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PHYSICO-CHEMICAL AND THERMAL PROPERTY STUDIES OF GG/PVA BLEND THIN FILMS

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ABSTRACT

Physico-chemical, and thermal properties of blend thin films of Guar Gum (GG) and poly(vinyl alcohol) (PVA) were studied by Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and Differential Scanning Calorimetric (DSC) methods. Based on FTIR, SEM, and DSC-Tgmeasurements, it is found that the polymer blend of Guar Gum/PVA is miscible by forming intermolecular hydrogen bonding only when the GG content is more than 60%. Below this critical GG concentration the blends were found to be immiscible. Hence GG/PVA blend in solid state is semi-miscible in nature.

Keywords: blends, PVA, Guar Gum, FTIR, SEM, DSC.

I. INTRODUCTION

In recent years polymer blends have gained considerable attention due to their cost effectiveness and the relative ease with which new tailor-made materials can be produced to meet specific applications. Blending polymers may result in reducing their basic cost, improving their processing and maximizing their important properties. The gain in properties of the blends depends on the degree of miscibility of polymers at molecular level [1-7].The miscibility of polymer blends is directly reflected by Scanning Electron Microscopy (SEM) and Fourier Transform Infra Red spectroscopic (FTIR) and Differential Scanning Calorimetric (DSC) analysis [8-11].

In our previous work we extensively investigated about the viscosity, density, ultrasonic velocity, and refractive index of guar gum/PVA blends in solution state [12].In this research miscibility of natural polymer guar gum, a synthetic polymerpoly(vinyl alcohol), and their blend thin films at different compositions were studied by FTIR, SEM, and DSC-Tgmeasurement techniques.

II. EXPERIMENTAL PROCEDURE

The polymers employed in the present study are guar gum (Merck, India) and PVA (Rolex, India).

Blends of GG/PVA of different compositions were prepared by mixing aqueous polymer solutions. Thin films of the polymers and their blends were prepared by solution casting method. Separate aqueous solutions of GG and PVA were prepared. A solution of PVA was added to that of GG with constant stirring. The mixture was stirred for 45 minutes at room temperature to ensure complete mixing. The total polymer concentration was kept at 0.1% (w/v). Stock solutions of GG and PVA and their different blend compositions were then casted onto Teflon-coated clean glass plate and dried in a dust free atmosphere. The dried thin films were peeled off from the glass plate and were found to be transparent. Scanning electron microscopic analysis were recorded using a JOEL (JSM 6380LA) analyzer. DSC thermograms were produced with a TA Q200 differential scanning calorimeter, under nitrogen environment. The first temperature cycle heated the sample to 100ºC, where it remained isothermal for between 15 and 60 min to remove the remaining water in the samples. The sample was then cooled to -10ºC before it was immediately reheated to 250ºC. The heating/cooling rate was set at 10ºC/min.

III. RESULTS AND DISCUSSIONS

Fourier transform infra-red spectroscopic measurements:

FTIR spectra of GG, PVA and their blend films (50/50, 60/40 and 80/20) were recorded. Figure 1 shows the FTIR spectra of pure and blend films in the wave length range of 4000-500cm^{-1}. The FTIR spectra of GG showed the presence of a very strong and broad absorption band at 3347.3cm^{-1} is assigned to –OH bond stretching, while the sharp absorption band located at 2918.2cm^{-1} may be attributed to C–H group stretching. The absorption band appearing at 1628.3 cm^{-1} is due the –OH bond belonging to water molecules. CH_2 group bending is assigned to an absorption band located at 1370.9cm^{-1}, and the bending of CH_2–O–CH_2 appears in the 1012.7cm^{-1} frequency region [13]. The FTIR spectra of PVA showed a broad peak at 3275.3cm^{-1} indicating stretching of hydroxyl groups and peak at 2919.2cm^{-1} due to C-H stretching [14].

It is noticed that the hydroxyl stretching bands became much broader with increasing PVA content. The carbonyl and hydroxyl characteristic bands shifted towards lower wave numbers compared to that of pure GG. This strongly supports the idea that a hydrogen bonding can form between the hydroxyl groups of PVA and carbonyl groups of GG.

Morphological studies:

All the solution-casted films of GG, PVA and their blends (50/50, 60/40 and 80/20) were transparent. To check the morphology of the blends SEM was used. The results are given in Figure 2. GG/PVA blends show aggregated particles for 60/40 and 50/50 GG/PVA blend compositions. For 80/20 GG/PVA, it can be observed that the PVA granule was well distributed in the GG matrix, confirming a good interaction between GG and PVA. As shown in figure, measured by high magnification (X5,000), it was observed distinctly that the blend

with 80/20 GG/PVA composition is homogeneous. The observation suggests that GG/PVA blend is miscible only when the GG content is more than 80 wt%. Hence GG/PVA blend is semi-miscible.

Glass transition temperature measurements:

The thermal properties of GG, PVA and their blend composition 80/20 were studied by means of DSC-Tg determination and the thermograms are given in Figure 3. The glass transition temperature was taken as the mid-point of the change of slope in the DSC curves. As it is observed in the respective traces all the blends showed single composition-depended glass transition temperatures Tg between the Pure GG and that of the pure PVA, indicating intermolecular interaction between the polymers. The experimental Tg values compared with theoretical Tgvalues [15-17] and are summarized in Table 1. Experimental Tg values for 80/20 GG/PVA blend is in good agreement with the theoretically calculated Tg values indicating an intermolecular interactions of hydrogen bonding type between the polymers [8].

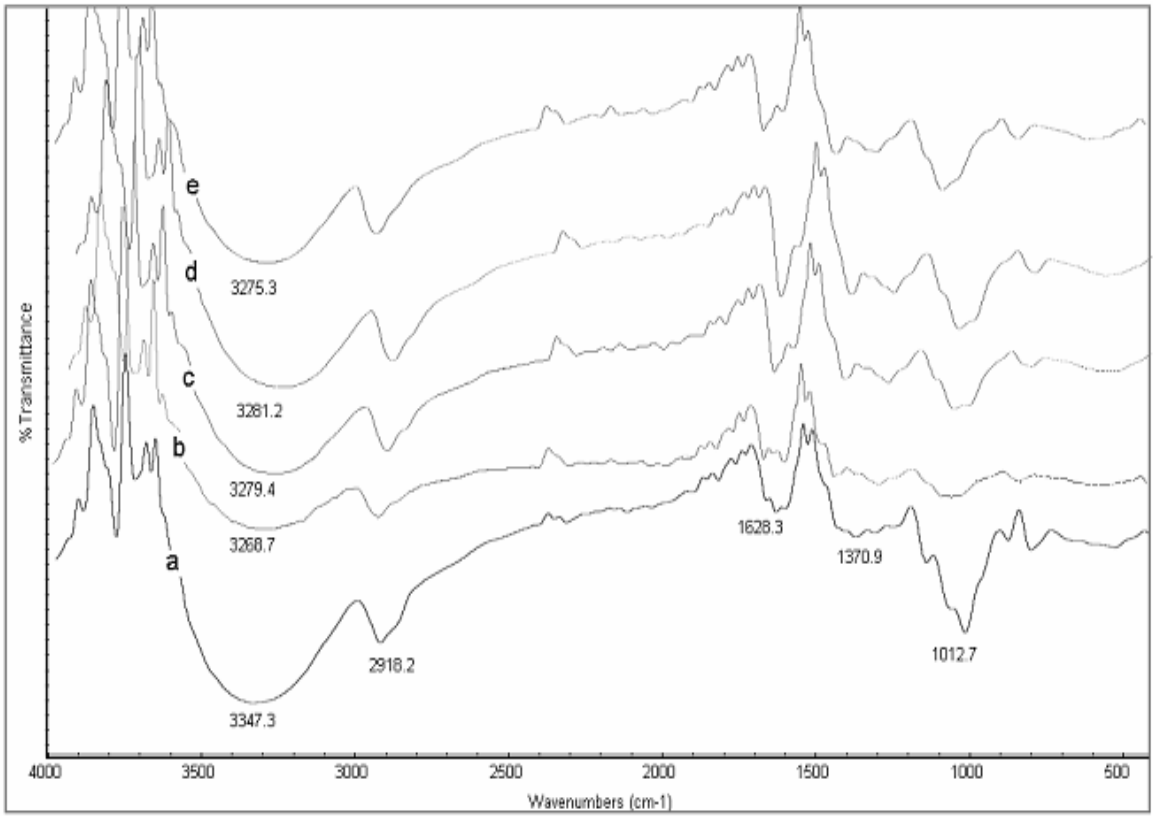

Figure 1: FTIR Spectroscopy for a) GG, b) 80/20 GG/PVA blend, c) 60/40 GG/PVA blend, d) 50/50 GG/PVA blend and e) PVA

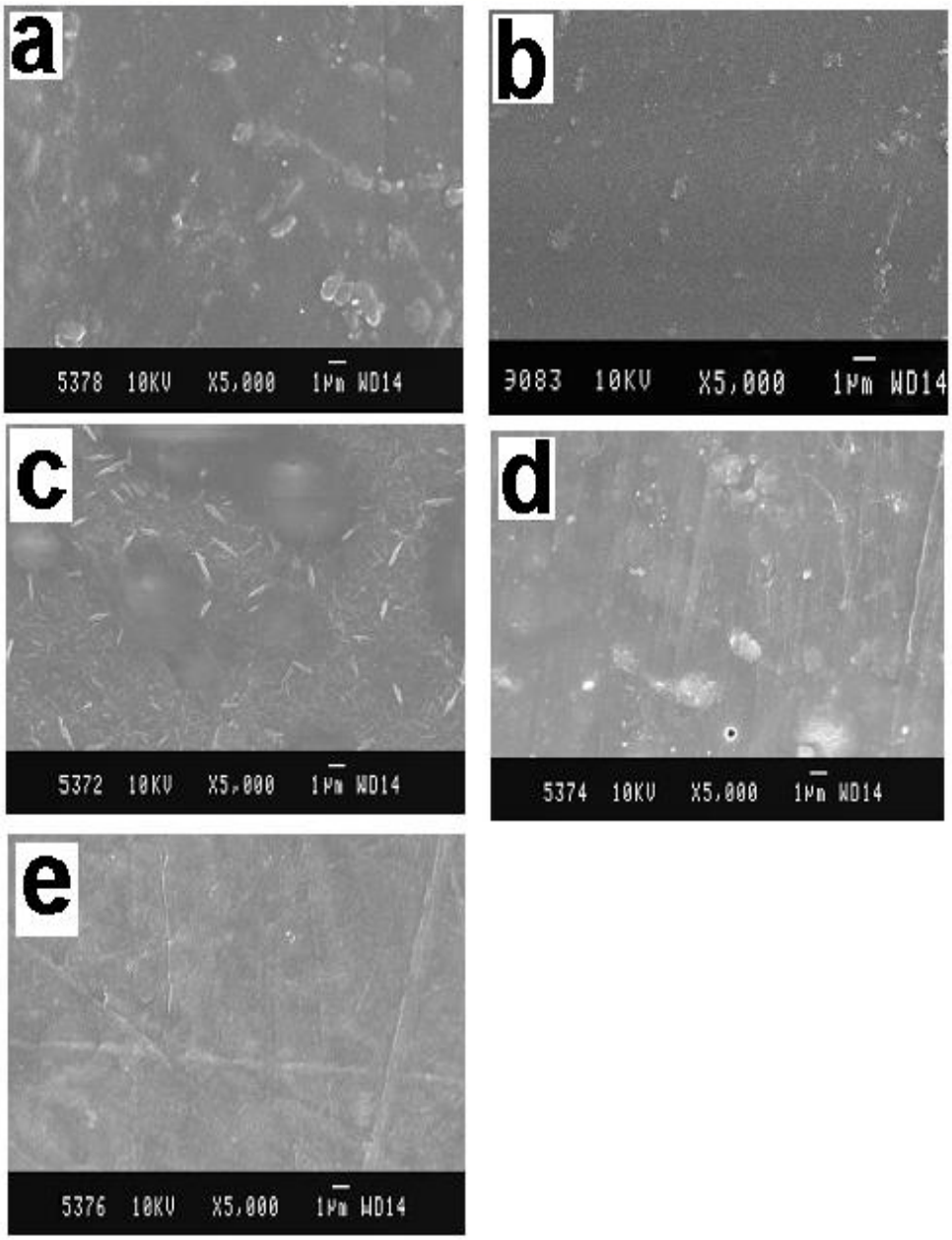

Figure 2: Scanning electron micrographs for (a) GG, (b) PVA, (c) 50/50 GG/PVA blend, (d) 60/40 GG/PVA blend and (e) 80/20 GG/PVA blend

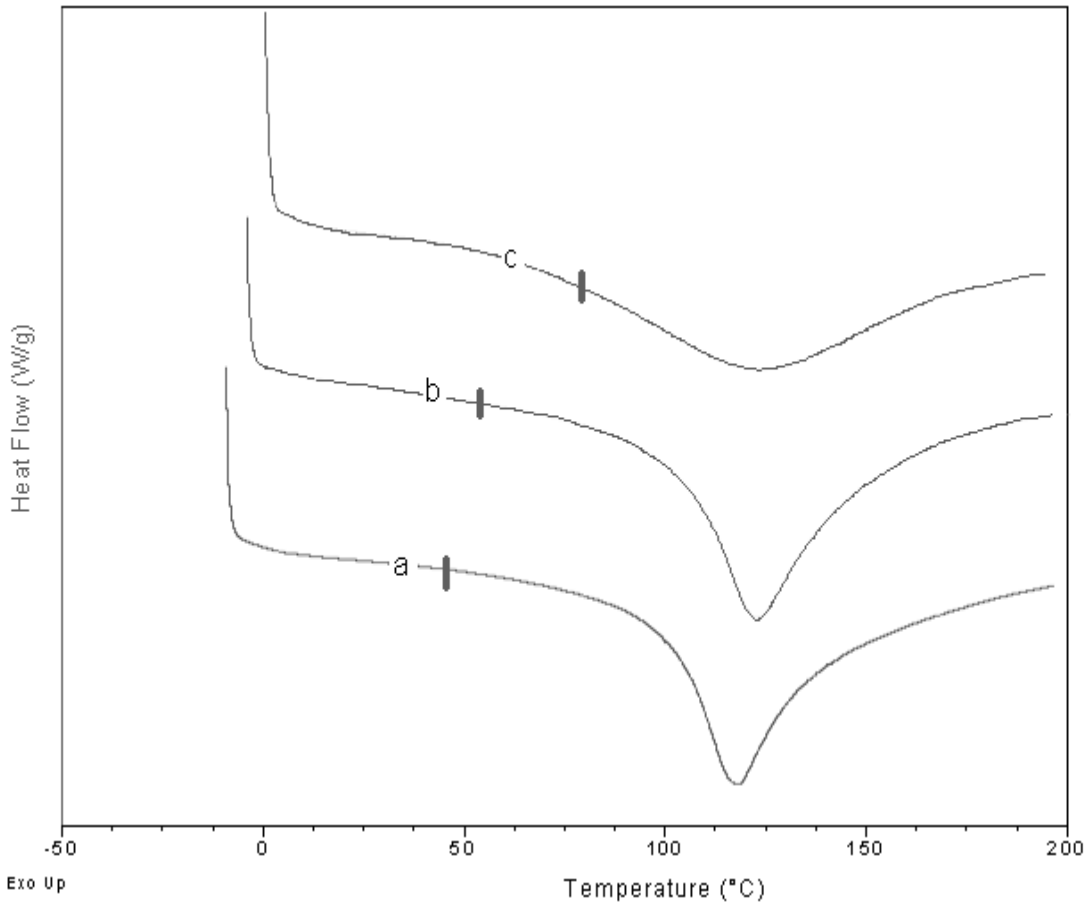

Figure 3: DSC traces of (a) GG, (b) 80/20 GG/PVA blend and (c) PVA

Table 1: Experimental and theoretical glass transition temperature (Tg) of GG/PVA blends

Blend comp. GG/PVA	Experimental Tg values (ºC)	Theoretical Tg values (ºC)		
		Fox equation	Wood equation	Pochan's equation
0/100	44.5	-	-	-
80/20	49.2	47.89	49.36	48.55
100/0	68.8	-	-	-

IV. CONCLUSION

Guar Gum/PVA blend thin films were prepared by solution casting method using distilled water as common solvent. The studies confirm that the polymer blend of Guar Gum/PVA is miscible only when the GG content is more than 60%. Below this critical GG concentration the blends were found to be immiscible. Homogeneity of miscible compositions of GG/PVA blends and specific intermolecular interactions of hydrogen bonding type were investigated by SEM, FTIR, and DSC analysis.

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