



Solvent induced miscibility between polymers, and its influence on the morphology, and mechanical properties of their blends

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ABSTRACT

Solvent dependent miscibility, morphology, thermal, and mechanical behavior of polystyrene (PS) + poly (styrene-co-acrylonitrile) (PSAN) blend films cast from dimethyl formamide (DMF), and chloroform (CHCl_3) solvents, were examined by scanning electron microscopy (SEM), Fourier transform infra-red (FTIR) spectroscopy, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and tensile testing techniques. Morphological analyzes revealed better interfacial adhesion between the blend components in DMF than CHCl_3 . Almost no signs of miscibility were detected in PS/PSAN blends irrespective of the type of casting-solvent by FTIR probably due to very weak intermolecular interactions. All the blend films, irrespective of the type of solvent, showed two glass transition temperatures that were composition-dependent in the case of PS + PSAN from DMF. However, in the case of PS/PSAN/chloroform blend system, almost all the blend compositions retained the T_g values of their components. The T_g results suggested partial miscibility of the components in the DMF and almost immiscibility in the CHCl_3 . Thermal degradation behavior also verified DSC results as PS/PSAN/DMF blend film having composition, 25/75 indicated greater thermal stability than the neat polymers, and other blend compositions. However, in the case of PS + PSAN from chloroform, all the blend compositions were thermally less stable as compared to the neat polymers. Mechanical properties also corroborated SEM, DSC, and TGA results for both the blend systems thereby confirming partial miscibility of PS + PSAN from DMF, and immiscibility of PS + PSAN from chloroform blend systems.

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1. Introduction

Polymer blending is an attractive method to obtain materials with tailored properties without manufacturing absolutely new polymers or copolymers [1–6]. The main purpose of blending is to attain synergism in the final properties of the resulting blend. The end properties of the resulting blend depend on the degree of miscibility between components, composition, solvent, and morphology of the blend. Many efforts have been made to understand miscibility of the blend components, in which the thermodynamic interaction between constituent polymers

is of prime significance. Studies on the solvent cast blends are quite large but only limited number is dedicated to study the effect of casting solvent on properties of the resulting blends [7–12]. Keeping in view this, we decided to correlate our solution state studies [13] with the solid state investigations in order to examine the effect of casting solvents on the miscibility, morphology, thermal, and mechanical properties of the polystyrene (PS) and poly(styrene-co-acrylonitrile) (PSAN) blend films. The techniques used for this purpose include scanning electron microscopy (SEM), Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and tensile tests. PS has been very successfully used in packaging, building, construction, and in injection moldings applications for

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many years. PS is a clear, hard, easily processed and low cost amorphous polymer. PS is also used in electrical/electronic, automotive, and industrial films applications [14,15]. However, PS has some demerits like low impact strength, poor chemical, and oil resistance properties [16].

On the other hand PSAN is also a thermoplastic with several exciting properties such as high transparency, excellent gloss, high mechanical strength, good chemical, and oil resistance [17]. Moreover, PSAN is widely used in many applications in the household and sanitary sectors, for packaging cosmetic products as well as for electronic and office items [18]. Large industrial batteries fitted with lead electrodes and filled with sulfuric acid having a service life of more than ten years is the extraordinary evidence of PSAN's resistance to chemicals [19]. Polystyrene (PS) and poly(styrene-co-acrylonitrile) (PSAN) are known to produce partially miscible or immiscible polymer blends in different solvents [13,20,21]. The origin of interaction responsible for partial miscibility is unknown but has been suggested to be related to phenyl rings coupling and homopolymer-copolymer pair unfavorable "repulsive" segmental interaction [22–24].

It is, therefore, expected that the PS + PSAN blend will be a better material resulting in the enhancement of the mechanical strength, and chemical resistance of PS, and thus will be a promising material regarding oils resistance in the food and locomotive industries.

2. Experimental

2.1. Materials

Polystyrene (PS) and poly (styrene-co-acrylonitrile) (PSAN), used during this study were procured from Aldrich (USA). Dimethyl form amide and chloroform were purchased from Fluka (Germany) and Acros (Spain),

respectively. Both the solvents used during this investigation were of analytical grade and used as received. The information regarding structure and molecular mass of polymers and the solvents are provided in Table 1.

2.2. Preparation of blends

PS/PSAN blends were prepared by solution casting technique using DMF, and CHCl_3 as common solvents. Solution of PS, PSAN and their blend were prepared in various mass ratios by the dissolution of required amount of component polymers separately in DMF and CHCl_3 at a concentration of 5.0 g/dL at ambient temperature. The resulting blend solutions were stirred for 24 h at ambient temperature using magnetic stirrer to ensure thorough mixing and better homogeneity. The mixtures were subsequently cast onto a clean, dry and smooth glass plate one by one for films formation of each solvent. The cast films were first dried under ambient conditions, at low evaporation rate in order to avoid film cracking and then peeled off from the glass plate for further drying under the vacuum in an oven at 60 °C for 72 h in order to remove completely the residual solvents.

2.3. Characterization of polymers and their blends

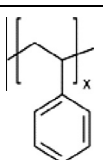
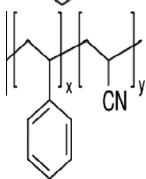
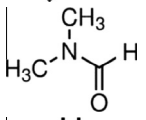
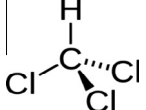
2.3.1. Scanning electron microscopy (SEM)

The morphological characterization of the samples, after sputter coating their surfaces with gold, was carried out using Scanning electron microscope, LEO 440i with EDS attachment.

2.3.2. Fourier transforms infrared (FTIR) spectrometry

Fourier transforms infrared spectrometry was used to find out the intermolecular interaction between the blend components. The spectra of samples were obtained using

Table 1
Information about the polymers and solvents used during the investigation.

Chemicals	Structure	M. mass	Source
Polystyrene (PS)		1.87×10^5	Aldrich (USA)
Poly(styrene-co-acrylonitrile) (PSAN) (AN contents 25 wt.%)		1.96×10^5	Aldrich (USA)
N,N-dimethyl form amide		73	Fluka (Germany)
Chloroform		119.5	Acros (Spain)

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