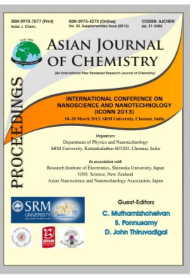
Estd. 1989
Asian Journal of Chemistry
Asian Journal of Chemistry; Vol. 25, Supplementary Issue (2013), S329-S332
ASIAN JOURNAL OF CHEMISTRY
www.asianjournalofchemistry.co.in



Characterisation of Polyblend-Nanofilms of Cellulose Acetate and Polystyrene†

S. SRILALITHA[1,*], K.N. JAYAVEERA[2], S.S. MADHVENDRA[3] and A. JAYANTH KUMAR[1]

[1]Institute of Aeronautical Engineering, Dundigal, Hyderabad-500 043, India
[2]Jawaharlal Nehru Technological University, Ananthapur-515 001, India
[3]Indian Institute of Chemical Technology, Hyderabad-500 007, India

*Corresponding author: E-mail: ssrilalitha@yahoo.com

AJC-12867

Nanotechnology has potential to create many new materials and devices with wide range of applications in medicine, electronics and energy production *etc*. Blending technique is applied for production of new polymeric materials. As cellulose acetate is thermoplastic moulding material, it is used in industrial and biochemical applications. In the present investigation, SEM and mechanical analysis of cellulose acetate and polystyrene nano films have been studied in accordance with the change in composition of polymer over a wide range of concentrations and temperatures. Super plasticity has been observed at low temperatures and at higher strain rates in nano crystalline materials. Mechanical properties of cellulose acetate and polystyrene nano films have been studied. Phase morphology of nano membranes have been studied by SEM. SEM studies were also performed to estimate pore size distribution of the support polymer. Nano structured ceramics readily interact with bone cells and have been applied as implant materials.

Key Words: Polymeric materials, Blending technique, Cellulose acetate, Polystyrene, Phase morphology.

INTRODUCTION

In recent years, nanotechnology has become one of the most important and exciting forefront fields in Physics, Chemistry, Biology, Engineering and Technology. Nanotechnology is the design, characterization, product and application of structures, devices and systems by controlling shape and size at the nanometer scale. Nanotechnology is the study of phenomenon and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

Characterisation of nanomaterial and nanostructures has been largely based on surface analysis technology and conventional characterisation methods developed for bulk material. Producers of polymeric materials have strong economic incentives to solve technical problems and upgrade their products by working with existing materials. Polymer blending technique has been considered a convenient and best route for modification of properties for the development of new polymeric materials with a wide range of properties as blending is less expensive method and its relative freedom from the patent coverage and enforcement compared to the synthesis of new homo polymers and co-polymers[1-4]. The improvement of the physical and mechanical properties of the blend mainly depends on the extent of adhesion at the interphase and how fine the dispersion is of one phase into other[2,3,5-7].

The polymer blends are physical mixtures of structurally different polymers which interact with secondary forces with no covalent bonding and have assumed a very important status scientifically and technologically. The polymer blends offer property, cost and processing advantages in their applications.

Compatibility of polymers has been one of the important areas in the field of polymer science and technology[1,2,8-10]. Many experimental and theoretical methods[2,4] have been used to investigate the polymer-polymer miscibility and the interaction between the polymers[11-14].

In the present studies the scanning electron microscopic and mechanical analysis of cellulose acetate (CA) and polystyrene (PS) nanofilms have been studied in accordance with the change in composition of polymer over a wide range of concentrations and temperatures.

EXPERIMENTAL

The grades of polymers used in the present investigation were polystyrene (PS) (BDH, England) and cellulose acetate (CA) (Aldrich, USA). The molecular weights are 1.0×10^5

---

†International Conference on Nanoscience & Nanotechnology, (ICONN 2013), 18-20 March 2013, SRM University, Kattankulathur, Chennai, India

and 1.6 × 10^5. The solvent 1,4-dioxane used was of BDH origin and of AR grade.

General procedure: Poly blending: poly(styrene) and cellulose acetate blends with compositions of 0/100, 12.5/87.5, 25/75, 37.5/62.5, 50/50, 62.5/37.5, 75/25, 87.5/12.5 and 100/0 were prepared.

Detection method

Film casting: Solutions of polymer blends of different compositions were used for casting of membranes of the desired thickness on a clean glass plate. The solvent was evaporated at room temperature for ten hours and then the plate was kept under vacuum at 60 ºC for complete removal of the solvent. The thickness of the dry membranes was measured with a micrometer (Mituotoyu, No. 2109-10, Japan with an accuracy of ± 1 µm) and flakes of the membranes were used in the experiments.

Scanning electron microscopy (SEM): The SEM studies of the films were carried out using scanning electron microscope (Model Hitachi S-520).

Mechanical studies: Mechanical studies were performed by Instron (Model AGS-10KNG, Shimadzu, Japan).

RESULTS AND DISCUSSION

Scanning electron mcroscopy: Phase morphology characterization for the poly(styrene)-cellulose acetate blend systems of compositions polystyrene/cellulose acetate 0/100, 12.5/87.5, 25/75, 37.5/62.5,50/50, 62.5/37.5, 75/25, 87.5/12.5 and 100/0, respectively has been done by SEM microscopic analysis.

From micrograph (Fig. 1) it is clear that cellulose acetate rich phase shows homogeneity as it is completely miscible. With increase in the percentage composition of polystyrene in the blend system formation of voids in the cellulose acetate matrix starts by the addition of hard, rigid and crystalline polystyrene as in Figs. 2 and 3. The heterogeneity of polystyrene/cellulose acetate 50/50 is clearly seen by the microscopic observation which may be due to the formation of polystyrene domains (Fig. 4). The increase in the weight percentage of polystyrene causes "optical heterogeneity" as the formation of polystyrene domains starts aggregating which is shown in the photomicrographs (Fig. 5). At the high composition range of polystyrene *i.e.*, in polystyrene/cellulose acetate 100/0 blend homogeneity appears due to the presence of uniformly distributed highly transparent pure polystyrene matrix transmission about 90 % of visible light with high refractive index of 1.59 (Fig. 6).

From the microscopic examination of polystyrene-cellulose acetate blend system of various compositions it is evident that the cast films are found to be transparent and slightly yellowish. The transparency of the films at higher concentrations shows compatible nature of the system while the yellow colour at lower concentrations indicates the specific interactions between the constituent polymers. The yellow colour of films intensifies with concentration of cellulose acetate. The heterogeneity indicating the two phase morphology confirms that the polystyrene-cellulose acetate blend system is incompatible at all concentrations. SEM study found to be useful in the compatibility analysis of the polymer blend[15,16].

Fig. 1. SEM micrographs of polystyrene-cellulose acetate blends of various compositions polystyrene/cellulose acetate 0/100

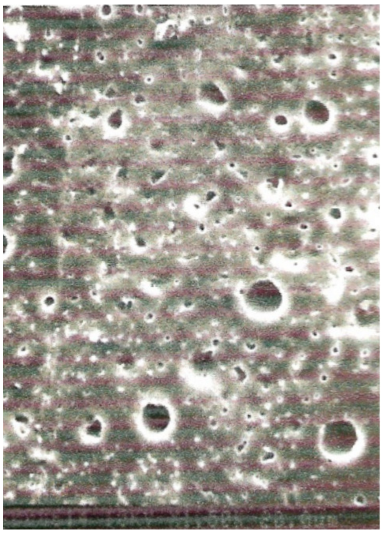


Fig. 2. SEM micrographs of polystyrene-cellulose acetate blends of various compositions polystyrene/cellulose acetate 12.5/100

Fig. 3. SEM micrographs of polystyrene-cellulose acetate blends of various compositions polystyrene/cellulose acetate 37.5/62.5

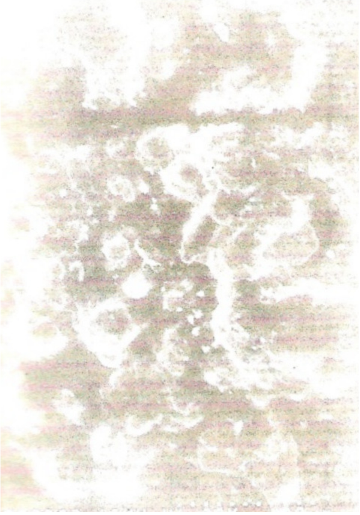


Fig. 4. SEM micrographs of polystyrene-cellulose acetate blends of various compositions polystyrene/cellulose acetate 50/50

Fig. 5. SEM micrographs of polystyrene-cellulose acetate blends of various compositions polystyrene/cellulose acetate 87.5/12.5

Fig. 6. SEM micrographs of polystyrene-cellulose acetate blends of various compositions polystyrene/cellulose acetate 100/0

Mechanical studies: The various mechanical properties studied on a series of films of films of polyblends of polystyrene-cellulose acetate system at various compositions are tabulated (Table-1).

It is observed from the table that polystyrene/cellulose acetate blends show higher values of strain and the percentage of elongation when the percentage composition of polyblend polystyrene/cellulose acetate is 25/75. It shows maximum values of stress and tensile strength at higher concentrations of cellulose acetate *i.e.*, 12.5/87.5 polystyrene/cellulose acetate. This may be due to the following reason. In thermoplastic polystyrene, the intermolecular forces and the barriers to rotation about C-C bonds are greater than in the rubbers or elastomeric polymers. These increased forces may rise because of bottom molecular packing and a high degree of crystallinity by the presence of side chains and increased steric forces. In cellulosic plastic, cellulose acetate hydrogen bond forces contribute to the intermolecular cohesion.

The stress-strain curve of polystyrene-cellulose acetate blends of different compositions (Fig. 7) confirms that the polyblend with maximum percentage composition of cellulose acetate is highly amorphous, soft and tough. With increase in percentage composition of polystyrene, the strength of the film decreases and becomes hard and brittle as polystyrene is susceptible to photo oxidative degradation which results in brittleness. So polyblends with compositions polystyrene/ cellulose acetate 12.5/87.5 and 25/75 are hard and brittle whereas 37.5/62.5 is of hard and strong. In polystyrene there is little yielding and fracture occurs at low strains. Polystyrene is namely considered brittle polymer at room temperature because it fractures in a tensile test run at normal speed after an elongation of only 1.5 % or so and has low impact strength. However, if similar tests are tested at temperature above 100 ºC, they show ductile behaviour and have high impact strength and high extensibility.

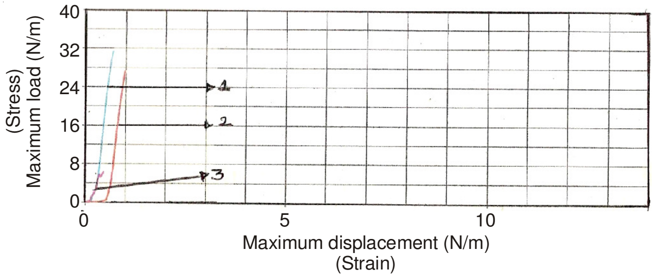


Fig. 7. Stress-strain relationship of polystyrene-cellulose acetate blends of various compositions

Conclusion

The present investigation indicates the compatibility of polymer blends may be studied by SEM and Mechanical analysis. It is clear that there is a distinct phase separation in the membranes at compositions of 50:50 of polystyrene-cellulose acetate. polystyrene-cellulose acetate blends show maximum values of stress and tensile strength at higher concentration of cellulose acetate. The stress-strain curve of polystyrene-cellulose acetate blends of different compositions (Fig. 7), confirm that the polymer blend with maximum

TABLE-1
MECHANICAL STUDIES OF FILMS OF PS-CA BLENDS OF DIFFERENT COMPOSITIONS

Composition of PS-CA blends	Max-load (Stress) (N)	Max. Disp. (strain) (mm)	Tensile strength (N/mm^2)	Max-strain (%)	Break-load (N)	Break-disp (mm)	Break-stress (N/mm^2)	Percentage of elongation (N/mm^2)
(1) 12.5/87.5	31.2625	0.68400	6.56775	6.84000	30.8500	0.67600	6.48109	6.76000
(2) 25/75	27.3125	0.99200	5.75000	9.92000	26.9375	0.98400	5.67105	9.84000
(3) 37.5/62.5	6.3125	0.45900	2.86932	4.59000	6.31250	0.45900	2.86932	4.59000
Mean	21.6291	0.71167	5.06236	7.11667	21.3666	0.70633	5.00715	7.06333

percentage composition of cellulose acetate is highly amorphous, soft and tough. With increase in percentage composition of polystyrene, strength of the film decreases becomes hard and brittle as polystyrene is susceptible to photo oxidative degradation which results in brittleness. Super plasticity has been observed at low temperature and at high strain rates in non-crystalline materials. Bio sensitive nano-particles have been used to tagging of DNA and DNA chips. Nano-structured ceramics readily interact with bone cells and have been applied as implant materials.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. P. Sita Devi, Dr. D.H.L. Prasad and Dr. V. Mohan Rao, Indian Institute of Chemical Technology, Hyderabad, India for providing research facilities.

REFERENCES

1. L.A. Utracki, Polymer Alloys and Blends, Thermodynamics and Rheology, Hansar Munich (1989).
2. O. Olabisi, L.M. Robeson and M.T. Shaw, In Polymer-Polymer Miscibility, Academic, New York (1978).
3. C. Koning M.V. Buin, C. Pagroulle and R. Jerome, *Polym. Sci*., **23**, 707 (1998).
4. K. Osamu and K. Masahiro, Ikeda Bassan Co., Japan, Patent 06,207, 037,1995; *Chem Abstr*., **122**, 135442d (1995).
5. D.R. Paul, in ed.: S. Newman, In Polymer Blends, Academic Press, New York, Vol. 1, Ch. 1 (1978).
6. S.N. Sathe, G.S.S. Rao, K.V. Rao and S. Devi, *J. Appl. Polm. Sci*., **61**, 107 (1996).
7. C.A. Patel, B.R. Brahmbhatt, B.D. Sarawade and S. Devi, *J. Appl. Polym. Sci*., **81**, 1731 (2001).
8. M.M. Coleman, J.F. Graf and P.C. Painiter, Specific Interaction and Miscibility of Polymer Blends, Technomic Publishing. Lancaster, P.A (1991).
9. C. Amello, C. De Rosa, G. Gueffa, V. Peffacone, P. Coltadin and G. Ajroldi, *Polymer*, **36**, 967 (1995).
10. J.Y. Feng and C.-M. Chan, *Polymer*, **38**, 6371 (1997).
11. Y.P. Singh and R.P. Singh, *Eur. Polym. J*., **20**, 201 (1984).
12. M.A. Sidkey. A.M. Abd Ei Fatta and N.S. Abd EI All, *J. Appl. Polym. Sci*., **46**, 581 (1992).
13. R. Paladhi and R.P. Singh, *J. Appl. Polym. Sci*., **51**, 1559 (1994).
14. S. Srilalitha, K.N. Jayaveera and S.S. Madhvendhra, Characterisation and Physico-Chemical Studies of Membranes of Cellulose Acetate and Poly(vinyl chloride), 58th Annual convention and International Seminar on Technolological Developments in the Fields of Oils, Fats and Allied Products, November 22-23 (2003).
15. B.R. Liang, J.L. White, J.E. Spruiell and B.C. Goswami, *J. Appl. Sci*., **8**, 2011 (1983).
16. S.D. Hong and C.H.J. Burns, *J. Appl. Polym. Sci*., **15**, 1971 (1995).