Research Journal of Engineering Sciences ISSN 2278 – 9472
Vol. **1(2),** 63-65, August **(2012)** *Res. J. Engineering Sci.*

Short Communication

Investigation of Mechanical Properties of Ternary Polymer PVC/PVAc/PEG Blended Films

Mudigoudra B.S.[1], Masti S.P.[2] and Chougale R.B.[1]
[1]Department of Materials Science, Mangalore University, Mangalgangotri - 574 199, INDIA
[2]Post-Graduate Department of Chemistry, Karnataka Science College, Dharwad- 580 008, INDIA

Available online at: www.isca.in
Received 27th June 2012, revised 4th July 2012, accepted 1st August 2012

Abstract

Ternary polymer blend films of poly (vinyl chloride) (PVC)/poly (vinyl acetate) (PVAc)/poly (ethylene glycol) (PEG) was prepared solution blending and solvent evaporation technique. The visual observation showed that the cast films of blend on various ratios of poly (vinyl chloride), poly (vinyl acetate) and poly (ethylene glycol) are semitransparent indicating the immiscibility of PVC/PVAc/PEG ternary blends. The tensile properties of the blend films containing different concentration (wt%) of PVC/PVAc/PEG were characterized using universal testing machine (UTM). All the blend films containing more concentration (wt%) of PVC in comparison with concentration of PVAc and PEG shows decrease in tensile strength.

Keywords: PVC, PVAc, PEG, ternary blend, tensile properties.

Introduction

Polymer blends, that is, physical mixture of structurally different polymers which interact with secondary forces such as hydrogen bonding with no covalent bonding. Polymer blends have been widely used in the industry because of their ability to combine in a unique material the properties of their components, at a relatively low cost when compared to the development of a new polymer. It is well-known that the properties of polymer blends are greatly influenced by the morphology that is developed during the mixing process[1]. The physical properties of polymer blends are controlled generally by many factors such as the nature of polymer[2], blend composition[3-5] and interfacial properties such as interfacial adhesion[6-12] and dispersed phase size and shape which are developed during solution blending. Likewise, the morphology of ternary blends is also influenced by thermodynamics and kinetic factors. In comparison with binary blends, ternary polymer system can be viewed technologically as the next generation in multiphase polymers[13]. The fundamental aspect of the ternary polymer blends, which have substantial commercial significance as adhesives and coating materials[14]. According to pita et al.[15] the addition of plasticizer to the PVC formulation decreases many mechanical properties such as hardness, tensile strength, modulus, etc. of PVC product. However, low temperature flexibility, elongation and ease of processing are all improved.

In general, plasticisers are solid relatively low melting point or liquid with relatively high melting point. They are well dispersed among plastic polymer molecules and polar group of plasticizer interact with counterpart of polymer molecules by supramolecular force, which is commonly considered as dipole-dipole interactions. The non polar sections of the plasticizer segregate polymer molecules and reduce the interactions between them. As a result, the mobility of polymer molecules are increased, which is especially helpful to processing.

Poly (vinyl chloride) (PVC) is one of the most common commodity plastics, which has been widely used in the automobile, building construction, packaging fields, etc., because of its low cost, easy method of preparation, and the broadening of the properties range[16]. Poly (vinyl acetate) (PVAc) is a petroleum-derived polymer usually obtained by emulsion polymerization. It has low T_g and acts as a plasticizer. It features excellent adhesion to various substrates. Thus large quantities of PVAc are produced for use as a binder in emulsion paints, adhesives, and various textile finishing operations[17]. Some of this material is converted into poly (vinyl alcohol) and poly (vinyl butyral). Owing to its inherent high cold flow, PVAc is of little value in moldings and extrusion. PVAc is rather brittle and rigid but compounding it with other polymers frequently improves physical properties[17]. PEGs has many industrial applications like lubricants, binders, carriers, solvent, and coatings in the cosmetics, pharmaceutical, paper, food, textile, and chemical specialty field[18].

It is well known that the choice of solvents as well as temperature casting strongly influences the apparent phase behavior of polymer mixtures when solution blending is used for samples. Tetrahydrofuran (THF) is a strong aprotic solvent commonly used in the miscibility of polymers and also in the pharmaceutical industry due to its broad solvency for both polar and non-polar compounds.

Material and Methods

Poly (vinyl chloride) procured from Sigma Aldrich and poly (ethylene glycol), Himedia, having molecular weight 3500-4000, poly (vinyl acetate) and tetrahydrofuran (stabilized with

0.1% quinol) obtained from loba chemie and were used as received without further purification.

Preparation of ternary PVC/PVAc/PEG polymer blend films: Ternary polymer blends films of poly (vinyl chloride)/poly (vinyl acetate)/poly (ethylene glycol) of different compositions were prepared by solution casting method using tetrahydrofuran (THF) as an organic solvent. For the preparation of blend films, exactly weighed amount of three 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 all 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 a week. After evaporation of complete solvent all films peeled off from petri and kept under evacuated desiccator over fresh silica gel until use. Solution of PVC and PVC and PEG were clear and transparent but solution of PVC, PEG and PVAc is non-transparent. All the blend solutions develop cloudiness as the slow and constant evaporation of solvent takes places. All obtained films were semitransparent, uniform thickness and bubble free.

Table-1
The composition of poly (vinyl chloride)/poly (vinyl acetate)/poly (ethylene glycol)

Blend ratios PVC/PVAc/PEG	wt% of PVC	wt% of PVAc	wt% of PEG
100/0/0	100	0	0
50/20/30	50	20	30
50/25/25	50	25	25
50/30/20	50	30	20
50/35/15	50	35	15
50/40/10	50	40	10
60/20/20	60	20	20

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 0.21 mm.

Table-2
Mechanical properties of PVC/PVAc/PEG polymer blend films

Blend ratios PVC/PVAc/PEG (wt %)	Tensile strength TS (MPa)	Young's modulus YM (MPa)	Elongation at break EB (%)
100/0/0	37.360	676.078	6.681
50/20/20	15.153	653.834	6.633
50/25/25	13.626	566.922	7.517
50/30/20	15.228	925.701	45.219
50/35/15	10.042	538.129	37.151
50/40/10	23.152	717.197	15.486
60/20/20	16.700	1011.095	28.125

Mechanical Properties: A LLOYD universal testing machine (LLOYDS – 5 KN, London, UK) was used to measure tensile strength, percent elongation (%) and modulus of elasticity. The tests were carried out according to ASTM D-882 standard test (ASTM, 1992) and calculated using NEXYGEN Plus software. Rectangular shaped sample of films (25×100 mm) were taken for the determination of tensile properties. Two metallic grips were attached for griping 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. All measurements were carried out at room temperature in air. 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.

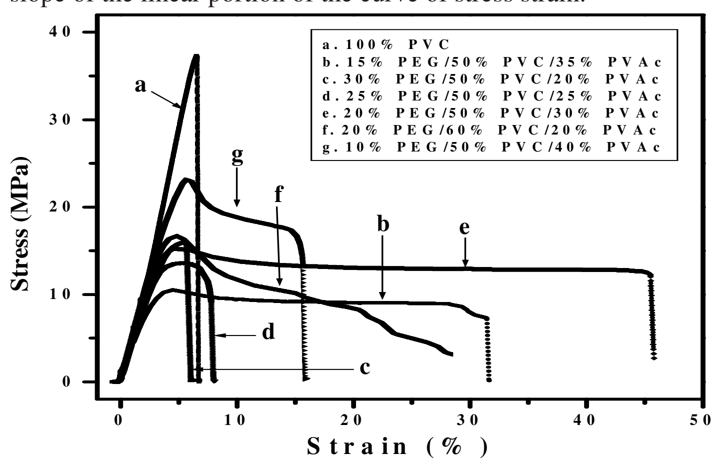

Figure-1
Stress-strain curves of pure PVC and PVC containing different weight % of PVAc and PEG

Results and Discussion

Mechanical properties were carried out to study the tensile properties of polymer blend films and they become important as polymer technology moves from laboratory into process development. 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 plasticizers to PVC decreases the young's modulus value and stress at peak of blend system. From table 2 and figure 1 it is obvious that pure PVC polymer exhibit high young's modulus value, high stress at peak and short elongation at peak, lower than 10% and their blends containing 30% PEG/50% PVC/20% PVAc and 25% PEG/50%

PVC/25% PVAc 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 PVAc/PEG to 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 among the blend components PVC/PVAc/PEG. This hypothesis will be confirmed by scanning electron microscopy.

The influence of poly (vinyl acetate) and 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 attraction 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 plasticizers such as poly (vinyl acetate) and poly (ethylene glycol) increasing its flexibility and reducing viscosity of the molten material, the young's modulus value.

Conclusion

Pure PVC films with high Young's modulus, high stress at peak and low elongation at peak can be changed from hard and brittle to soft and tough depending on the content of plasticizers. The addition of plasticizers enhances the young's modulus value and flexibility of the blend system.

Acknowledgements

The couple of the authors, Chougale R.B. (PI), Masti S.P. (Co-PI), would like to thank the University Grants Commission (UGC), New Delhi, India, for financially supporting this research projects (F.No.34-397/2008 (SR)/30 Feb., 2008).

References

1. Ticiane S. Valera, Augusto T. Morita and Nicole R. Demarquette, Study of Morphologies of PMMA/PP/PS Ternary Blends, *Macromolecules*, **39**, 2663 **(2006)**

2. George K.E., in *Blends and Alloys*, Chapman and Hall, London, UK, 1st edition **(1993)**

3. Walters M.W. and Keyte D.N., Heterogeneous Structure in Blends of Rubber Polymers, *Rubber Chemistry and Technology*, **38**, 62 **(1965)**

4. Valsamis L.N., Kear M.R., Joseph R. and Francis D., Specific Enzyme Release of Cellulose-Bound Drugs, Experimental and Theoretical Study, *Journal of Applied Polymer Science*, **32 (1),** 2851 **(1986)**

5. Valsamis L.N., Kearney M.R., Dagli S.S., Merhta D.D., and Polchocki A.P., Phase Morphology of a Model Polyblend Fabricated in Industrial Mixers: Tme and Melt Flow Dependent Supradomain Structures, *Advances in Polymer Technology*, **8 (2),** 115 **(1998)**

6. Li J., Shanks R.A., and Long Y., Mechanical Properties and Morphology of Polyethylene-Polypropylene Blends with Controlled Thermal History, *Journal of Applied Polymer Science*, **76(7),** 1151–1164 **(2000)**

7. Yao Z., Yin Z., Sun G., et al., Morphology, Thermal Behavior and Mechanical Properties of PA6/UHMWPE Blends with HDPE-g-MAH as a Compatibilizing Agent, *Journal of Applied Polymer Science*, **75(2),** 232-238 **(2000)**

8. Sathe S.N., Devi S. and Rao K.V., Relationship Between Morphology and Mechanical Properties of Binary and Compatibilized Ternary Blends of Polypropylene and Nylon 6, *Journal of Applied Polymer Science*, **61(1),** 97-107 **(1996)**

9. Yang W., Wu Q., Zhon L. and Wang S, Styrene-Co-Acrylonitrile Resin Modifications of PVC/CPE blends, *Journal of Applied Polymer Science*, **66(8),** 1455-1460 **(1997)**

10. Koklas S.N., Sotiropoulou D.D., Kallitsis J.K. and Kalfoglou K., Compatibilization of Chlorinated Polyethylene/Poly(vinyl chloride) Blends with Epoxidized Natural Rubber, *Polymer*, **32(1),** 66–72 **(1991)**

11. Kukaleva N., Jollands M., Cser F., and Kosior E., Influence of Phase Structure on Impact Toughening of Isotactic Polypropylene by Metallocene-Catalyzed Linear Low-Density Polyethylene, *Journal of Applied Polymer Science*, **76(7)**, 1011-1018 **(2000)**

12. Ohlsson B., Hassander H. and Tornell B., Effect of the Mixing Procedure on the Morphology and Properties of Compatibilized Polypropylene/Polyamide Blends, *Polymer*, **39(20),** 4715–4721 **(1998)**

13. Hossam M. Said, Effect of Electron Beam Irradiation on the Structural Properties of PVA/PAM/CMC Ternary Polymer Blends, Journal of Macromolecular Science, Part A: *Pure and Applied Chemistry*, **44**, 495-502 **(2007)**

14. Young Gyu Jeong, Suriyakala Ramalingam, Jared Archer, and Shaw Ling Hsu, Influence of Copolymer Configuration on the Phase Behavior of Ternary Blends, *J. Phys. Chem. B*, **110 (6),** 2541-2548 **(2006)**

15. Ramesh S., Tan Winie and Arof A.K., Investigation of Mechanical Properties of Polyvinyl chloride-Polyethylene Oxide (PVC-PEO) Based Polymer Electrolyte for Lithium Polymer Cells, *European Polymer Journal,* **43**, 1963-1968 **(2007)**

16. Jiliang Wang, Wanqing Yang and Jingxin Lei, Study on a Novel Ion-Conductive Compound Plasticizer for Soft and Antistatic PVC, *Materials polymer engineering and science*, 57 -60 **(2010)**

17. Stephen S. Ochigbo, Adriaan S. Luyt and Walter W. Focke, Latex Derived Blends of Polyvinyl Acetate and Natural Rubber: Thermal and Mechanical Properties, *Journal of Materials Science,* **44**, 3248-3254 **(2009)**

18. Mruthyunjaya Swamy T.M., Siddaramaiah, Studies on Miscibility polyacrylamide/ Polyethylene Glycol Blends, *Journal of Applied Polymer Science*, **104**, 2048–2053 **(2007)**