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ABSTRACT

Biocompatible polymer blends with natural polymer guar gum (GG), and a modified natural polymer carboxymethylcellulose (CMC) have been studied for their compatibilization with biocompatible maghemite magnetic nanoparticles. Ultrasonic velocity, density, and dilute solution viscometry methods were used to assess the intermolecular interaction between GG and CMC in the presence of maghemite nanoparticles at 30°C and 40°C. The solution state studies confirmed that GG/CMC blends are compatible in the presence of maghemite nanoparticle only if the GG content is more than 30% in the blend. These biocompatible polymer blend-maghemite nanocomposites can be used for their applications in controlled drug release formulations.

Keywords: Maghemite, Guar gum, Carboxymethylcellulose, Biocompatibility, Polymer blend – nanocomposites.

1. INTRODUCTION :

Polymer blending is a novel method to produce a new polymer system with improved properties for applications [1]. The properties of blends depend on their miscibility at the molecular level [2, 3]. Many water-soluble biocompatible blend systems were studied to record their miscibility nature [4-10]. Guar gum (GG) [11, 12] and carboxymethylcellulose (CMC) [13, 14] are useful polymers for their applications in drug release formulations. In our previous work, the miscibility of GG with CMC was extensively studied with refractive index, ultrasonic velocity, density, and dilute solution viscometry methods in aqueous solution [15], and the blend thin films were characterized for the presence of intermolecular hydrogen bonding by SEM, FTIR, and DSC measurements [16]. It was confirmed that GG/CMC blends are miscible when GG content is more than 60% in the blend.

The immiscible polymer blends can be made compatible with the addition of suitable compatibilizers. For the applications of the blend systems for drug release formulations the compatibilizer also must be biocompatible [17-19]. Maghemite is a biocompatible magnetic nanoparticle having potential application in controlled release formulations [20-23]. In this paper extended research work on the influence of maghemite magnetic nanoparticle on the properties of GG/CMC blends is studied with dilute solution viscometry, ultrasonic interferometry, and density measurements at 30°C and 40°C in aqueous solution.

2. EXPERIMENTALPROCEDURE :

The polymers employed in the present study are guar gum and carboxymethylcellulose, and the nanoparticle used is maghemite. All the chemicals were purchased from Merck, India. Distilled water was used for the experiments. 0.02 wt% of maghemite nanoparticles were added to the prepared polymer solutions and different blend – maghemite composite compositions (10/90, 30/70, 50/50, 30/70, and 10/90) were prepared with the total polymer concentration as 0.5% w/v. Ultrasonic velocity and density were measured at 30°C and 40ºC by an interferometric technique employing an ultrasonic interferometer (Mittal Enterprises, New Delhi) at frequency 2MHz and using specific gravity bottle, respectively. Different temperatures were maintained using a thermostat bath with the thermal stability of ± 0.05ºC.

Stock solutions of GG – maghemite composite and CMC– maghemite composite were prepared (0.1% w/v) with 0.02 wt% maghemite nanoparticles. The blend – maghemite composite stock solutions (10/90, 30/70, 50/50, 70/30, and 90/10) were prepared by stirring the mixtures at room temperature for about 45 minutes. Using the above pure and blend – composite stock solutions, different blend – nanocomposite 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 30°C and 40ºC using an Ubbelohde suspended level viscometer. Different temperatures were maintained using a thermostat bath with the thermal stability of ± 0.05ºC.

3. RESULTS AND DISCUSSIONS :

3.1 Ultrasonic velocity, density, and adiabatic compressibility measurements :

The experimental ultrasonic velocity values of GG – maghemite is higher compared to that of pure GG at both 30°C and 40°C. This may be due to the uncoiling of the GG molecule, whereas the CMC – maghemite composite showed almost similar ultrasonic velocity as that of pure CMC. The presence of maghemite increased the density value of both GG, and CMC. The variation of ultrasonic velocity, density, and adiabatic compressibility with the percentage composition of GG is given in Figures 1, 2, and 3, respectively. All these graphs show both linear and non-linear regions indicating the semi-miscible nature of the GG/CMC blend – maghemite composites. GG/CMC blends showed linearity for the blend compositions with more than 60% of GG in the blend [4-8]. With the compatibilization effect of maghemite the 30/70, 50/50, 70/30, and 90/10 blend compositions show linearity, whereas 10/90 blend composition got deviated from linearity compared with GG and CMC. Hence it indicates that with the presence of 0.02 wt% maghemite the GG/CMC blends are compatible when GG content is more than 30% in the blend.

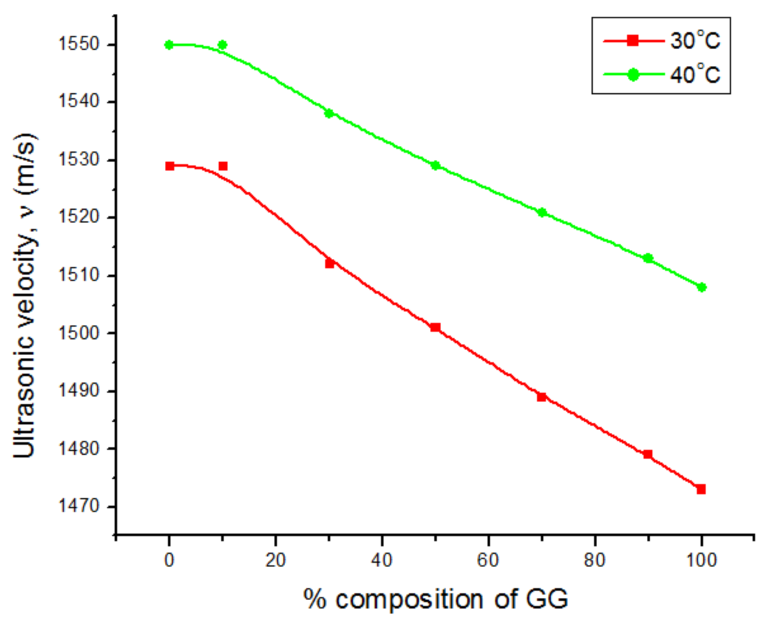

Fig. 1: Variation of ultrasonic velocity with a composition of 0.02 wt% maghemite nanoparticles composites with GG, CMC, and GG/CMC blends in aqueous solution at 30°C and 40°C

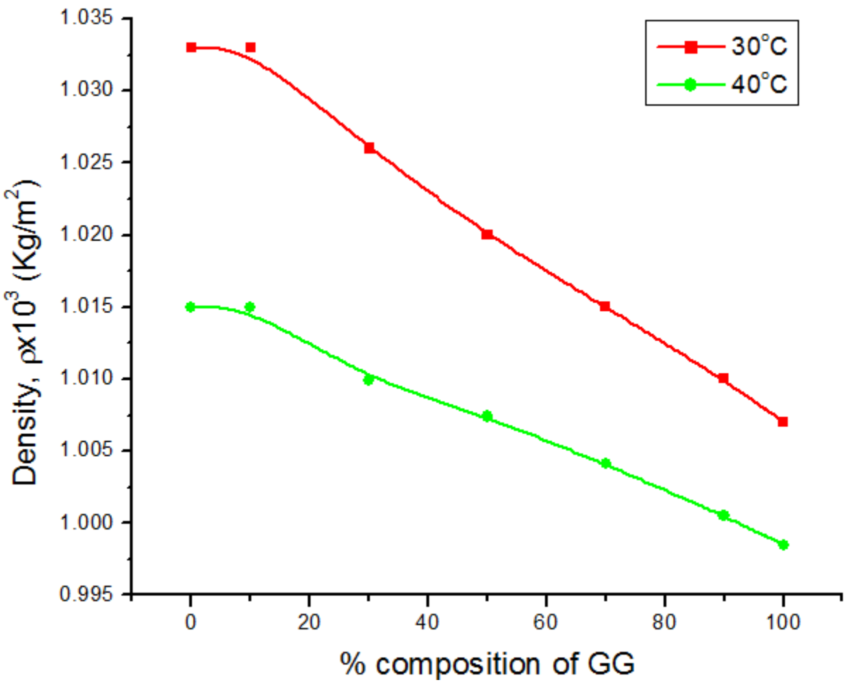

Fig. 2: Variation of density with a composition of 0.02 wt% maghemite nanoparticle composites with GG, CMC, and GG/CMC blends in aqueous solution at 30°C and 40°C

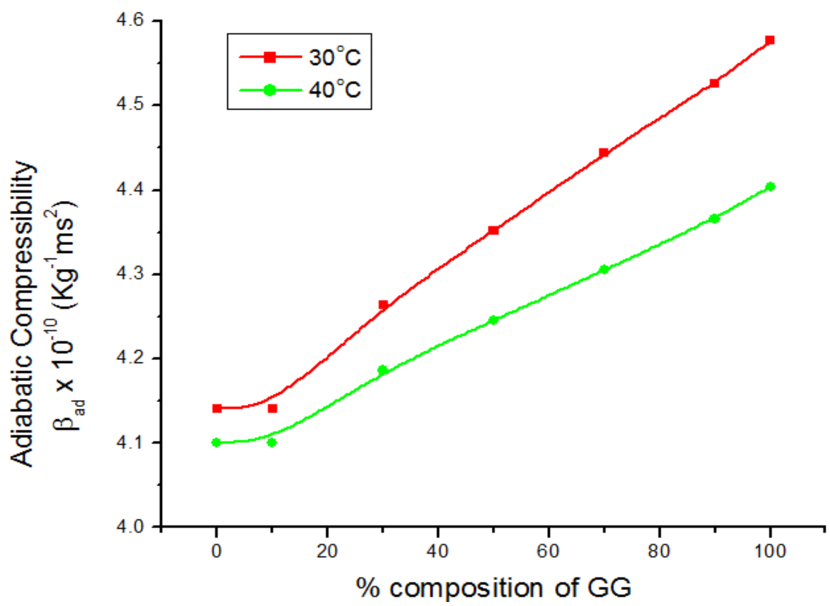

Fig. 3: Variation of adiabatic compressibility with the composition of 0.02 wt% maghemite nanoparticle composites with GG, CMC, and GG/CMC blends in aqueous solution at 30°C and 40°C

3.2 Reduced viscosity measurements :

Reduced viscosities of maghemite nanocomposites with GG, CMC, and their blend compositions (10/90, 30/70, 50/50, 70/30, and 90/10) were measured at 30°C and 40ºC. Huggin's plots of reduced viscosities of the pure polymer – maghemite nanocomposites and their blend – maghemite nanocomposite compositions against concentrations are shown in Figures 4, and 5, respectively.

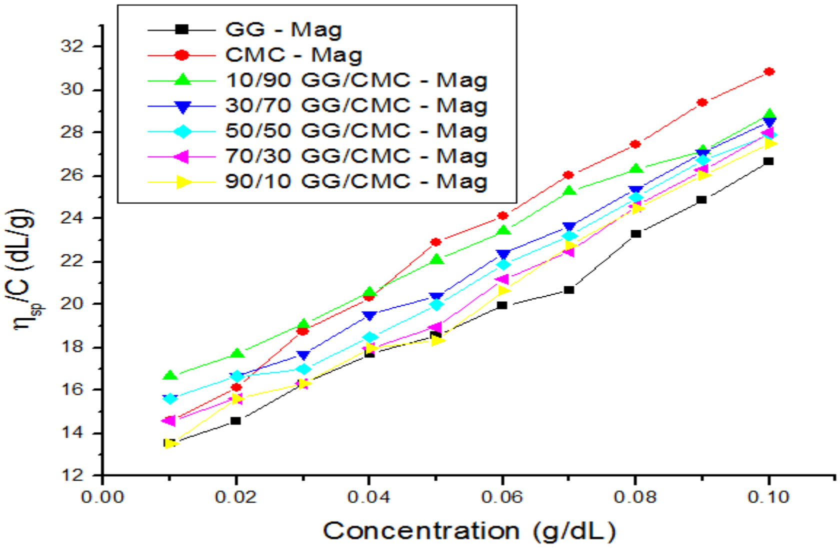

Fig. 4: Huggins's plot for 0.1% (w/v) GG/CMC blend – 0.02 wt% maghemite nanocomposites at 30°C

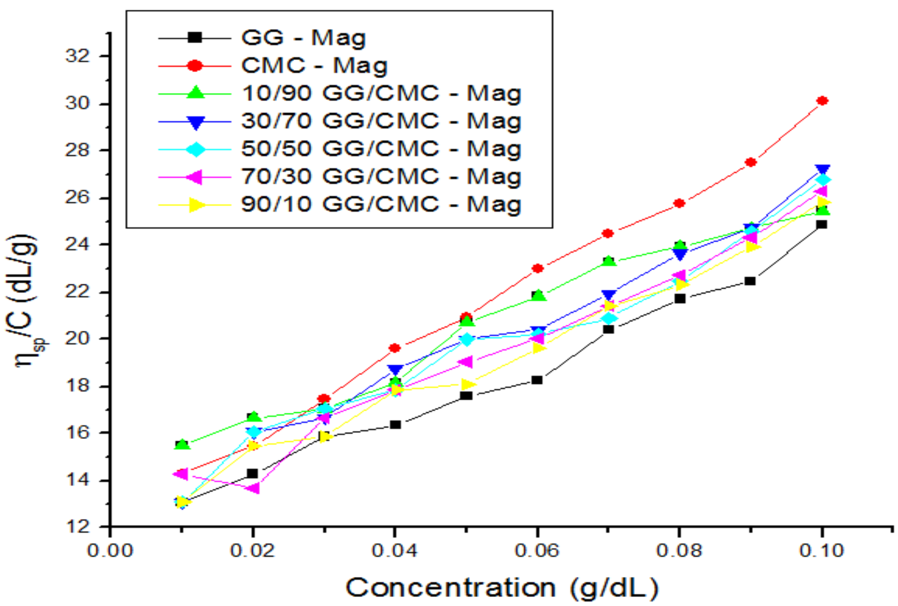

Fig. 5: Huggins's plot for 0.1% (w/v) GG/CMC blend – 0.02 wt% maghemite nanocomposites at 40°C

Table 1: Slope values from Huggins plots

Composition of GG/CMC blend – maghemite nanocomposites	30°C	40°C
100/0	142.721	124.557
90/10	155.212	132.400
70/30	153.163	136.157
50/50	143.703	132.957
30/70	146.690	141.284
10/90	138.000	119.678
0/100	182.430	169.709

The plots were linear. The slopes of the curves were measured and tabulated in Table 1. A higher slope variation for 90/10, 70/30, 50/50, and 30/70 compositions are attributed to the mutual attraction of macromolecules in solution which leads to the increase of hydrodynamic volume [24-27]. The 10/90 compositions showed a lower slope may be due to the phase separation of polymers. According to the criterion of reduced viscosity-concentration, this polymer blend should be compatible with 90/10, 70/30, 5/50, and 30/70 compositions and incompatible for 30/70 compositions.

4. CONCLUSION :

Based on viscosity, ultrasonic velocity, and density measurements, it is found that the incorporation of maghemite magnetic nanoparticles improved the miscibility/compatibility of a polymer blend of Guar Gum/CMC. The blend – maghemite nanocomposites are compatible when the GG content is more than 30%. Below this critical GG concentration the blend – maghemite nanocomposites were found to be immiscible. Hence GG/CMC blend – maghemite nanocomposites in aqueous solution at 30ºC and 40ºC is semi-miscible in nature. The variation of temperature did not have any significant effect on the miscibility/compatibility.

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