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Influence of Polymeric Plasticizer on Mechanical Properties of Poly (vinyl chloride) Films

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Research Article

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***For Correspondence:**Department of Materials Science,
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574 199, Karnataka, India.**Keywords:** PVC, PEG, binary blend,
morphology, tensile properties.**ABSTRACT**

Polymeric plasticizer doped in different weight percent poly (vinyl chloride) films was prepared by solution blending and solvent evaporation technique. The tensile properties of the doped films containing different weight percent of PVC/PEG were characterized using universal testing machine (UTM). Tensile strength and young's modulus of blend films decreases and elongation at break increases compared to the pure PVC film. Phase morphology of polymeric plasticizer incorporated PVC films were investigated using scanning electron microscopy (SEM).

INTRODUCTION

Polymer blends are the physical mixtures of two or more homopolymer, copolymers, which interact with secondary forces such as hydrogen bonding with no covalent bonding. Polymer blends are getting importance by providing many useful properties, which are the results of a combination of properties of the individual components [1]. Polymer blends are mainly classified as homogenous blends, in which the components are miscible, and heterogeneous blends, in which the components are immiscible. Most polymer pairs are immiscible due to the positive enthalpy change of mixing and a negligible entropic contribution to free energy of mixing, the resulting high interfacial tension and poor adhesion often leading to poor mechanical properties [2]. The final properties of the blends mainly depend on the properties of the constituent polymers and also on the phase morphology developed during blending [3]. Poly (vinyl chloride) (PVC) is a chemically and mechanically stable polymer that can be easily processed and is mainly used as construction material, rigid pipe, flooring, wire and cable insulation, house wares, packing films, sheets etc. [4]. PEG has many industrial applications like lubricants, binders, carriers, solvent, and coatings in the cosmetics, pharmaceutical, paper, food, textile, and chemical specialty field [5]. But, it is very difficult to obtain a thin film of PEG alone because of its weak mechanical and thermal strength. Tetrahydrofuran (THF) is a strong aprotic solvent commonly used in the pharmaceutical industry due to its broad solvency for both polar and non-polar compounds.

EXPERIMENTAL**Materials and methods**

Poly (vinyl chloride) procured from Sigma Aldrich and poly (ethylene glycol) 4000, Himedia, having molecular weight 3500–4000, and tetrahydrofuran (THF) (stabilized with 0.1% quinol) obtained from loba chemie and were used as received without further purification.

Preparation of Blend Films

Polymer blends films of poly (ethylene glycol)/poly (vinyl chloride) of different compositions were prepared by solution casting method using tetrahydrofuran (THF) as solvent. For the preparation of blend films, accurately weighed amount of two different polymers were dissolved separately in tetrahydrofuran (THF) solvent. After allowing them to dissolve completely, the polymer solutions were mixed

with continuous stirring until complete miscibility and subsequently definite volume of clear and transparent blend solutions poured onto previously cleaned and dried glass petri dishes and solvent is evaporated at room temperature to form blend films. Finally the petri dishes containing films was dried in hot air oven to ensure complete removal of trace amount of solvent present in the blend films at 45° C for 48 hours. After evaporation of complete solvent, all films were peeled off from petri and kept under evacuated desiccator over fresh silica gel until use. All the blend solutions develop cloudiness as the slow and constant evaporation of solvent takes places. All obtained films were semitransparent, uniform in thickness and free from air bubbles.

Film Thickness

The thickness of the blend film was measured with screw gauge. Several thickness measurements were taken at several points of the film and then average was calculated. The thickness of the films was found to be around 0.23 mm.

Mechanical Properties

Mechanical properties such as tensile strength, young modulus and percent of elongation (%) were measured using a universal testing machine (UTM) (LLOYDS - 5 KN, London, UK). These tests were carried out according to ASTM D-882 standard test (ASTM, 1992) at room temperature in air. Rectangular shaped sample of films (2.5 × 10 cm) were taken for the evaluation of tensile properties. Two metallic grips were attached for gripping both ends of the test specimen of the film. The lower grip was stationary and the upper grip moved upward with constant rate of extension 50 mm/min keeping constant initial grip separation 50 mm for all samples. An automatic speed controller was attached to keep the speed of the upper grip. The machine was electrically driven. Tensile Strength was calculated by dividing the maximum load for breaking the film by cross-sectional area. Elongation at Break by dividing the film elongation at rupture to initial gauge length (% elongation is the ratio of the extension to the length of the sample). The modulus of elasticity (young's modulus) is the ratio of stress to strain at the linear portion of the curve or slope of the linear portion of the curve of stress strain.

Scanning Electron Microscopy

Surface morphology of blend films were examined using scanning electron microscopy (SEM). The small pieces of dried blend films were fixed on double-sided carbon adhesive tape which is mounted on aluminum metal stub. The samples were coated with platinum using a vacuum evaporator to aid the conduction during scanning. The morphological structures of the films were studied by a JSM- 6360 scanning electron microscope (SEM) of JEOL, Germany, and the images were taken at accelerating voltage 10 kV and a magnification 500 times of origin specimen size. SEM images of the film are shown in the figure 1.

RESULTS AND DISCUSSIONS

Mechanical Properties

Mechanical properties were carried out to study the tensile properties of polymeric plasticizer incorporated PVC films. It is well known that mechanical properties might be used to assess the miscibility in polymer blends through a comparison of experimental results and predictions based on various models. Indeed, the mechanical properties of polymer blends depend on the intermolecular forces, chain stiffness, and molecular symmetry of the individual polymers used to prepare the blend. In general addition of plasticizer like poly (ethylene glycol) to PVC decreases the young's modulus value and stress at peak of blend system. From table 1 and figure 1 it is obvious that pure PVC polymer exhibit high young's modulus value, high stress at peak and low elongation at peak, lower than 10% and their blends containing 95% PVC/5% PEG, 90% PVC/10% PEG, 85% PVC /15% PEG, 80% PVC /20% PEG and 75% PVC /25% PEG exhibits decrease in Young's modulus and tensile strength value compared to pure PVC indicate blend become more amorphous. PVC, having higher young's modulus and lower elongation at break values is hard and brittle. The incorporation of different weight fraction of PEG in PVC increases the Young's modulus value for blend 10% PEG/50% PVC/40% PVAc and 20% PEG/50% PVC/30% PVAc and decreases the tensile strength with improved the flexibility of the blend system. This results in harder and more brittle blends. The decrease in tensile strength is due to almost lack of interfacial interaction between the blend components PVC/PEG. This hypothesis was confirmed by scanning electron microscopy (SEM). But elongation at break increases due to plasticization effect.

Table 1: Tensile Properties of PVC/PEG blend films.

| PVC/PEG (Wt %) | Tensile Strength, TS (MPa) | Young's Modulus, YM (MPa) | Elongation at Break, EB (%) |
|----------------|----------------------------|---------------------------|-----------------------------|
| 100/0 | 37.360 | 676.078 | 6.681 |
| 95/5 | 31.722 | 648.658 | 14.545 |
| 90/10 | 28.908 | 570.195 | 22.605 |
| 85/15 | 27.660 | 584.393 | 39.193 |
| 80/20 | 22.599 | 461.546 | 48.067 |
| 75/25 | 15.070 | 260.566 | 51.801 |

Scanning Electron Microscopy

Figure 2 shows SEM micrographs of pure PVC and at different weight percent of PVC/PEG. The pores in the micrographs indicate the occurrence of phase-separation in the blend films. At 5% PEG large number of small pores which have been formed on the surface, this suggest poor immiscibility of PEG with PVC, due to rapid evaporation of solvent, THF and as the PEG content increases, size of the pores increases. The difference in the pore size is related with the difference in the driving force for phase separation^[6].

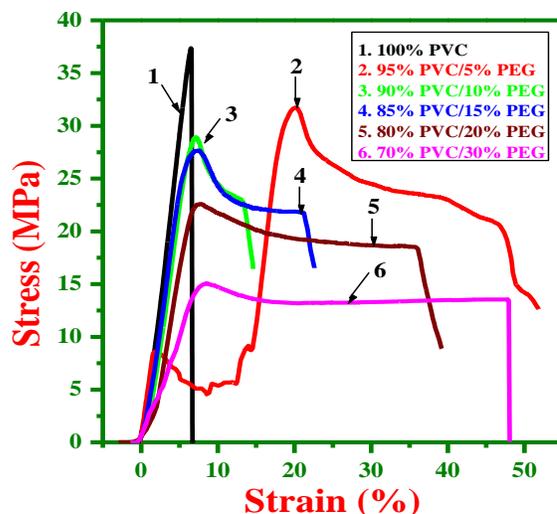
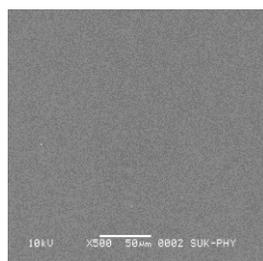
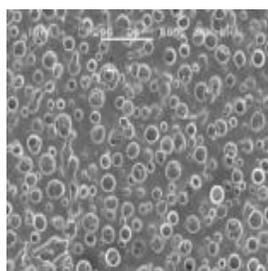


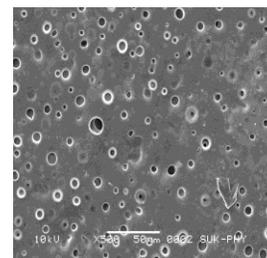
Figure 1: Pure PVC and PVC containing different weight percent of PEG.



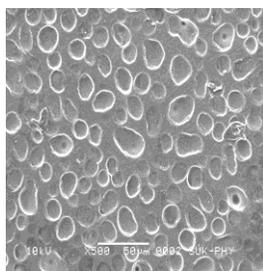
a) 0% PEG



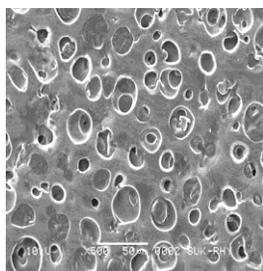
b) 5 % PEG



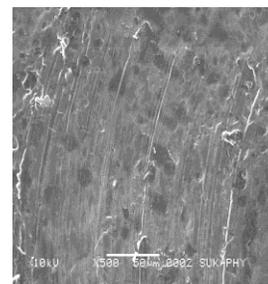
c) 10% PEG



d) 15% PEG



e) 20 % PEG



f) 25% PEG

Figure 2: Pure PVC and PVC contain different weight fractions of PEG.

CONCLUSION

The influence of poly (ethylene glycol) on mechanical behavior of poly (vinyl chloride) film shows plasticization effect. Poly (vinyl chloride) is a hard and strong material and shows dipole–dipole type interaction as a result of the electrostatic interactions between chlorine atom of one chain and hydrogen of another chain. These interactions are weakened by presence of plasticizer such as poly (ethylene glycol) increasing its flexibility and reducing the tensile strength.

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