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Electrical Conductivity of Polymer Blends of poly (styrene): poly (vinyl acetate)

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Abstract

The objective of this study is to determine the Electrical conductivity and Dielectric constant of the poly (styrene) when blended with poly (vinyl acetate) measured at different temperatures (313K, 323K, 333K and 343K) and at the different frequencies (1KHz to 1MHz) using 4284 LCR meter. It is found that a c conductivity of thin film varies with temperature for all values of frequencies and it varies with increase in frequencies at constant temperature. The dielectric constant also varies with the increasing of the temperature of blends. In this blend the miscibility exists as evidenced by FTIR spectroscopy.

Keywords: Polystyrene (PS), Polyvinyl acetate (PVAc), Miscibility, AC Conductivity, Dielectric Constants.

Introduction

Polymer blending is one of the most important contemporary ways for the development of new polymeric materials. Polymeric materials are uniquely recognized by its applications of everyday life as well as in high-technology industries such as electronics, aerospace and medicine. So that polymeric materials have been of great research interest in the past few years because of its importance in applications in many areas. The relationship between their molecular structures and their behavior as materials has been the subject of extensive theoretical and experimental study for many decades. These extensive properties studied by using different solvents during synthesis of polymeric materials.

Beth A. Miller-Chou [1] studied effects of different solvents and additives with his co-worker. So conclude that the properties of the solvents used in these processes are critical for surface formation in these polymers. Solvents properties such as polarity, volatility and specific interaction properties with the polymer material are important factors in the process of surface formation. The polymer blends composed of polystyrene (PS) and poly (vinyl acetate) (PVAc) have been widely investigated. The copolymer of PS and PVAc is a typical amphiphilic system in which the PS segment is hydrophobic and the PVAc segment is hydrophilic. Much research has been performed on the graft copolymer of PS and PVAc, including its micelle behavior [2].

Mohammed et al [3] studied the phase separation process of the polymer blend thin films. In this they made effort to synthesized polystyrene in toluene at a 4% solution concentration. AFM of polystyrene gives the detailed information about the topographical features and the mechanical phase shift imaging of the sample. This phase shift can be correlated with specific mechanical properties which affect sample interaction confirmed by quantitatively measuring the value of the dielectric permittivity [3].

The present paper focused on studies of solvent effects in AC electrical conductivity and dielectric constants at different temperature of polyblends (PS-PVAc). Polymer blends solutions systems are discussed.

Methodology

Poly (styrene) and Poly(vinyl acetate) were supplied by SIGMA –ALDRICH, Co., 3050 spruce street, St. Louis. MO 63103 USA 314-771-5765. Tetrahydrofuran (THF-E-Merck India Ltd., Mumbai) is being used as a solvent for polyblending process. In the present work, thin films were prepared by isothermal evaporation technique.

1. Preparation of blends

Poly (styrene) and poly(vinyl acetate) were dissolved in tetrahydrofuran (THF). Stirring was continued for one hour before deposition of film. Total concentration of the polymeric mixture in solvent was kept 5%. Films of polymer blends were prepared by isothermal evaporation technique.

2. Measurements

FT-IR measurements were carried out using the single beam FT-IR [Agilent Technologies, Singapore]. The FT-IR spectra of all samples are in the range of 700-3800 cm^{-1}. The ac frequencies were applied (in the range 1 KHz – 1 MHz) across the sample by using the 4284 A precision LCR meter (20 Hz –1 MHz) [Agilent Technologies, Singapore].

Result and Discussion

1. FT-IR Spectroscopic Analysis

Fourier transform infrared (FTIR) spectroscopy is one of the widely used optical methods to study the interaction of electromagnetic radiation in the infrared region with chemical compounds.

The FTIR spectrum of pure PS polymer in the frequency range 700 – 3800 cm^{-1} is shown in **Figure 1 (a).** It is known that; PS consists of alternating methylene and methane groups. However, each repeat unit in PS contains a pendant benzene ring. The main PS characterizing bands are observed. The methylene (CH_2) asymmetric stretching bands are observed at 2920.86 cm^{-1}. There is a C=O stretchingat 1727.65 cm^{-1}. The out-of-plane C–H bending mode of the aromatic ring is shown at 796 $cm^{-1}$and the ring-bending vibrational band appears at 693 cm^{-1}[7].

Figure 1 (b) which is FTIR spectrum of pure PVAc, it is observed from the spectrum reported by Elashmawi and Hakeem [8] is similar to our spectrum. For pure PVAc, the vibrational bands observed at 2926 and 2694 cm^{-1} are ascribed to O–CH_3 (ester group) asymmetric stretching and symmetric stretching vibrations, respectively. The intense band at around 1728.62 cm^{-1}represents the C+O stretching band of an unconjugated ester. At 1369cm^{-1}, a prominent band is evident, here the CH_3 (C=O) group strongly absorbs acetate esters. The strong band at 1223 cm-1and the band at 1114.97 cm-1are ascribed to C–O–C symmetric stretching and C–O stretching vibrations, respectively. Also, the peak at 943cm-1is ascribed to CH bending vibrations.

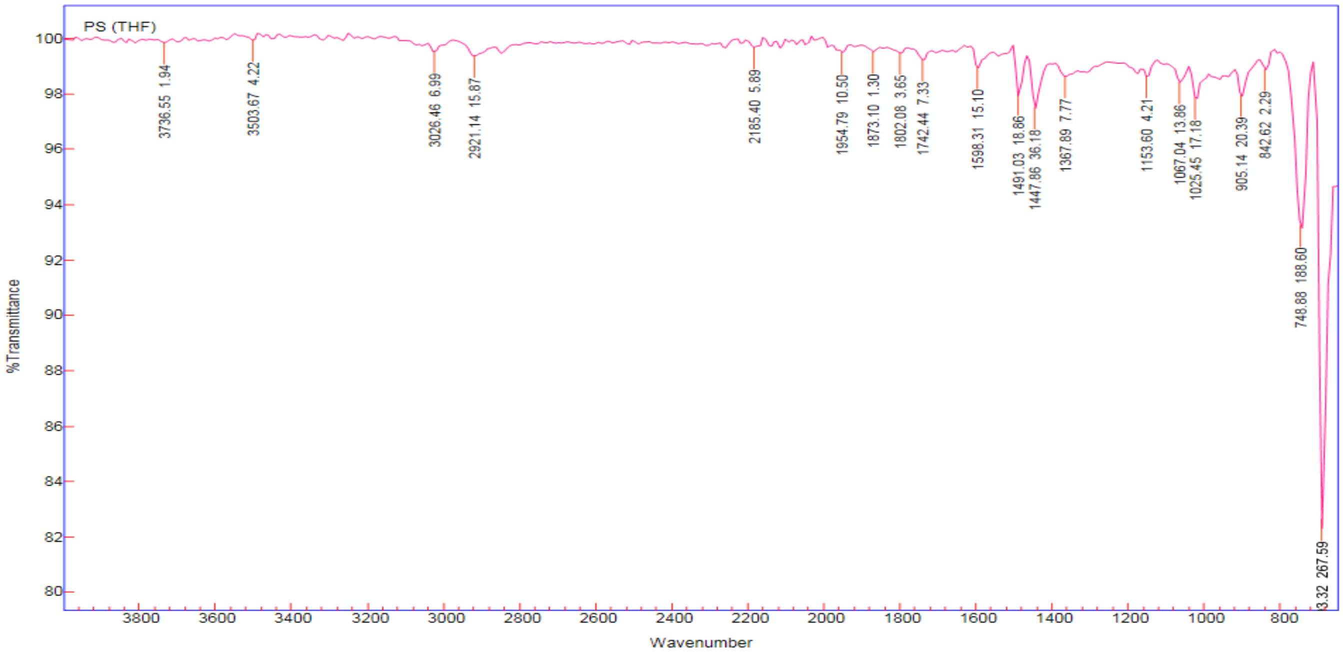


Fig.1 (a) FTIR of Pure PS

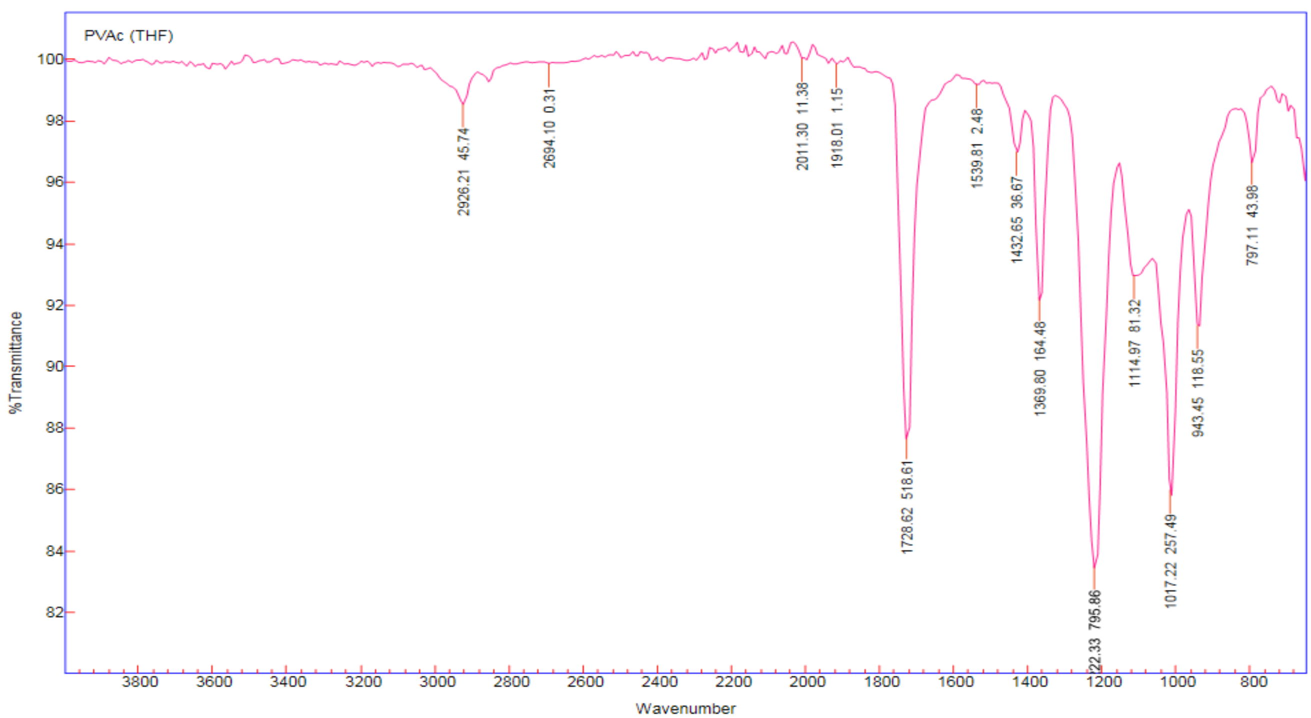
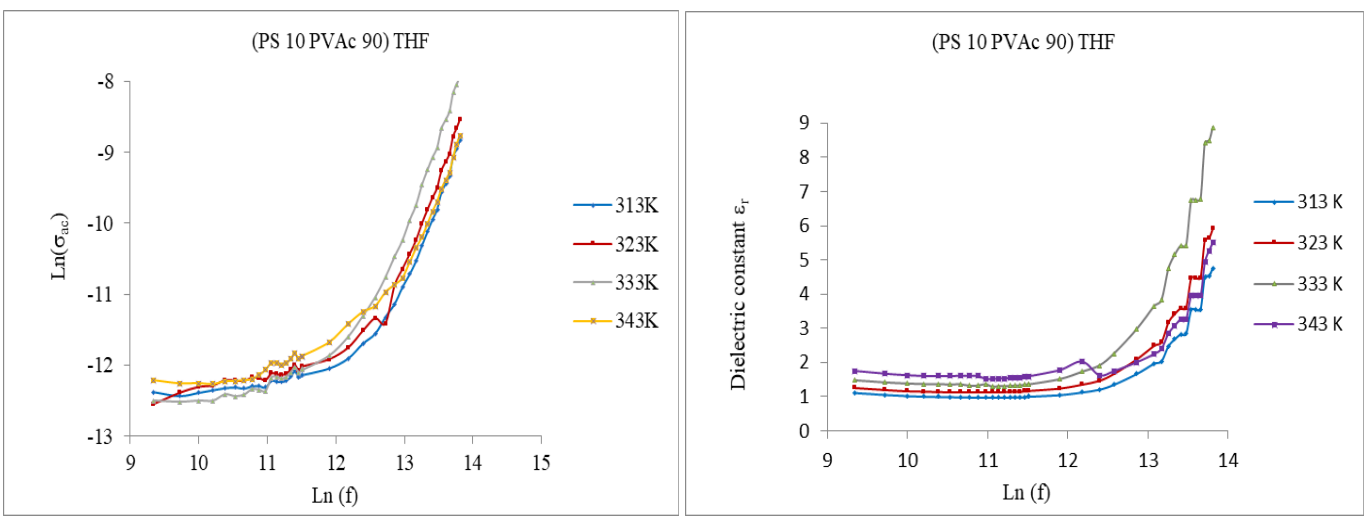


Fig.1 (b) FTIR of Pure PVAc

Fig.1 (c) FTIR of PS+ PVAc Polyblends



(a) **(b)**

Fig 2 (a): Variation between Ac Conductivity and Frequency at Different Constant Temperatures. (b): Variation between Dielectric Constant and Frequency at Different Constant Temperatures.

Figure 1 (c) Which is FTIR spectrum of PS+PVAc polyblends. For a blend it is observed from the spectrumthat C=O stretching at 1727 cm^{-1} and C-C stretching in aromatic ring found at 1433 cm^{-1} and typical C–H bend being usually present as band at 1369 cm^{-1}. Some bands are disappeared in the blends and the intensity of some bands was changed. All results data suggest that homogeneous polymer composites are formed over all the blend compositions.

2. AC Electrical Conductivity and Dielectric Constant Studies

Figure 2 (a) shows the relation between ac conductivity and frequency at different constant temperatures 313K, 323K, 333K and 343K. Plot shows rise in conductivity with increasing frequencies from 1 KHz to 1MHz. The rise of conductivity upon increasing the frequency and temperature is a common respond for polymeric and semiconductor samples. It is due to the tremendous increase of the mobility of charge carriers in the composite film i.e. at higher frequencies blends of molecules starts vibrating with large amplitude within the polymeric chains hence the effect of increase in conductivity of blends [9,10].

Figure 2 (b) shows the relation between dielectric constant and frequency at different constant temperatures 313K, 323K, 333K and 343K. Plot shows rise in dielectric constant with increasing frequencies from 1 KHz to 1MHz. The rise of dielectric constant upon increasing the frequency and temperature is a common respond for polymeric and semiconductor samples [11]. It is due to the tremendous increase of the mobility of charge carriers in the composite film i.e. at higher frequencies blends of molecules starts vibrating with large amplitude within the polymeric chains hence the effect of increase in conductivity of blends [12].

Conclusion

AC electrical conductivity and dielectric constants have been measured at different temperatures and at the different frequencies, it is found that ac conductivity of thin film increases with increase in temperature for all values of frequencies and it increases with increase in frequencies at constant temperature and also the dielectric constant increases with the increasing of the temperature of blends. Hence in this blend the miscibility exists.

Conflicts of interest: The authors stated that no conflicts of interest.

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