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PREPARATION AND CHARACTERIZATION OF POLY (METHYL METHACRYLATE) (PMMA) AND POLYSTYRENE (PST) ALLOYS

ABSTRACT

Alloys of Poly (methyl methacrylate) (PMMA) and Polystyrene (PST) were prepared by solvent casting techniques. Physiochemical characteristics of the products were studied. These results were interpreted in terms of the interactions between the components of these blends. By means of FT infra red studies, it was established that functional groups were the major players in interactions. Other modes include dipole-dipole, van der waals and mere physical entanglements. It was also found that at certain relative concentration, some of these properties were enhanced, while in some, degraded relative to the constituent homopolymers.

Keywords: PMMA, PST, FT infra red, van der waals, homopolymers and physical entanglements.

INTRODUCTION

The earliest significant use of blends as plastic materials dated from the late 1940's, when rubbers were blended with polystyrene in order to improve toughness which resulted in the well-known "high impact polystyrene" (HIPS) and later, acrylonitrile-Butadiene-Styrene (ABS) materials^(8,12). A similar rubber toughening of polyvinyl-chloride (PVC) was also developed at an early stage⁽¹³⁾. Actually, blending has remained one of the most active areas of growth in polymer materials. Advances in the production of high perform polymer-based compositions will in the future, more likely result from the utilization of few mixtures of polymers rather than from new polymers compositions. It has been said that blends have an enviable and continuing growth. The wide diversity of the applications for which it is put virtually guarantees a healthy business at least for the foreseeable future. It has also been predicted that by the end of this century, half of all engineering plastics will be blends or it is however argued that within this period, and subsequently, plastics are destined to replace metals. This trend can be supported by the fact that

- Plastics can be blended to improve their physical properties.
- They weigh less and are generally corrosion resistant.
- Plastics can be manufactured and processed with lower energy input than metals and/or glasses.
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Polymer materials may be grouped in different ways. An overview of the most common two-phase systems consisting of polymers is shown below in fig 1.

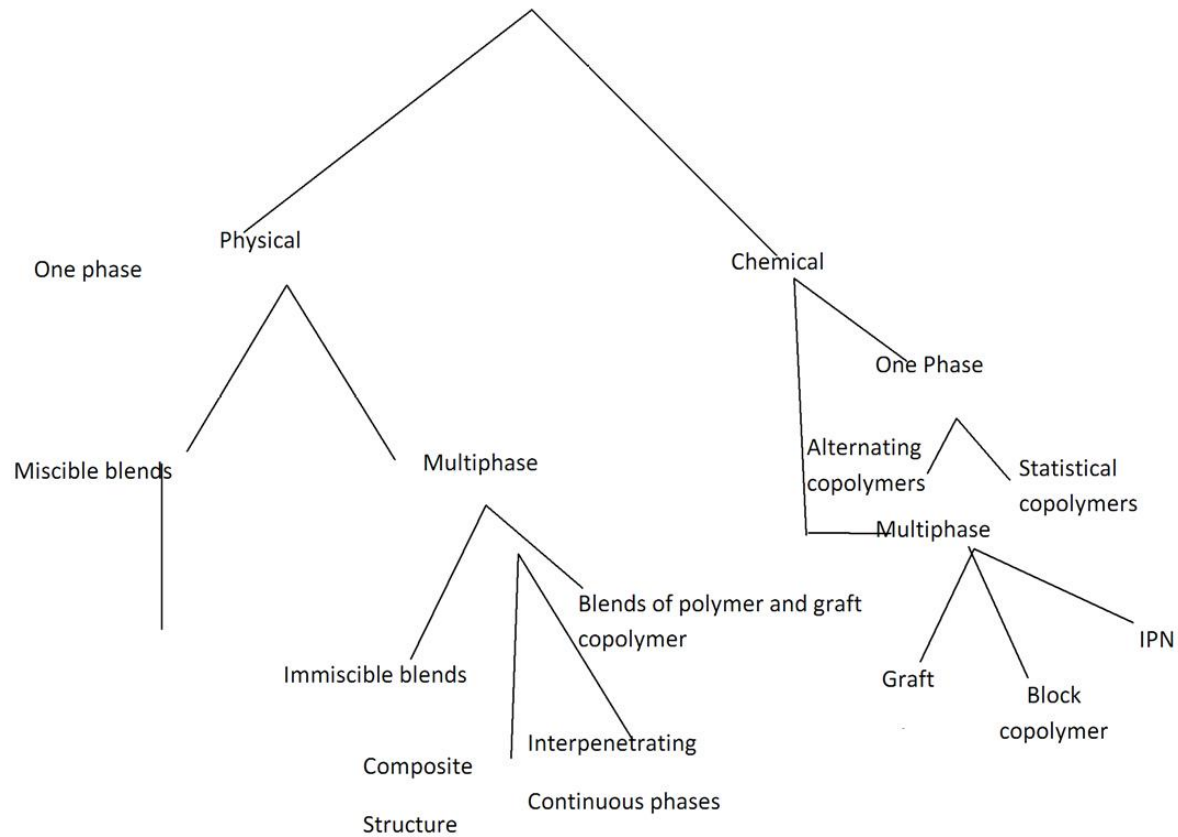


Fig. 1: microstructure of polymer blends and alloys⁽²⁾

POLYSTYRENE (PST)

Polystyrene and styrene copolymers are noted for their high tensile strength and optical clarity but they are brittle under many normal conditions. Rubber modification opens up many markets unavailable to unmodified polystyrene⁽²³⁾.

Synthesis: Commercial high impact polystyrene (HIPS) products are made by polymerization of rubber dissolved in styrene in a solution or mass-suspension process. The rubber, generally polybutadiene, is dispersed throughout the polystyrene matrix in the form of discrete particles. The rubber-in – styrene polymerization usually results in a superior product when compared with blended products, that is, higher modulus and equivalent impact strength are achieved with less rubber. The property improvement is due to a chemical interaction (grafting) between the growing polystyrene chain and the rubber, chemical cross-linking of the rubber, and occlusion of the continuous-phase polymer inside the rubber particles, which increase the effective volume of the rubber phase. Rubber reinforcement produces other physical property improvements such as increased elongation, ductility and environmental stress crack resistance (ESCR). These improvements in the composite polymer are accompanied by loss of clarity and a large decrease in tensile strength and modulus from the unmodified polymer.

The properties of styrene-methacrylate copolymers generally fall between those of the individual homopolymers. Thus the weather ability and solvent resistance of this copolymer are superior to those of polystyrene homopolymer.

APPLICATION OF POLYSTYRENE

Polystyrene has a wide application in the production/manufacturing of toys, Styrofoam, plastics, foam insulation 'safeguard' materials for electronics products on packaging, among other useful applications.

POLY (METHYLMETHACRYLATE) (PMMA)

PMMA is noted for its outstanding water-clear colour and the stability of the properties on aging under severe service conditions. Methylmethacrylate is a derivative of ethylene. It polymerizes readily, rapidly, and exothermally. The acetone cyanohydrin process is the only one employed for the manufacture of methyl methacrylate⁽¹⁾. The most likely future route for the manufacture of methacrylates is based on C⁴-oxidation technology isobutylene or t-butyl alcohol. Methyl acrylate, ethyl acrylate, methyl methacrylate, methyl methacrylate and methacrylate have flash points below. They are classified by the DOT as flammable liquids, and shipping regulations required posting of ICC red labels^(5,14).

PMMA is a tough, rubbery and moderately hard polymer. It's solubility occurs when the free energy of mixing is negative. On solution, there is more movement of polymer chains, therefore, entropy increases as a polymer dissolves. Polymer solution viscosity is dependent on the concentration of the solvent, the molecular weight of the polymer, the polymer composition, the solvent composition and the temperature. PMMA transmits light in the range of 360-1000nm almost perfectly. Commercial grades of poly (methyl methacrylate) often contain uv radiation absorbers that block light in the

290-350mm range, thus screening the user from sunburn and in addition, protection, protecting the polymer against long-term degradation from light⁽¹⁾. The surface resistivity of PMMA is higher than that of most plastic materials. Weathering and moisture affects it only to a minor degree.

Application of polymethyl methacrylate (PMMA)

PMMA is a synthetic polymer made by the chain-growth method of polymerization, thus an addition polymer. High resistant and non tracking characteristics have resulted in its use in high voltage applications, and its excellent weather resistance has promoted the use of **PMMA** for outdoor electrical applications. Non rigid applications include coatings, textiles, paper and oil additives. Rigid applications include glazing materials, biomedical appliances and optical application⁽¹⁾.

MATERIALS AND METHODS

PMMA/PST BLEND

MATERIALS AND SOURCES

PMMA sample was kindly supplied by Prof. A.N. Eboatu while PST was obtained from safeguard materials for electronics products on packaging.

METHOD

wt/wt solutions of both samples of PMMA and PST were made, with 2 butanone and benzene as their respective solvents. The blend percentage composition obtained as earlier described are as follows: (wt%) PMMA/PST: 0:100, 20:80, 40:60, 50:50, 60:40, 80:20, 100:0.

The solutions were cast as films on mercury surface at room temperature. The solvent was allowed to evaporate very slowly under a stream of air. The resulting films were collected and characterized for the above listed physio-chemical properties which are then separately plotted against the base mole fractions of the blends.

The base mole fractions of the blends obtained from the fraction of moles of blend A and moles of blend A plus that of blend B as shown below.

$$\text{That is } \frac{\text{moles of blend A}}{\text{Moles of blend A} + \text{moles of blend B}}$$

$$\% \text{ base mole fraction} = \frac{\text{moles of blend A}}{\text{Moles of blend A} + \text{moles of blend B}} \times \frac{100}{1}$$

INSTRON

Instron testing equipment was used as a standard quality control instrument. The Instron model 1000 had been used in the pursuit of this work to test for force and extension at break of each samples, this was done by placing each of the films of different polymer compositions in between the upper and lower grip. Through the adjustment of the air control units, the films was held and placed in the right position for test to take place. Tensile strength which is the maximum stress or force/unit area in units of Nm^{-2} was then determined, extensions at break which is the increase in sample length during a tensile test was also determined. It was expressed as a percentage of original length.

PROFILE ENLARGER

The profile enlarger Model 1091 was used in measuring film thickness. This was done by placing the sample on its stand and adjusting the x and y-axis knobs which now places the sample in the right position for readings to be taken.

RESULTS AND DISCUSSION**Blend Composition****Film Properties**

PST	PMMA	THICKNESS (M)	AREA (M ²)	FORCE (N)	NOMINAL STRESS (NM ⁻²)	EXTENSION AT BREAK (%)	MELTING POINT (°C)	SOLUBILITY IN 2-BUTAN ONE	SOLUBILITY IN BENZENE
100	0	1.37×10^{-2}	6.16×10^{-4}	183	29.70×10^4	80	205	Soluble	Soluble
80	20	1.34×10^{-2}	6.98×10^{-4}	150	21.49×10^4	40	195	Soluble	Soluble
60	40	1.43×10^{-2}	7.88×10^{-4}	45	15.71×10^4	35	187	Soluble	Soluble
50	50	1.40×10^{-2}	8.41×10^{-4}	127	15.10×10^4	35	170	Soluble	Soluble
40	60	1.54×10^{-2}	9.26×10^{-4}	91	9.83×10^4	25	168	Soluble	Soluble
20	80	1.27×10^{-2}	9.15×10^{-4}	108	11.80×10^4	20	165	Soluble	Soluble
0	100	1.05×10^{-2}	6.27×10^{-4}	20	3.20×10^4	10	201	Soluble	Soluble

TABLE 1: Summary of Properties of Films of PMMA/PST Blend

Blend composition

PMMA	PST	Frequency (Cm ⁻¹)	Transmittance (%)	Δ T (%)
100	0	1755.64	0.00	0.00
80	20	Frequency band weak	-	-
60	50	1730.25	0.03	0.03
50	50	1713.78	2.65	2.65
40	60	1729.85	0.33	0.33
20	80	1714.15	0.58	0.58
0	100	No-C=O	-	-

Table 2: PMMA/PST (wt%) blends result for I.R at C=O Bands.**DISCUSSION**

Blending has remained one of the most active areas of growth in polymer materials. Advances in production of high perform polymer-based compositions will in future result from the utilization of few mixtures of polymers rather than from new polymers compositions. The results from this research as shown above in table 1 and 2 showed that the tensile strength of PST/PMMA contents decreased with an increase in PMMA contents while tensile strength increased with an increase in PST. The extensibility of PST/PMMA blend increased with an increase in PST contents while extensibility decreased with an increase in PMMA. Increase in PMMA generally decreased the melting points while increase in PST generally increased the melting points. PMMA/PST blend films were completely soluble in both solvents when left for about 5h.40 mins. Therefore, PMMA and PST were both soluble in 2-butanone and benzene.

FT Infra red testing apparatus was used in determining the concentration of maximum interaction in PMMA/PST blends. The C=O absorption band of saturated aliphatic esters is in the 1750-1735cm⁻¹ region that of aryl esters at 1730-1715cm⁻¹ but C=O at different blends proportions because of the presence of PST. Also when unsaturation is adjacent to C=O group, a marked rise in the carbonyl frequency was observed. Also halogen substitution results in a rise in the C=O stretching frequency.

A maximum transmittance was observed when the concentration of PMMA/PST blend is 50/50. This indicates that 50/50 was the concentration of maximum interaction of the PMMA/PST blends and that is the concentration at which the polymers can be mixed to obtain maximum efficiency.

CONCLUSION

In conclusion, PMMA/PST blends were found to be miscible and at the same time soluble in 2-butanone and benzene solvents.

REFERENCES

1. Janqueline I. Kroschwiz; (1997). Concise Encyclopedia of polymer Science and Engineering pp. 16-1255.
2. Folkes M.J. and Hope P.S.(1993). Polymer Blends and Alloys 46-159,Chapman & Hall, Glassgow.
3. Cheremisinoff, Nicholas P. (1990), Product Design and Testing of polymeric Materials, Maracel Dekker,Inc. New York, 21-121.
4. Eboatu A.N., Animashav B., Spiff S.T. and Abdulrahman F.M.J. (1999), Thermal Analysis, Vol.36,85-91.
5. Utracki L.A., Bata G.L., Tan V.and Kamal M.R.(1981), Proceedings 2nd World Congress of Chemical Engineering, 428,Montreal. Polymer News 7 (2), 86 (1981).
6. Bonner,J.G. and Hope P.S.:(1993) Compatibilisation and reactive blending .
7. Plochochi A.P.(1978), In polymer Blends, Academic Press, London.
8. Progelof, R.C.; April 17, (1981), Plastic Engineering.
9. Eugenia Munoz Elena,C.,Milagros C.,and Antoio, Santamaria: (1982)
10. Polymer Bulletin 7,295-301,Sringer – Verlag.
11. Paul D.R.(1978), In Polymer Blends,Vol.2, Paul D.R. and Newman S. Academic Press, London.
12. Buknall. C.B. Britain Plastics; (1967), 40 (11), 118: 0 (12), 84 Buknall. C.B. and Smith R.R., (1965), Polymer 6,437.
13. Utracki, L.A. (1990), Polymer Alloys and Blends, Thermodynamics and Rheology, Hanser Publications.
14. Lyngage- Jorgensen, J. (1989), Phase transitions in simple flow Field, ACS Symposium series N0. 395, ACS Washington D.C. Chapter.
15. Krause, S. (1978), in polymer Blends, Vol.1.Paul, D.R. and Newman S.Academic Press, London.
16. Subramanian P.M. and Mehra V., (1987) Polym. Eng.Sci.27, 633.
17. Paul D.R (1978), in polymer blend Vol. 2, Paul D.R and Newman S. eds. Academic Press, London.
18. Heikens D, Hoen N Barentsen W. Piet P, and Ladan H. (1978), *J. Polymer Sci. Polym. Symp.* 62. 309.
19. Miles, A.F, Bonner, J.G and Hope P.S (1992).
20. Wollrab F, Declerck F, Dumoulin J, Obsomer M. and Georletter P. (1972) Am. Chem. Sci, Polym Div. propr. 13(1) 499.
21. Del Guidice L, Cohen, R.E. Attalla, G. and Bertinotti, F. (1985) *J. Appl. Polym Sci* 30, 4305.
22. Robeson L.M. Matzner M. Fetter L.J. and Mc Grath J.E. (1974) in Recent advance in polymer blends, grafts and blocks, sperling L.H. ed. Plenum, New York.
23. Bryant W.M.D, (1947) *J. Polymer Sci* 2, 547.
24. Waddington D.J. Modern Organic Chemistry, Edn. 4 R.O.C. Norman

25. Wade L.G.Jr, (1992) Organic Chemistry, Edn 3 Brooks/Cole, California.
26. Structure and Reactivity, (1999) Edn. 4 Houghton Mifflin Co. Boston.
27. Lyngage-Jorgensen J. (1989) Phase transitions in simple flow fields, ACS symposium series No. 395, ACS Washington DC, chapter 6.