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ABSTRACT

The semi-miscible polymer blends of natural polymer guar gum and synthetic polymer poly (vinyl alcohol) have been studied for their compatibilization with biocompatible γ-Fe_2O_3nanoparticles. Ultrasonic velocity, density, adiabatic compressibility, and dilute solution viscometry studies at 30°C and 40°C has confirmed that γ-Fe_2O_3nanocomposites of GG/PVA blends are compatible. The presence of well-dispersed nanoparticles may have allowed the uncoiling of guar gum molecules to form intermolecular hydrogen bonding with PVA. The GG/PVA blend – γ-Fe_2O_3composites are potential candidates for biomedical applications.

Keywords: γ-Fe_2O_3nanoparticles, guar gum, PVA, biocompatibility, polymer blend-nanocomposites.

1. INTRODUCTION :

Guar gum (GG) obtained from guar bean (*Cyamopsistetragonoloba*) is a hydrophilic polymer. It has got applications in cosmetic and pharmaceutical industries [1-4]. Polymer blending [5-10] introduces new miscible/semi-miscible macromolecules with newer properties or with additive properties of the two or more polymers involved in it. The blending of guar gum with other polymers has been investigated by many researchers for their applications in biomedical engineering [11, 12]. Poly (vinyl alcohol) (PVA) is a synthetic biodegradable polymer and has been widely used in biodegradable packaging and biomedical industries [13, 14]. In our previous work, we have characterized the miscibility of GG/PVA blends in aqueous solution by reduced viscosity, density, adiabatic compressibility, and refractive index methods in aqueous solution [15] and the blend thin films were characterized by FTIR, SEM, and DSC methods [16]. The maghemite nanoparticles in the blend solutions may introduce potential drug release applications. Maghemite is an iron oxide nanomaterial with chemical formula γ-Fe_2O_3. These nanoparticles are used in biomedicine as they are non-toxic, and biocompatible. Even their magnetic property makes them a potential candidate for magnetic controlled drug delivery systems [17, 18].In this paper, the compatibility of natural polymer guar gum and a synthetic polymer poly(vinyl alcohol) at different compositions were studied by density, ultrasonic velocity, and viscosity measurement techniques in their dilute solution at 30ºC and 40ºC.

2. MATERIALS AND METHODS :

The polymers employed in the present study guar gum (GG), poly (vinyl alcohol) (PVA), and maghemite (γ-Fe_2O_3) were purchased from Merck, India. Blend – maghemite nanocomposites of GG/PVA (0.5 w/v of polymer and 0.02 wt% of maghemite) of different compositions were prepared by mixing aqueous polymer – maghemite composite solutions. Ultrasonic velocity (ν) was measured at 30ºC and 40ºC by an interferometric technique employing an ultrasonic interferometer (Mittal Enterprises, New Delhi) at frequency 2MHz. The densities (ρ) of the GG/PVA blend – maghemite nanocomposites were measured at 30ºC and 40ºC using specific gravity bottle. Different temperatures were maintained using a thermostat bath with a thermal stability of ± 0.05ºC. Adiabatic compressibility (βad) were calculated as per the equation: $\beta ad = 1/(v^2\rho)$.

Stock solutions of nanocomposites of GG, PVA, and their blends (10/90, 30/70, 50/50, 70/30, and 90/10) were prepared (0.1% w/v polymer, and 0.02 wt% maghemite) by stirring the mixtures at room temperature for about 45 minutes. Using the above pure and blend stock solutions, different blend solutions (0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09 and 0.1 w/v concentrations) were prepared and viscosity measurements were done at 30ºC and 40ºC using an Ubbelohde suspended level viscometer. Different temperatures were maintained using a thermostat bath with a thermal stability of ± 0.05ºC.

3. RESULTS AND DISCUSSIONS :

3.1Ultrasonic velocity, density, and adiabatic compressibility measurements

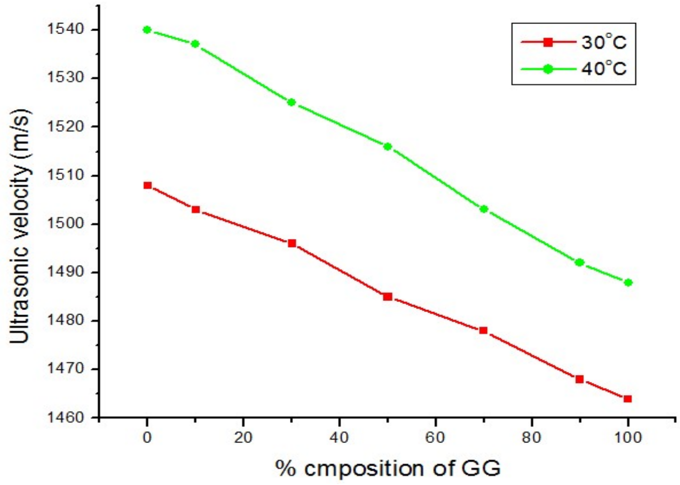

Fig.1: Variation of ultrasonic velocity with the composition of GG/PVA blend – maghemite nanocomposites in aqueous solution at 30°C and 40°C

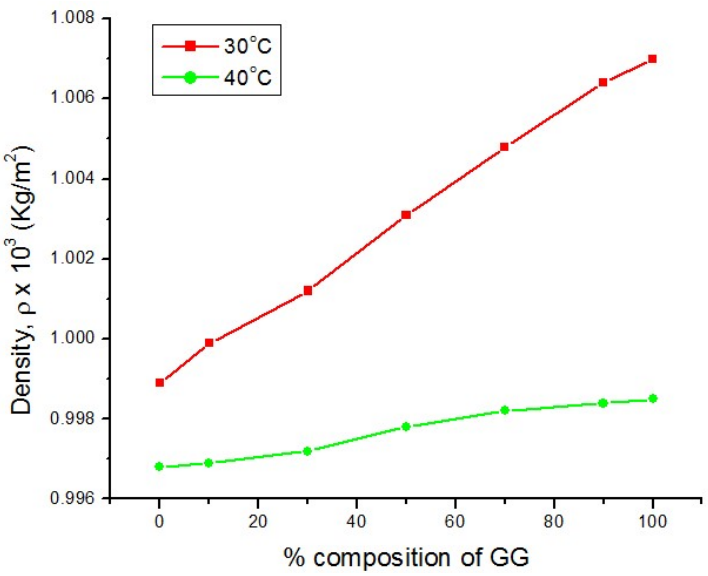

Fig.2: Variation of density with the composition of GG/PVA blend – maghemite nanocomposites in aqueous solution at 30°C and 40°C

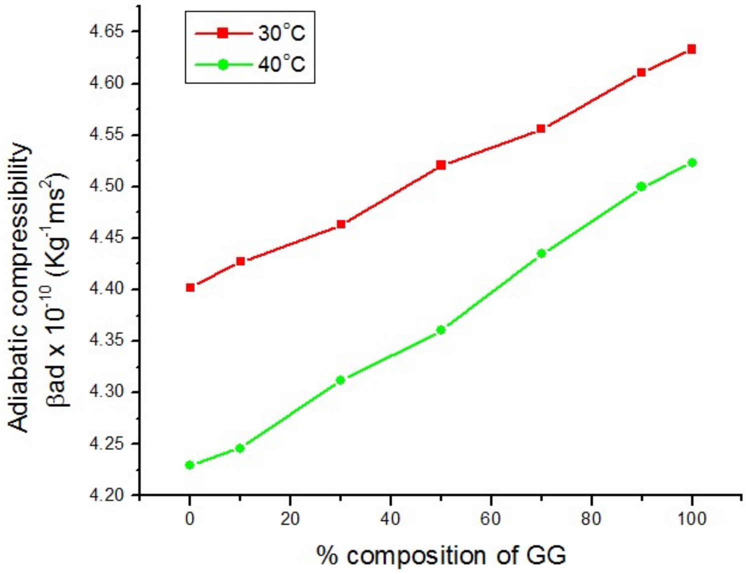

Fig.3: Variation of adiabatic compressibility with composition of GG/PVA blend – maghemite nanocomposites in aqueous solution at 30°C and 40°C

The ultrasonic velocity of PVA – maghemite nanocomposite solution is 1508 m/s, and 1540 m/s at 30°C and 40°C whereas for GG – maghemite nanocomposite solution it is 1464 m/s, and 1488 m/s, respectively. The density values were found to be 0.9989x10^3 Kg/$m^3$and 0.9968 x10^3 Kg/m^3 for PVA – maghemite nanocomposite and 1.007x10^3 Kg/m^3 and 0.9985x10^3 Kg/m^3 for GG – maghemite nanocomposite. The calculated adiabatic compressibility values are 4.40226 x10^{-10} $Kg^{-1}ms^2$ and 4.2301 x10^{-10} $Kg^{-1}ms^2$ for PVA – maghemite nanocomposite; and 4.63328 x10^{-10} $Kg^{-1}ms^2$ and 4.5232 x10^{-10} $Kg^{-1}ms^2$ for GG – maghemite nanocomposites. The ultrasonic velocity, density, and adiabatic compressibility values for the entire blend – maghemite nanocomposites were found to be composition dependent and all the plots (Figures 1, 2, and 3) were linear indicating compatibility [19-21] at 30°C and 40°C.

3.2 Reduced viscosity measurements

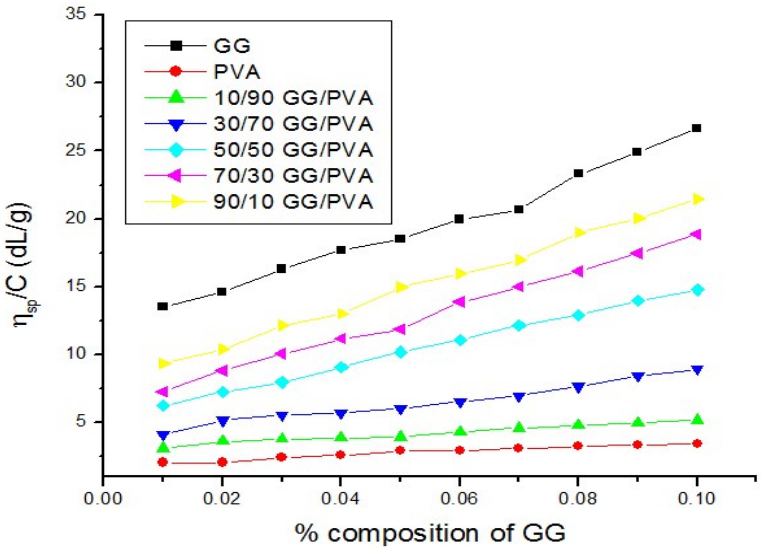

Fig. 4: Huggins's plot for 0.1% (w/v) GG/PVA blend – 0.02 wt% maghemite nanocomposites at 30°C

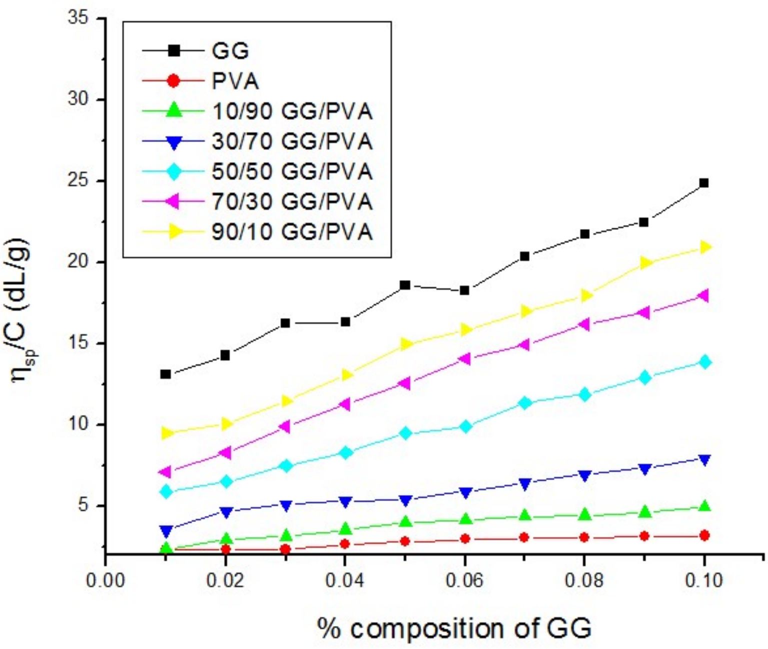

Fig.5: Huggins's plot for 0.1% (w/v) GG/PVA blend – 0.02 wt% maghemite nanocomposites at 40°C

Table 1: Slope values from Huggin's plots

Composition of GG/PVA blend – maghemite nanocomposites	30°C	40°C
0/100	16.206	10.903
10/90	21.545	26.818
30/70	48.969	43.084
50/50	96.096	89.757
70/30	126.230	122.193
90/10	135.200	131.509
100/0	142.721	122.793

Reduced viscosities of maghemite nanocomposites of GG, PVA, and their blend compositions (10/90, 30/70, 50/50, 70/30, and 90/10) were measured at 30ºC and 40ºC. Huggin's plots of reduced viscosities against concentrations are shown in Figures 4, and Figure 5, respectively.

The plots were linear. A higher slope variation for the entire blend – maghemite nanocomposites is attributed to the mutual attraction of macromolecules in solution which leads to the increase of hydrodynamic volume [22-24]. The temperature did not have any significant effect on the compatibility maghemite nanocomposites with GG/PVA blends.

4. CONCLUSION :

The plots of ultrasonic velocity, density, and adiabatic compressibility against blend – maghemite nanocomposite compositions found to be linear and composition-dependent. This indicates that the blends were compatibilized by the presence of maghemite nanoparticles. Based on dilute solution viscosity measurements it is confirmed that the entire blend – maghemite nanocomposite of guar gum and poly (vinyl alcohol) are compatible at 30ºC and 40ºC.The variation of temperature did not have any significant effect on the compatibility.

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