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COMPATIBILIZATION OF NR/PS BLENDS

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Abstract: The blend of natural rubber (NR) and polystyrene (PS) are immiscible and incompatible. The compatibility of the system can be improved by the addition of a graft copolymer of natural rubber and polystyrene (NR-g-PS). The morphology of the system has been studied as a function of copolymer concentration by means of optical microscopy. The domain size of the dispersed phase was decreased by the addition of small percentage of the graft copolymer followed by a levelling of at higher concentrations. The levelling off is an indication of interfacial saturation. The mechanical properties of the blend increased with the addition of the graft. Attempts were made to correlate the mechanical properties with the morphology of the system.

Introduction

Blending an elastomer with a thermoplastic will give rise to a new class of materials called thermoplastic elastomers (TPEs). Blends of natural rubber (NR) and polystyrene (PS) combine the excellent processability and mechanical properties of PS and the elastic properties of NR. These blends are incompatible, immiscible and exhibit poor mechanical properties. This problem can be alleviated by the addition of a suitable compatibilizer.

Inove and co-workers(1) have studied the compatibilizing action of copolymers in heterogeneous blends. Thomas and Prud'homme[2] studied the PS/PMMA system which was made compatible by the addition of PS-b-PMMA. Teyssie and coworkers[3,4] have examined the compatibilizing action of copolymers in a number of systems. We here report on the interfacial activity of NR-g-PS in heterogeneous NR/PS blends. The characteristics of NR and PS are given in Table.1.

Table 1. Characteristics of the materials used

Material	Density gm/cc	Solubility Parameter (Cal/cm^3)	Intrinsic Viscosity $^1/_2$dl/gm	Molecular weight (Mw)
NR	0.90	7.75	4.25	7.79×10^5
PS	1.04	8.56	1.241	3.51×10^5
NR-g-PS	-	-	3.09	3.95×10^5

2. Experimental

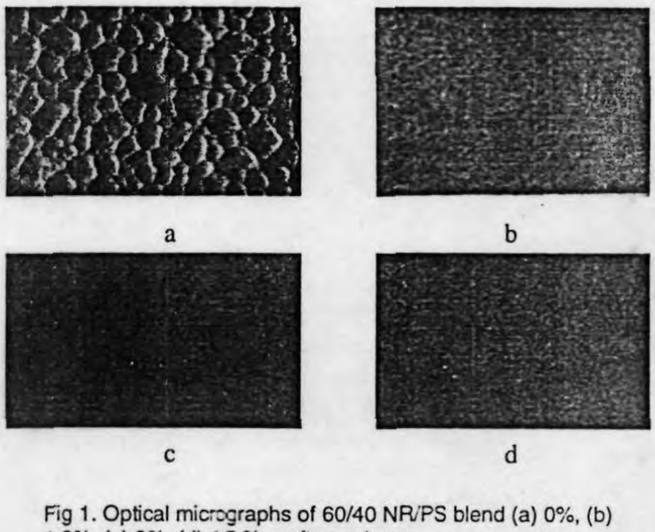
Graft copolymer of NR and PS was prepared by polymerizing styrene in rubber latex using ^{60}Co radiation as the initiator[5]. The free homopolymers natural rubber and polystyrene were removed from the crude sample by extraction with petroleum ether and methyl ethyl ketone, respectively. The obtained graft copolymer was characterised by spectroscopic methods.

Natural rubber and polystyrene were blended (60/40 composition) together in a common solvent (chloroform) with and without the addition of the graft copolymer. The morphologies of the samples were studied using optical microscopy and mechanical properties were determined according to ASTM standards using Zwick Universal testing machine.

3. Results and Discussion

The compatibilizing effect of the graft copolymer in heterogeneous blends depends on the composition, concentration, molecular weight and conformation of the graft copolymer at the interface etc. The compatibilizing activity of the NR-g-PS in NR/PS blend is analysed by the decrease in domain-size of the dispersed PS phase in the continuous NR matrix. The size of the dispersed phase was measured from the optical photographs.

Figs 1. a, b, c and d show the domain morphology of 60/40 NR/PS blends containing 0, 1.2, 3 and 4.5 of graft copolymer respectively. It can be seen that the addition of graft



a b c d

Fig 1. Optical micrographs of 60/40 NR/PS blend (a) 0%, (b) 1.2%, (c) 3%, (d) 4.5 % graft copolymer

copolymer reduces the domain size of the dispersed phase. The average domain size of uncompatibilized blend is 27.6 µm. By the addition of 1.2% of the compatibilizer, the domain size decreased to 7.29 µm i.e., a reduction of 73.5% occurs. Addition of further 1.8% of the compatibilizer causes a domain size reduction of 66%. The size of the domains finally gets levelled off at higher concentrations. The size of the dispersed phase as a function of graft copolymer content is given in fig. 2. It can be seen that particle size decreases sharply by the addition of a few per cent of the copolymer followed by a levelling off at higher concentrations. The levelling occurs at about 4.5% of the compatibilizer loading. The levelling point can be taken as the so called critical micelle concentration (CMC), i.e., the concentration at which micelles are formed. Further addition of the compatibilizer beyond CMC will not modify the interface anymore, but create micelle formation which is highly undesirable.

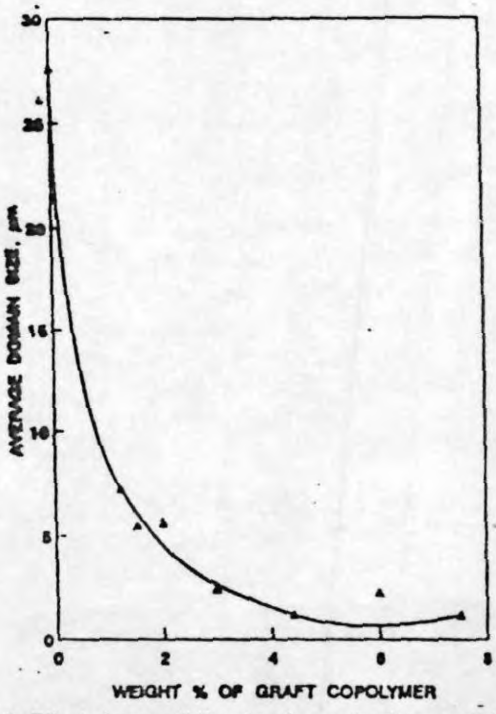


Fig 2. Effect of compatibilizer loading on the dispersed phase size of NR/PS blends.

The domain size distribution is given in fig. 3. The polydispersity is higher for blend without graft copolymer as evidenced by the large width of the distribution curve. The polydispersity is much reduced by the addition of 4.5% of the graft copolymer which is evident from the very narrow width of the distribution curve. The standard deviation values (Table 2) also support the large particle size distribution for blends having no graft. These values decrease sharply with increasing loading of the compatibilizer. Finer and narrow distribution of the domains always provide better mechanical properties.

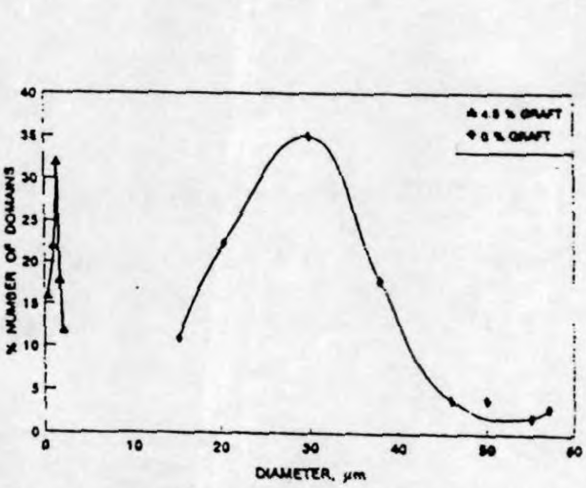


Fig 3. Particle size distribution of NR/PS blends.

Table 2. Domain size of dispersed phase

Weight per cent graft copolymer	Average size µm	Standard deviation
0	27.6	11.067
1.2	7.2912	1.8452
1.5	5.481	1.1044
3.0	2.45	1.0960
4.5	1.225	0.5344

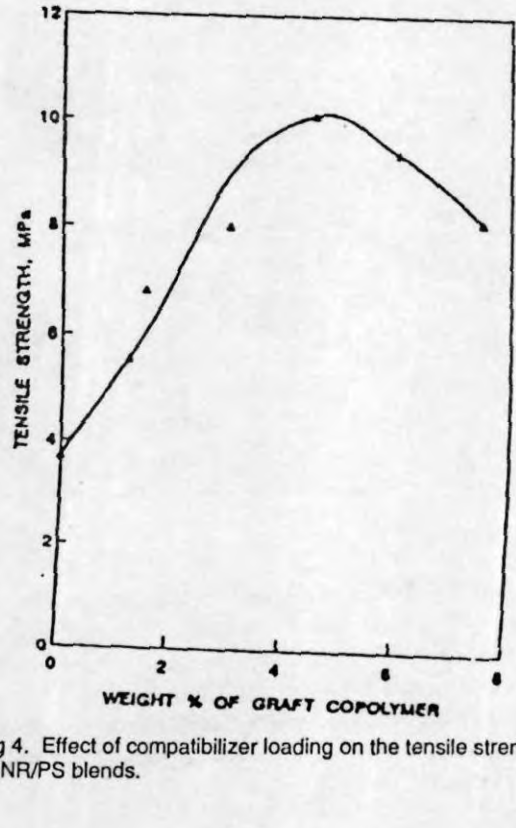


Fig 4. Effect of compatibilizer loading on the tensile strength of NR/PS blends.

Table 3. Mechanical properties of 60/40 NR/PS blends

Weight percentage of graft	Stress at 10 % elo-ngation MPa	Stress at 15% elo-ngation MPa	Stress at 50% elo-ngation MPa	Stress at 150% elo-Mpa	Tensile Strength MPa	Elongation at break %	Young's modulus MPa
0	1.37	1.164	2.56	--	3.7	77	14
1.2	1.46	1.61	2.04	2.84	4.832	308	--
1.5	1.59	1.72	2.23	3.98	6.815	325	24
3.0	2.81	3.03	3.71	5.50	8.01	270	50
4.5	2.84	3.35	4.29	6.69	10.14	279	56
6.5	3.09	3.37	4.05	6.21	10.24	351	58

Fig. 4 shows the tensile strength of the blend as a function of copolymer concentration. The tensile strength increases sharply upto saturation point and then decreases. Table 3 shows the mechanical properties of the system. It is seen that properties like modulus, elongation at break, young's modulus increase with increasing concentration of the compatibilizer. The properties level off at higher concentrations. The improvement in tensile strength, modulus and elongation at break is associated with microbridge formation between the incompatible PS and NR phases through the graft copolymer.

4. Conclusion

The addition of a graft copolymer has great influence on the morphology and properties of binary NR/PS blends. The domain size of the dispersed phase decreases sharply by the addition of small amount of the copolymer, followed by a levelling off as the copolymer content is increased. The mechanical properties of the blend increases with increasing concentration of the copolymer and levels off at the saturation point.

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DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM FOR CITIES

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Abstract : This paper gives a brief description of the salient features of a geographic information system (GIS) that is being developed around the data pertaining to Thiruvananthapuram city. The GIS is expected to contribute immensely to the monitoring and control of the city's growth in terms of population agglomeration and proliferation of buildings, improvement in property valuation, tourism planning, riot and crime control, equitable distribution of schools and colleges, location of urban waste disposal centres et cetra.

1. Introduction

Remarkable strides have been made during the past 20 years in using computers for processing, storing, and retrieving information traditionally represented in the form of maps. Depending upon the specific requirements, various kinds of geographic data processing systems have been introduced. Some are primarily repositories of image data received from remote sensing satellites (Zobrist and Nagy, 1981), while others store no image but use maps to render geographically