

PREPARATION AND CHARACTERIZATION OF POLY (METHYL METHACRYLATE) (PMMA) AND POLY (VINYL CHLORIDE) (PVC) ALLOYS.

ABSTRACT

Alloys of Poly (Methyl methacrylate) (PMMA) and Poly (vinyl Chloride) (PVC) were prepared by solvent casting techniques. Physicochemical characteristics of the products were studied. It was found that at certain relative concentration, some of these properties were enhanced, while in some, degraded relative to the constituent homopolymers. 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.

Keywords: PMMA, PVC, Blends, Alloys, Casting techniques and Homopolymers.

INTRODUCTION

Mixing of two or more polymers together to produce blends or alloys is a well established strategy for achieving a specified portfolio of physical properties, without the need to synthesize specialized polymer systems. The subject is vast and has been the focus of much work, both theoretical and experimental⁽¹⁻²⁾.

Much of the earlier work in this field was necessarily empirical and many of the blends produced were of academic rather than commercial interest⁽³⁾. While some polymers are miscible, some are not compatible. Compatibility for the latter forms could be achieved still by addition of a third component known as a compatibilizer, such as in block and graft copolymers, functional/creative polymer etc. when two or more polymers are blended successfully, a novel material or film is formed. By this technique, the composition uniformity approaches unity whereas the composition non-uniformity is reduced⁽⁴⁾.

The implication is that properties which include physical, mechanical and chemical as well as appearance of the new material would depend on the compatibility of the polymers. An exact formular for a polymer cannot be written because the molecule depends on how it forms.

There is no single "poly (vinyl chloride)" molecule. PVC is really a mixture of compounds with a range of molecular weights. For this reason, polymers are represented by placing the repeating unit derived from the monomer within a set of parenthesis. PVC is one of the world's major bulk polymers, it owes its popularity to its versatility.

The polymer itself is chemically inert and non flammable, burning only in presence of a source of ignition. It is compatible with many additives, including plasticizers, heat stabilizers, lubricants, fillers, and other polymers. These additives enable the polymer to be processed easily by a wide range of techniques without the fear of degradation to produce articles with a variety of mechanical properties. The articles may be rigid, such as house sidings, rain gutters, and window frames, or flexible as in cable insulation, medical tubing, and plastic gloves. PVC is transparent and can be used in making clear bottle and sheets. Finally, it is one of the least expensive plastic resins^(27,28).

Approximately 75% of the world's PVC is produced by the suspension polymerization (S-PVC) process in which the polymerization is carried out inside vinyl chloride monomer (VCM) droplets dispersed in water. The product is in the form of porous 100-150um-diameter grains.

PVC is used as an insulator for cables and in the manufacture of 'artificial' leather (e.g car upholstery), household goods such as curtains and table clothes, of records (records generally) and floor coverings others include the use of PVC as garden hoses, 'vinyl plastics' films water pipes, phonograph records, table below can be used to illustrate more on the uses of PVC which stipulates the processing techniques and the PVC of rigid and plasticized type.

Poly (Methyl methacrylate) PMMA is noted for its outstanding water-clear colour and the stability of the properties on aging under severe service conditions. Methyl methacrylate is a derivative of ethylene. It polymerize 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 the C⁴-oxidation technology isobutylene or t-butyl alcohol

are the most likely raw materials. 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). Poly (Methyl methacrylate) 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 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 290-350nm range, thus screening the user from sunburn and in a 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. 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. Also, because of its high hardness, tends to be used. 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/PVC BLEND

MATERIALS AND SOURCES

PMMA sample was kindly supplied by Prof. A.N. Eboatu while PVC was obtained from the Louis Carter Nig. Ind. Limited Newwi, Anambra State, Nigeria. 2-butanone was used as solvent.

EQUIPMENT USED

The Instron Tensile Tester, Model 1000, The Profile Enlarger Model 1091, Naber Electrical Furnance Model 2804 and FTF I.R-testing apparatus.

METHODS

Blend composition and film preparation

500cm³ stock solutions were made from pure samples of PMMA and PVC pellets each. Thus, both polymers were dissolved in 2-butanone. The mixture of polymer maintained in solution for a period of one week with frequent agitation to assure homogeneity. Mixtures of both solution with varying compositions and volumes were made and cast as film on to a mercury surface at room temperature. The solvent was allowed to evaporate very slowly under a stream of air. The resulting films were left for a week further drying. Then the thickness, length and area of the films were taken. The solubility, melting point, tensile strength and extension at break of each of the films were tested. The blend percentage composition obtained by mixing are as follows PMMA/PVC 0/100, 20/80, 50/50, 60/40, 80/20, 100/0 where the ratios of PMMA and PVC in the mixtures refer to weight proportions.

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

Table 1: Summary of Properties of Films of PMMA/PVC Blends

BLEND COMPOSITION					FILM PROPERTIES				
PMMA	PVC	THICKNESS (M)	AREA (M ²)	FORCE (N)	NOMINAL STRESS (NM ⁻²)	EXTENSION AT BREAK (%)	MELTING POINT (°C)	SOLUBILITY IN 2-BUTANONE	SOLUBILITY IN BENZENE
100	0	1.05 x 10 ⁻²	6.27 x 10 ⁻⁴	20	3.20 x 10 ⁴	10	201	Soluble	Insoluble
80	20	1.14 x 10 ⁻²	8.01 x 10 ⁻⁴	27	3.37 x 10 ⁴	15	222	Soluble	Insoluble Sparingly
60	40	1.40 x 10 ⁻²	9.79 x 10 ⁻⁴	48	4.90 x 10 ⁴	25	228	Soluble	Insoluble
50	50	1.37 x 10 ⁻²	9.29 x 10 ⁻⁴	28	3.01 x 10 ⁴	15	230	Soluble	Insoluble
40	60	1.34 x 10 ⁻²	8.69 x 10 ⁻⁴	47	5.41 x 10 ⁴	25	235	Soluble	Insoluble
20	80	1.06 x 10 ⁻²	7.18 x 10 ⁻⁴	8	1.11 x 10 ⁴	-	240	Soluble	Insoluble
0	100	1.03 x 10 ⁻²	4.14 x 10 ⁻⁴	3	0.72 x 10 ⁴	-	261	Soluble	Insoluble

**Table 2: PMMA/PVC (wt%) blends results for I.R at C= O Bands.
Blend composition**

PMMA	PVC	Frequency (Cm ⁻¹)	Transmittance (%)	Δ T (%)
0	100	-	-	-
20	80	1924.99	0.02	0.02
50	50	1966.19	0.13	0.13
60	40	1963.84	0.54	0.54
80	20	1963.86	0.28	0.28
100	0	1755.64	0.00	0.00

DISCUSSION AND CONCLUSION

DISCUSSION

From Table 1 and 2 above, It was observed that the tensile strength of PVC is low, but increases with the addition of PMMA. At 50/50 PMMA/PVC blend ratio, there was a decrease which increases again at 60/40 concentration. This shows that the plasticity of PVC can be a bit hardened by blending with PMMA.

From the table of extension at break against the base mole fractions of PVC/PMMA blends. It was observed that blends of 100% and 80% PVC are brittle. The extensibility of the blends increases sharply with increase in PMMA (for PVC/PMMA blends) as shown in table 1 and 2 above.

The melting point against base mole fractions of PVC/PMMA blends increased with an increase in PVC as shown in table 1 above. Table 1 shows how soluble PVC/PMMA blends are when a particular quantity of the blends was dissolved in 10cm³ of 2-butanone and benzene respectively.

FT Infra red testing apparatus was used to determine the concentration of maximum interaction in PMMA/PVC blend. The maximum interaction is at 60/40 concentration which is the concentration at which the polymers can be mixed to obtain maximum results. The tensile strength and extensibility of PMMA/PVC blend at 60/40 concentration is also good. When compared with other concentrations, some are of good strength and extensibility like the 40/60 blend concentration while some are of low strength and extensibility like the 50/50 concentration, but could still be good when needed.

CONCLUSION

From the analysis and research above, the following conclusions have been drawn:

1. There is now a clear indication of feasibility of producing better grade polymers from polymer blend studied in this research.
2. By detecting the concentration of maximum interaction between the functional groups of the polymer blend, a cheaper, more flexible, toughened and better commercial grade polymer can be produced.
3. Some properties, like tensile strength, extension at break melting point, varied with an increase in one components of the blend. This shows improved characteristics of the blend when compared to that of individual polymers, hence reducing production cost for materials which require the use of very expensive material, making toughened polymer more flexible for production and vice versa.

REFERENCES

1. Janqueline I. Kroschwiz; (1997). Concise Encyclopedia of polymer Science and Engineering p-p. 16-1255.
2. Folkes M.J. and Hope P.S.(1993). Polymer Blends and Alloys 46-159,Chapman & Hall, Glassgow.
3. Cheremisinaff, 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
 - a. 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.

INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

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.

¹Udeozo I. P., ²Eboatu A.N., ³Ugwu Okechukwu P.C., ¹Chukwuemeka I.M. and ¹Eze-Stephen P.E.

¹Department of Chemical Sciences, College of Natural and Applied Sciences, Tansian University Umunya (Oba Campus), Anambra State, Nigeria.

² Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University Awka, Anambra State, Nigeria.

³ Department of Biochemistry, University of Nigeria Nsukka, Enugu State, Nigeria