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Miscibility Studies of Hydroxypropyl Methylcellulose/Poly(ethylene glycol) Blend in Water by Viscosity, Density, Refractive Index and Ultrasonic Velocity Methods

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ABSTRACT

The miscibility of hydroxypropyl methylcellulose/poly(ethylene glycol) (HPMC/PEG) blends in water was studied by viscosity, density, ultrasonic, velocity and refractive index techniques at laboratory temperature. Using viscosity data, the interaction parameters ΔB, μ and α were calculated. These values revealed that HPMC/PEG blends are immiscible at all compositions except 50/50 compositions at laboratory temperature. Hence, the blend system HPMC/PEG is found to be partially miscible. In addition, the adiabatic compressibility β_{ad} and intermolecular free length L_f were also computed.

Key words: *Blends, Miscibility, Interactions, Ultrasonic velocity, Refractive index.*

1. INTRODUCTION

Ultrasonic method is a tool in interdisciplinary sciences and the added advantages of being less costly with more efficiency comparable to other techniques. Ultrasonic technique is one of the basic non-destructive methods for the evaluation of materials and structures. The effect of ultrasound in polymerization reactions, organic synthesis, electropolymerization, electroplating, and electrosynthesis has been exploited to good effect. Volumetric properties of binary mixtures are complex properties because they depend not only on solute-solvent interactions but also of structural effects arising from interstitial accommodation due to the difference in molar volume and free volume between the components present in the solution [1]. Ultrasound involves various ranges power waves, low power waves which pass through materials without affecting their physical or chemical structures, however, very high-intensity ultrasound can be used to cause chemical and physical change in materials.

2. EXPERIMENTAL

2.1.Materials

Hydroxypropyl methylcellulose (HPMC) of 4000 Mpas, poly(ethylene glycol) (PEG) 6000 flaks average molecular weight 5000-7000.

2.2. Preparation of Blend Solutions

The 1% polymer solutions of HPMC and PEG in water have been prepared. The blends of different compositions (10/90, 20/80, 30/70, 40/60, 50/50, 60/40, 70/30, 80/20, and 90/10) of different concentrations (0.02%, 0.04%, 0.06%, 0.08%, and 0.1%), (i) The ultrasonic velocities of blend solutions with different compositions were measured at laboratory temperature using ultrasonic interferometer, (ii) the refractive indices were measured using Abbe's refractometer, (iii) the density measurements were done by specific gravity bottle, and (iv) viscosity measurement were made using Ubbelohde suspended level viscometer. The Chee's interaction parameters ΔB, μ (Equations 1 and 2) and Sun *et al*.; interaction parameters α (Equation 3) shown below are the evidence for the miscibility of polymer blends (Table 1).

$$\Delta B = \frac{b - b^{-}}{2w_1 w_2} \quad (1)$$

$$\mu = \frac{\Delta B}{\{[\eta]_1 - [\eta]_2\}^2} \quad (2)$$

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Table 1: Data of ΔB, μ, α, β_{ad} and L_f for HPMC/PEG blends of different compositions.

Composition A – HPMC B – PEG A/B	ΔB	μ	α	$\beta_{ad}\times10^{-7}$	$L_f\times10^{-13}$
10/90	−297.913	−35.424	−1.120	4.337	8.587
20/80	−272.079	−32.352	−0.340	3.949	7.819
30/70	−281.543	−33.477	−0.1356	4.336	8.585
40/60	−315.203	−37.479	−0.0512	4.409	8.730
50/50	−364.578	−43.350	+0.0139	4.372	8.657
60/40	−429.163	−51.030	−0.0041	4.403	8.718
70/30	−569.336	−67.697	−0.0012	4.302	8.518
80/20	−841.965	−100.116	−0.0022	4.492	8.894
90/10	−1658.928	−197.256	−0.0099	4.397	8.706

HPMC=Hydroxypropyl methylcellulose, PEG=Poly (ethylene glycol)

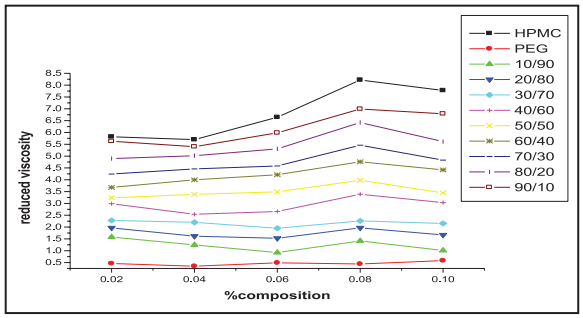

Figure 1: Huggin's plot hydroxypropyl methylcellulose/poly(ethylene glycol) blends.

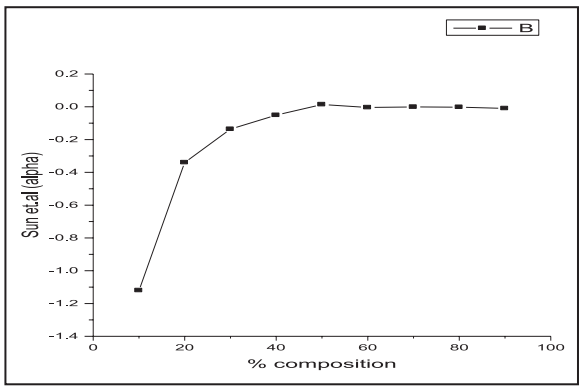

Figure 2: Sun *et al*.; interaction parameter (α).

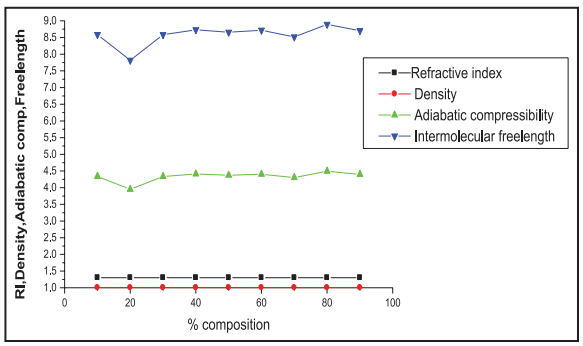

Figure 3: Refractive index, density, β_{ad} and L_f.

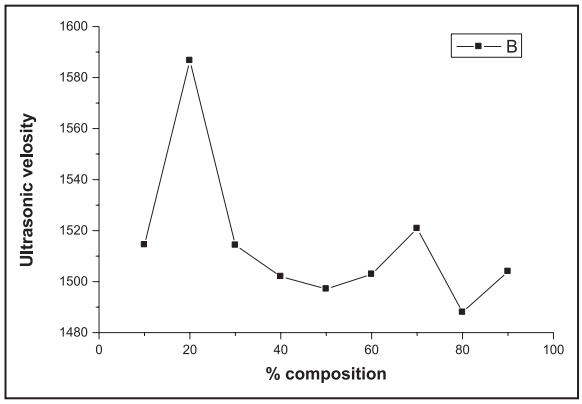

Figure 4: Ultrasonic velocity of hydroxypropyl methylcellulose/poly(ethylene glycol) blends.

$$\alpha = K_m - \frac{K_1[\eta]_1^2 w_1^2 + K_2[\eta]_2^2 w_2^2 + 2\sqrt{K_1K_2}[\eta_1][\eta_2]w_1w_2}{\{[\eta]_1 w_1 + [\eta]_2 w_2\}^2} \quad (3)$$

If ΔB, μ and α > 0, the blend is miscible. If ΔB, μ and α < 0, the blend is immiscible.

3. RESULTS AND DISCUSSION

3.1. Viscosity Studies

The reduced viscosity v/s concentration (Huggin's plots) curves for the blends of HPMC/PEG of different compositions at laboratory temperature in water are as shown in Figure 1. It was well established earlier by many workers [2-7]. The viscosity data reports that the polymer blends of HPMC/PEG are found to be immiscible at all compositions except 50/50% of HPMC/PEG at laboratory temperature (Figure 2). The density and refractive index studies revealed that the blend is miscible at all compositions (Figure 3). Whereas the ultrasonic velocity measurements deal with the blend is found to be non-linear (Figure 4), hence the blend is immiscible at all compositions at laboratory

temperature. In addition, adiabatic compressibility (β_{ad}) and intermolecular free length (L_f) have not affect on HPMC/PEG concentrations and compositions at laboratory temperature (Table 1 and Figure 3). The miscibility of HPMC/PEG blends is due to the secondary interaction such as hydrogen bond between hydroxyl group of HPMC with the hydroxyl groups of PEG [4].

4. CONCLUSIONS

The miscibility of HPMC/PEG blends in water has been studied by solution methods such as viscosity, density, ultrasonic velocity, and refractive index techniques at laboratory temperature. Using viscosity data interaction parameters such as ΔB, μ and α were computed. These values revolved that the blend is immiscible at all compositions except 50% of HPMC content at laboratory temperature.

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***Bibliographical Sketch**

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