — DSC Thermograms of blend membrane of SA/KG-0 (a) and PWA loaded MMMs of SA/KG-5 (b), and SA/KG-15(c).

inorganic phases that would allow isopropanol to transport across the membrane along with some of the water molecules, thus causing increased permeation flux exhibiting a lower selectivity.

X-ray diffraction (XRD) studies

The X-RD patterns of plain PWA, plain blend membrane SA/KG-0 (a) and PWA loaded MMMs of SA/KG-5 (b) and SA/KG-10 (c) are presented in Fig. 3.

The X-ray diffraction spectra of the membranes are presented in Fig. 3 and it is observed that the curve for plain PWA shows strong characteristic diffraction peaks, suggesting crystalline nature of PWA. However, curve for (SA/KG-0) blend membrane, two diffraction peaks observed at various diffraction peaks at around 12.09° and 29.48° of 2θ showed a decrease in intensity in case of MMMs, due to random entanglement of SA/KG chains caused by the addition of PWA particles. After incorporating PWA particles into the SA/KG matrix, amorphous region increased, thus allowing the transport of more permeate molecules through the barrier membrane, thereby offering higher flux for MMMs than plain SA/KG blend membrane. A similar observation was reported by Chen et.al[22] from the pervaporation dehydration of acetic acid in PWA incorporated polymer hybrid membranes.

Scanning Electron Microscopy (SEM) Studies

SEM images of the pristine blend membrane of SA/KG-0 (a) and 5, 10 and 15 wt.% of PWA loaded (b, c and d) blend membranes are shown in Fig. 4.

From Fig. 4, it is observed that a smooth image is observed for pristine blend membrane (a) indicating the uniform dense 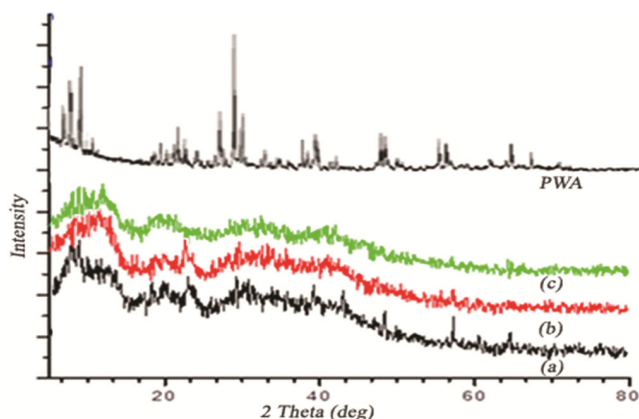matrix. However, in the case of composite membranes as shown in Fig. 4(b-d), we observe a smooth surface with uniform distribution of PWA particles. Such a homogenous mixing of PWA particles in the bulk of the polymer phase would facilitate higher water transport through the membrane due to the creation of channels that are more favourable for higher water transport than isopropanol through the membrane. With increasing loading of PWA as in (c) and (d) membranes, some surface roughness can be seen, but with not so much of uniform distribution of PWA particles on the surfaces of the membranes.

Membrane sorption studies

The mass transport through membrane is a complex phenomenon because the interaction between liquid feed components and the membrane would result in membrane swelling affecting the PV data. The results are presented in Table 1. The variation of degree of sorption vs percentage of water through plain SA/KG-0 and PWA filled blend membranes (SA/KG-5, SA/KG-10 and SA/KG-15) are shown in Fig. 5.

Figure 5 present the results of % degree of swelling of SA-KG-0, and it's MMM's filled with PWA

Table 1 — Percentage of sorption data of IPA/water mixtures in SA+KG and PWA filled membranes at 30°C

% of water in the feed	% Sorption in different membranes			
	SA/KG-0	SA/KG-5	SA/KG-10	SA/KG-15
10	290	384	465	489
20	400	560	602	704
30	530	702	819	852
40	624	920	960	980

Fig. 3 — XRD Spectrum of plain PWA, the blend membrane of SA/KG-0 (a) and PWA loaded MMMs of SA/KG-5 (b), and SA/KG-10(c).
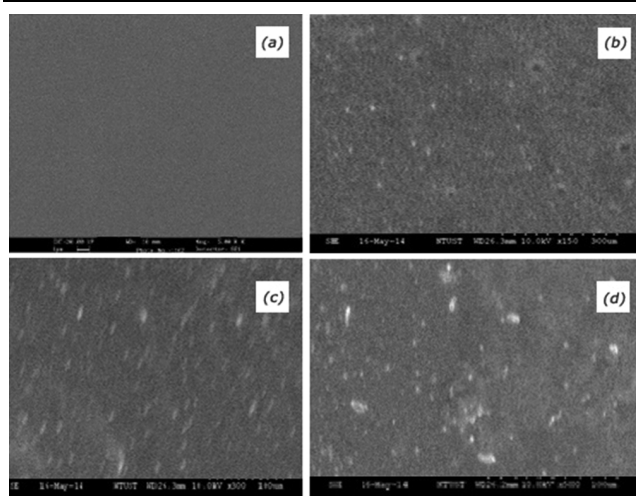

Fig. 4 — SEM images of the pristine blend membrane of SA/KG-0 (a) and 5, 10 and 15 wt.% of PWA loaded (b, c and d) blend membranes
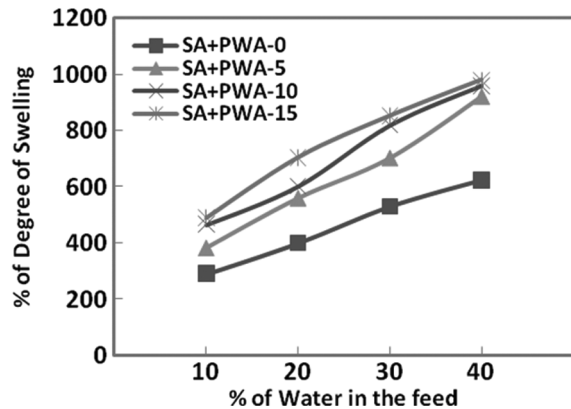
Fig. 5 — Plots of degree of swelling of SA/KG-0 and SA/KG incorporated PWA membranes

membranes in different mass % of water/IPA mixture in the feed at 30°C. The results indicate that the swelling ratio of SA/KG increases with increase in the PWA content up to 15%. Both PWA and pristine SA-KG-0 blend membranes are hydrophilic, so PWA-filled MMM's can be used effectively in dehydration of IPA by PV, mainly at azeotropic mixtures. The PWA-filled membranes are maintained by the strong interaction between PWA and blend membranes. During the PV processes, when water molecules diffuse into the membrane, the membranes become swollen; swelling leads to further increase the interaction between PWA and the blend membranes. This might result in the formation of some tiny cracks developing at the interface between the PWA and SA/KG blend membrane, which allows water molecules to pass through. This the reason for the higher swelling noticed 15 mass % PWA-filled SA/KG-15 membranes and also shows the more stability through the PV process compared to pristine blend membrane.

Pervaporation studies

Influence of PWA loading on PV Performance

The importance of using filler-filled membranes in PV separation has been well documented in the earlier literature for a variety of polymer-filler combinations [26-27]. The crystalline ordered structure of hydrophilic PWA with a narrow size distribution has a higher resistivity to organic liquids than water. Thus, by dispersing PWA particles into blend polymer matrix, the increase in permeation flux of the MMMs could be the result of preferential interaction of water molecules, which would accommodate higher amount of water than isopropanol. This could be possibly due to: (1) strong

adsorptive hydrophilic interaction of water molecules onto PWA particles, (2) surface diffusion from cage to cage and (3) vaporization on the permeate side. Physical adsorption involves both Vander Waals type dispersion-repulsive and electrostatic interactions due to polarization, as well as dipole and quadrupole type interactions. The complementary effects of PWA on water transport would thus improve the membrane performance. It is worth mentioning that the varying effects of flux and selectivity are attributed to the amount of PWA filler present in the blend matrix.

Membrane performance was studied by calculating flux, selectivity and PSI at different concentrations of PWA loaded blend, and different water feed compositions are presented in Table 2. The variations of Flux & Selectivity with different feed compositions are shown in Fig. 6 and Fig. 7 respectively. The water flux for 5% PWA loaded blend membrane has increased from 0.263 to 0.461 kg/m^{2}h, while the water flux for 10% PWA loaded blend membrane increased from 0.325 to 0.491 kg/m^{2}h, whereas in case of 15 % PWA loaded blend membrane, water flux increased from 0.385 to 0.531. For all these 5,10 and 15% of PWA mixed matrix membranes this also further show that the, flux increases with increasing amount of water in the feed from 10 to 40%. The flux values all of the MMMs are higher than the pristine blend membrane which can be clearly observed from the values of flux in Table 2 and also from the Fig. 6. Mainly, selectivity of 5 wt.% PWA-containing membrane (i.e., SA/KG-5) increased considerably compared to pristine SA/KG-0 blend membrane. At the same time, it is observed from Fig. 7 that at higher concentrations of PWA i.e., SA/KG-10, SA/KG-15 membranes, the selectivity values increased considerably compared to pristine blend membrane.

Effect of feed water composition

In PV process, the overall selectivity of a membrane is generally explained on the basis of interaction between the membrane and permeating molecules, molecular size of the permeating species. Fig. 6 displays the effect of water compositions on the flux for all the membranes prepared with different amounts of PWA in SA/KG matrix and the results are also tabulated in Table 2. It is observed that the flux of water in the feed increased drastically for all water/IPA compositions under the studied PWA concentration range (5 to 15 mass%). At higher concentration of water in the feed, the membranes swell greatly due to the formation of a strong

Table 2 — Pervaporation results of water/IPA mixtures for different membranes at 30^0C.

Feed compositions		Permeate compositions (wt%)		Selectivity (α)	Flux (kg/m^{2}h)	PSI
Water (x)	IPA(1-x)	Water (y)	IPA (1-y)			
		SA/KG -0				
10	90	98.89	1.11	561.80	0.242	135.95
20	80	98.54	1.46	365.71	0.255	93.25
30	70	98.42	1.58	210.15	0.291	61.15
40	60	97.82	2.18	110.25	0.373	41.21
		SA/KG-5				
10	90	99.72	0.28	1802.17	0.263	473.97
20	80	99.48	0.52	1062.23	0.303	321.85
30	70	99.28	0.72	632.74	0.381	241.07
40	60	99.02	0.98	325.56	0.461	150.08
		SA/KG-10				
10	90	99.84	0.16	3605.28	0.325	1171.71
20	80	99.54	0.46	1819.13	0.374	680.35
30	70	99.42	0.58	1012.84	0.431	436.53
40	60	99.28	0.72	602.08	0.491	295.62
		SA/KG-15				
10	90	99.92	0.08	5525.10	0.385	2127.16
20	80	99.77	0.23	2965.84	0.462	1370.21
30	70	99.58	0.42	1612.62	0.486	783.73
40	60	99.32	0.68	787.12	0.531	417.96

Fig. 6 — Effect of wt% of water in feed on Flux for different blend membranes.
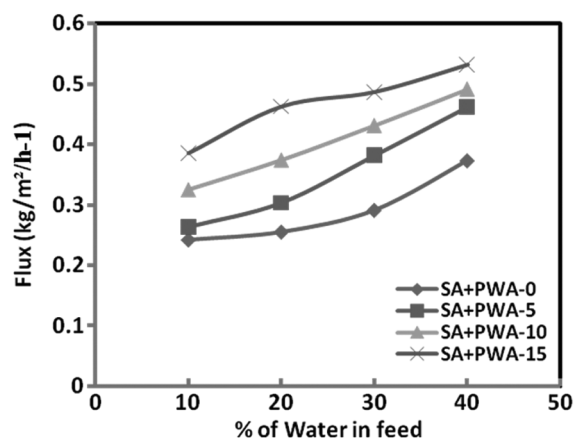

Fig. 7 — Effect of wt% of water in feed on Selectivity for different blend membranes.

interaction between the membrane and water molecules. This might have led to allow water molecules to pass through the membranes[28]. As a result, flux of water increases drastically at higher concentration of water in the feed, irrespective of the amount of PWA loading in the membrane matrix.

On the contrary, the selectivity decreased significantly from 10 to 40 upon increasing the water content in the feed. This can be clearly observed from 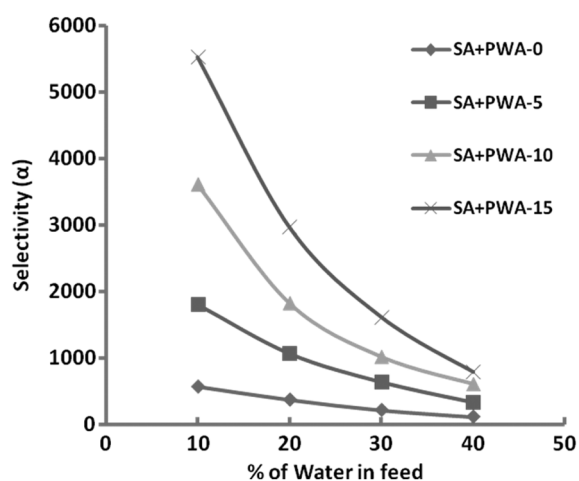Fig. 7 showing the variation of selectivity as a function of wt% of water in the feed in the membrane for different mass% of PWA (5-15 wt%) in the membrane. Generally, with increasing the water content in the feed compositions, the permeation flux increases and selectivity decreases[29]. Similar observations were also observed in the present case with increasing water content in the feed composition. The highest flux observed for SA/KG-15 is 0.531kg/m^2/h at a feed composition of 40 wt% feed

mixture. Whereas, highest selectivity observed is 5525 for SA/KG-15 at 10wt% of water a in the feed.

Conclusion

In this paper, the preparation of mixed matrix blend membranes of SA/KG and PWA loaded MMMs for the PV separation of water-isopropanol mixtures has been reported. It is observed that MMMs are better than the nascent blend membrane in separating azeotropic water-isopropanol mixture. At high concentration of PWA, membranes attained increased rigidity, resulting in reduced free volume, due to the creation of extra free volume for water to permeate through. Characterization of the membranes revealed adequate film properties, thermal properties, surface morphology and free volumes that are essential to achieve efficient dehydration of isopropanol. A reduction in free volume fraction reflected the effect of incorporation of PWA nanoparticles. Feed water composition had an effect on water flux, but with only a slight influence on isopropanol permeability. The results of this work concluded that the present polymer matrix is an effective membrane for dehydration of isopropanol.

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