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Impact modification of SAN using NR-g-SAN copolymers

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Abstract The paper demonstrates the efficacy of natural rubber-g-poly (styrene-co-acrylonitrile) (NR-g-SAN) copolymers as impact modifier for SAN. The impact behaviour of SAN /NR-g-SAN blends were studied as a function of cross-link density of NR, percent grafting, rubber content in the blend and the AN content in the grafted chain. The cross-link density of NR had no significant effect on impact strength of the blends whereas increase in percent grafting (PG) of the rubber significantly improved the impact strength. Thus the impact strength increased four times when the PG of the rubber was increased from 34.2 to 65%. Further increase in PG decreased the impact strength. Similar trend was observed on increase in the rubber content, the maximum impact strength was observed at 20% rubber. The impact strength also depended on the acrylonitrile content of the grafted chain. Tensile and flexural strength and modulus of these blends were not influenced by PG and AN content in the grafted chain whereas these properties decreased with the increase in the rubber content. Scanning electron microscopic studies of the impact fractured surfaces showed cavitation of rubber particles and craze induced matrix deformation. Dynamic mechanical studies confirmed the two-phase structure of these blends.

Introduction

Graft copolymers of synthetic elastomers such as polybutadiene (PB), styrene butadiene rubber (SBR), ethylene propylene diene rubber (EPDM) etc. have been extensively used to impact modify brittle thermoplastics. High impact polystyrene (HIPS) and acrylonitrile–butadiene–styrene (ABS) are two most successful commercial rubber toughened plastics [1]. ABS consists of poly (styrene-co-acrylonitrile) (SAN) matrix containing 15–25% SAN grafted PB rubber dispersed as discrete particles. Grafting of PB rubber with SAN facilitates dispersion of rubber particles in the SAN matrix and imparts satisfactory adhesion between rubber particles and the matrix, which in turn ensures effective stress transfer during impact.

The current method of preparation of ABS involves graft copolymerisation of styrene and acrylonitrile onto partially cross-linked PB latex particles (0.1–1.2 μm) using radical initiators [2–4]. This graft stock is then mechanically blended with separately prepared SAN in required proportions to give desired ratio of SAN: PB and marketed as ABS. The low glass transition temperature of PB (T_g = –85 °C) and the ease with which it can be graft copolymerised to get PB-g-SAN copolymers makes it the rubber of choice for impact modification of brittle thermoplastics.

Numerous patents [5–8] and publications [6–8] are available on the preparation of PB-g-SAN copolymers and structure property analysis of its blends with SAN. Morbitzer et al. studied impact modification of SAN using PB-g-SAN having a bimodal rubber particle size distribution with low and high level of percent grafting [9]. Low level of grafting in large particles with highly grafted small particles imparted optimum toughening. Kranz et al. studied the effect of percent grafting and molecular weight of the grafted chain on toughening efficiency [10]. The best

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ABS performance was obtained at low degrees of grafting. Similar conclusions were reached by Ricco et al. [11] and Rink et al. [12]. Paul and co-workers reported the use of PB-g-PMMA and PB-g-SAN monodisperse latex particles as impact modifier for a series of SAN copolymers having varied acrylonitrile content [13–15]. The mechanical properties of the blends were the best when AN content in the matrix was higher than that of the grafted chain. Recently, Okinawa and Suzuki reported the synthesis of ABS graft stock at the ultimate high ratio of PB/monomer of 70/30 using a free radical initiator in the presence of t-dodecanethiol which led to high percent grafting and efficient coverage of the grafted SAN layer on PB latex particles [16]. These graft particles when blended with SAN gave excellent impact resistance.

Natural rubber (NR) with its low T_g (–72 °C) and overall good mechanical properties has not been used as impact modifier for brittle thermoplastics. The reasons for the apparent absence of commercial polyisoprene (PI) modified polystyrene (PS) was reported by Keskkula and Turly [17]. They have synthesised PI modified PS by a mass polymerisation process similar to HIPS preparation. PI did reinforce PS by the formation of complex rubber phase particles similar to those in commercial PB reinforced PS when samples were prepared by compression moulding. But, when samples were injection moulded, the high shearing destroyed the rubber phase structure (rubber particles with large sub inclusions of PS) to very small particles below the optimum level required for toughening of PS, leading to significant drop in impact strength. This particle morphology destruction was attributed to the lack of sufficient cross-link formation in PI during polymerisation.

To overcome insufficient cross-linking in the rubber phase, Tangboriboonrate and Tiyapiboonchiya used a novel method to toughen PS [18]. By titrating the negatively charged-radiation vulcanised NR latex with benzyldimethyl hexadecyl ammonium chloride in presence of styrene, they transferred the cross-linked rubber particles from latex to the styrene phase, which was then bulk polymerised. Though the blend showed two phase morphology, the size of the PS sub inclusions inside the rubber particles were extremely small compared to that of the commercial HIPS and the modified PS showed only moderate improvement in impact strength.

Recently Schneider et al. have shown that NR based composite latex particles could be used to impact modify SAN, PMMA and PS [19–21]. NR latex particles with PS sub inclusions were first prepared by polymerising styrene and these particles were then coated with cross-linked PMMA in a second stage emulsion polymerisation of MMA. This composite latex was then dispersed in molten SAN using a specially designed twin-screw extruder. The impact strength as high as 60 kJ/m^2 was observed in the blend having 30% of the composite latex particles. The impact modification of SAN using NR-g-SAN copolymers has not been reported so far. This may be due to the problems associated with the simultaneous graft copolymerisation of styrene and acrylonitrile in NR latex using chemical initiators. We have recently reported that styrene and acrylonitrile could be polymerised in NR latex to very high conversions (>95%) using γ-ray initiation from a ^{60}Co source [22]. The present paper reports the mechanical properties of SAN/NR-g-SAN blends with special emphasis on impact strength. The properties were studied as a function of cross link density of the rubber, percent grafting, acrylonitrile content in the grafted chain and rubber content in the blend. The improvement in impact properties is correlated with SEM analysis of the fractured surfaces.

Experimental

Materials

Centrifuged high ammonia preserved NR latex with 60% dry rubber content was supplied by Rubber Research Institute of India, Kottayam, Kerala. Styrene and acrylonitrile (E. Merck) were washed with 10% NaOH solution and further washed with distilled water, dried over $CaCl_2$ and distilled under reduced pressure before use. Poly (styrene-co-acrylonitrile) (SAN) (Absolan 25, AN content = 25%) and a commercial high impact acrylonitrile–butadiene–styrene (ABS 100) were supplied by Bayer India Ltd and a phenolic antioxidant Irganox 1010 was supplied by Ciba Geigy.

Preparation of SAN/NR-g-SAN blends

The preparation and characterisation of NR-g-SAN graft copolymers is described elsewhere [22]. Radiation prevulcanised NR latexes having varying cross-link density were prepared [23] and used for graft copolymerisation of styrene/acrylonitrile monomer mixture in a second stage emulsion polymerisation using γ-radiation. The percent grafting (PG) of the rubber was varied by changing NR: monomer (NR: M) ratio in the feed. The PG was determined by extracting the SAN homopolymer using methyl ethyl ketone. Inorder to get graft copolymers with grafted chain having different styrene: acrylonitrile (S: AN) composition, the feed ratios of styrene and acrylonitrile were varied as 92: 08–60: 40 at different NR: M ratios. The details of the graft copolymers are given in Table 1. NR- g- polystyrene (NR-g-PS) was also prepared at the NR: Styrene ratio 50:50 in the feed.

Table 1 Details of NR-g-SAN graft copolymers

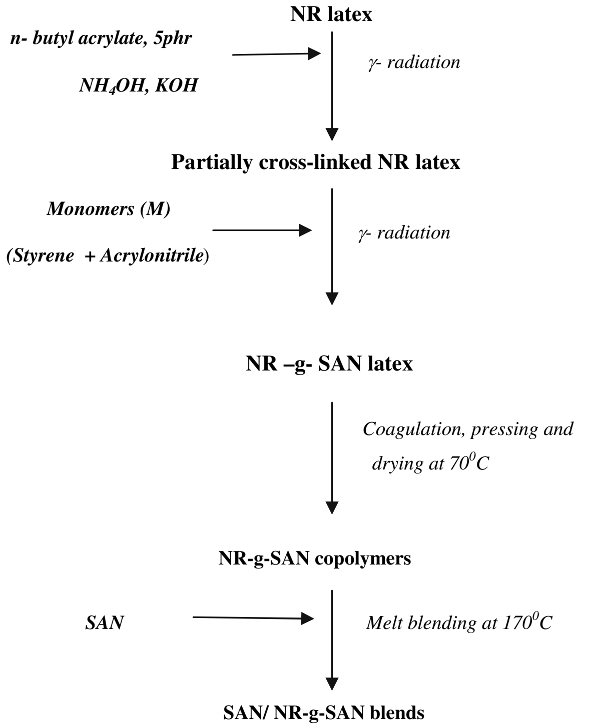
Sample series	[a]NR: M ratio	[a]S: AN ratio	Percent grafting	Sample designation
A	60:40	92:08	25.4	A8
		85:15	28.5	A15
		78:22	34.2	A22
		70:30	40.1	A30
B	50:50	92:08	33.0	B8
		85:15	37.4	B15
		78:22	49.0	B22
		70:30	54.4	B30
C	40:60	92:08	37.8	C8
		85:15	43.8	C15
		78:22	64.3	C22
		70:30	61.2	C30
		60:40	64.5	C40
D	32:68	78:22	85.0	D22

[a] Ratio in the feed for the preparation of graft copolymers

Both SAN and the graft copolymers (containing free SAN homopolymer) were dried in vacuum oven at 80 °C and 60 °C respectively for 12 h before blending. Blends of batch size 270 g were prepared in a Haake Rheocord 90 having Banbury type rotors at 170 °C at 70 rpm for 10 min. Blends having different rubber contents were prepared by varying the resin and graft copolymer proportions in the blends. The hot mix discharged after blending was made into a sheet using a two roll mill and cut into pieces while hot. This was then pulverised in a crusher to small pieces and test pieces were injection moulded at 220 °C using a Windsor SP1 injection moulding machine. Scheme 1 summarises the various steps involved in the preparation of NR-g-SAN and SAN /NR-g-SAN blends.

Testing procedures

Tensile and flexural properties were determined following ASTM D-638 (type 1) and ASTM D-790 test procedures respectively. Izod impact strength of notched specimens was measured on a CEAST impact tester (Falling hammer type, Model No. Resil 25). The dimensions of the sample are given in Fig. 1. A notch of 2.54 mm depth with an angle of 45° was made on the impact specimen prior to testing. Fractured surfaces were analysed using a scanning electron microscope. The dynamic mechanical properties of the blends were measured using DMA 2980 of TA Instruments Ltd. A three-point cantilever cell was used at a frequency of 5 Hz. The temperature range was –100 °C to + 150 °C and a heating rate of 1 °C/min was used in all measurements.



Scheme 1 Summary of preparation of SAN/NR-g-SAN blends

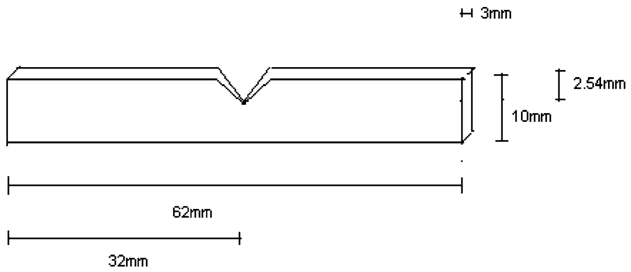


Fig. 1 Dimensions of the izod impact test sample

Results and discussion

Impact behaviour

Cross-link density of rubber

The main purpose of introducing partial cross-linking in rubber particles in the graft copolymer was to maintain the integrity of the rubber particles during the high shear experienced during the processing of the blend. The optimum particle size of the rubber graft for achieving maximum impact toughness for SAN is reported [24] to be 0.75 ± 0.15 μm. The cross-linking in the rubber prevents the rubber getting dispersed to smaller sizes than the optimum particle size required for the matrix to get better impact toughness [25]. Changing the cross-link density of

Table 2 Effect of cross-link density of NR on the impact strength of SAN/NR-g-SAN blends (B22/20)[a]

Sample No.	Cross-link density, v (mol m^{-3})	Impact strength, kJ/m^2
1	0	14.3
2	1.389	14
3	1.612	15.8
4	2.003	14.6
5	3.321	16.9

[a] Blend containing 20% rubber prepared using copolymer B22. Similarly blends containing A, C and D series copolymers were designated

rubber changes the modulus of the rubber particles which influence the deformation process of the matrix and hence the toughness. The effect of changing the cross-link density of the grafted rubber particles dispersed in the SAN matrix at a rubber content of 20% and percent grafting 45 ± 3 is given in Table 2. These results show that the changes in cross-link density did not influence the impact strength of SAN/NR-g-SAN blends. It is quite likely that during the γ-ray induced graft copolymerisation, cross-linking in NR might also have taken place. It is known that olefinic monomers can act as sensitiser for γ-ray induced cross-linking of NR latex [26, 27]. Though the initial cross link densities of the seed rubber particles were different, the cross-linking during the graft copolymerisation might have resulted in comparable cross-link density in all samples.

Percent grafting and rubber content

Matrix compatible graft chains perform two functions: (a) provide sufficient adhesion between matrix and the rubber particles which is essential for preventing crazes growing into cracks and (b) prevents agglomeration of the rubber particles in the matrix. Figure 2 shows the effect of percent grafting of the grafted rubber particles and the rubber content on the notched Izod impact strength of the blends. The results show that the impact strength of the blend increased more than fourfold when percent grafting was increased from 34.2 to 65%. Further increase in PG decreased the impact value.

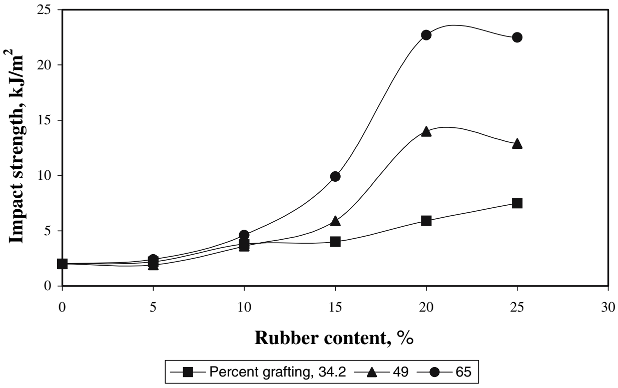


Fig. 2 Effect of percent grafting (NR: M ratio) and rubber content on impact strength of SAN/NR-g-SAN blends (S: AN = 78:22)

In blends having medium and high levels of percent grafting (49 and 65% respectively), the impact strength increased with increase in rubber content, reached a maximum and then decreased with further increase in rubber content. In these blends the highest impact strength was achieved when the rubber content was 20%. However in blends containing graft copolymer of low percent grafting, the impact toughness was only marginally increased with increase in rubber content.

Effect of AN content

In addition to percent grafting, the AN content in the grafted chain was varied by using different S: AN in the initial monomer feed during graft copolymerisation. The profound effect of AN content on impact properties of the blend is evident from the results (Fig. 3). The impact strength of the blend increased with an increase in AN content in the graft copolymer samples. A maximum value of 22.7 kJ/m^2 was obtained at NR: M ratio 40:60 and at 22% AN content in the feed. However, further increase in AN content had only a marginal influence on the impact behaviour when the NR: M ratio in the feed was 40:60 (high percent grafting).

Interpretation of impact behaviour

The results presented above show the importance three major parameters, viz. rubber content in the blend, percent

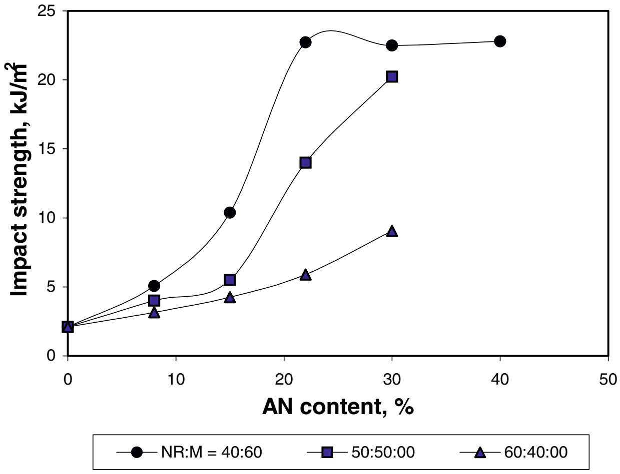


Fig. 3 Effect of AN content and percent grafting (NR: M ratio) on impact strength of SAN/ NR-g-SAN blends (Rubber content = 20%)

grafting and AN content in the graft for achieving high toughness of the SAN matrix. The dispersion of rubber particles in the matrix and the adhesion between the matrix and the rubber particles are controlled by the graft density and AN content of the grafted chains. Adhesion is important for transfer of stress and to avoid development of catastrophic cracks between the matrix and the rubber particles [28]. Insufficient grafting leads to incomplete or wart-like graft coverage of rubber particles leading to rubber particle agglomeration. Chances for the formation of insufficiently grafted rubber particles are very high during the graft copolymerisation of NR latex due to the high heterogeneity in particle size. Transmission electron microscopic studies of NR-g-PMMA latex particles prepared under various conditions showed that the smaller particles are heavily coated while larger particles are not completely coated when rubber hydrocarbon: monomer ratio was high [23]. Rubber particle agglomeration leads to large areas of matrix devoid of rubber particles leading to lower impact strength. At lower levels of grafting, increase in AN content need not necessarily bring about dispersion as well as adhesion between the particles and the matrix. Results of the blends containing rubber particles with lower PG (NR:M = 60:40) support such an argument. However, impact behaviour of blends containing rubber particles of intermediate levels of grafting (NR:M = 50:50), AN content in the grafted chain play a critical role in improving the impact strength. Thus after reaching sufficient coverage of the rubber particles, the dispersion of the rubber particles and its adhesion with the matrix is controlled by AN content in the grafted chain. The importance of intermediate levels of dispersion and satisfactory levels of adhesion for obtaining maximum toughness in ABS has been reported earlier [14, 15]. These studies also indicated that some mismatch in the AN content between the SAN matrix and that in the grafted chain was advantageous.

The impact strength increases up to a certain level of rubber content in the blend and then decreases above this level. In the present study the maximum toughness was obtained at 20% rubber content while further increase of rubber content decreased the toughness. Similar results have been reported earlier [29]. The decrease of toughness above certain rubber content is related to the decrease in the modulus and the yield stress with the increase of rubber content. If blends have a low modulus and low yield stress, the stress cannot be transferred far from the crack tip. This results in a decrease in toughness [30]. In other words, the principal effect of increasing the rubber content is to raise the level of stress concentration in the neighbourhood of the equator of each particle. As the rubber content is increased beyond a certain level, not only the volume fraction of the load-bearing matrix is reduced, but also stress fields begin to overlap. Though larger number of rubber particles initiate large number of crazes, each terminates at a neighbouring rubber particle at a correspondingly earlier stage of growth. Thus there is little net gain in rate of crazing and hence lower toughness results.

Fractured surface analysis

Figure 4 shows the variation in the extent of stress whitening at varying rubber content (PG = 64.3%). The rubber content was varied from 5 to 25%. Different extent of stress whitening is caused by different extents of craze initiation and propagation or cavitation of the rubber particles. The fractured surface of the blend containing 5% rubber did not show any stress whitening. At 10% rubber content, a very faint indication of crazing in the region of the notch tip was observed while the residual area of the fracture surface does not show any stress whitening. At higher rubber levels, the stress whitening of the fractured surface increased. The entire fractured surface was intensely stress-whitened in the blends having 20 and 25% rubber content. This behaviour is consistent with the impact strength values obtained for these blends (Fig. 2). Maximum stress whitening was observed at 20% rubber content which gives the highest impact strength. Similar trend was observed when the percent grafting and AN content was varied at fixed rubber concentration of these blends.

More details of the fracture surface could be obtained from the SEM analysis of the samples. SEM photographs of the fractured surfaces produced by notched Izod impact test at room temperature are shown in Fig. 5 (a, b) and Fig. 6 (a–c). Figure 5a shows the fractured surface of SAN/NR blends having 20% rubber content. The brittle fracture surface clearly shows the cavities of solid rubber particles debonded from the SAN matrix. The size of the holes also indicates considerable rubber agglomeration. SEM of the fractured surface of SAN /NR-g-PS blend at 20% rubber

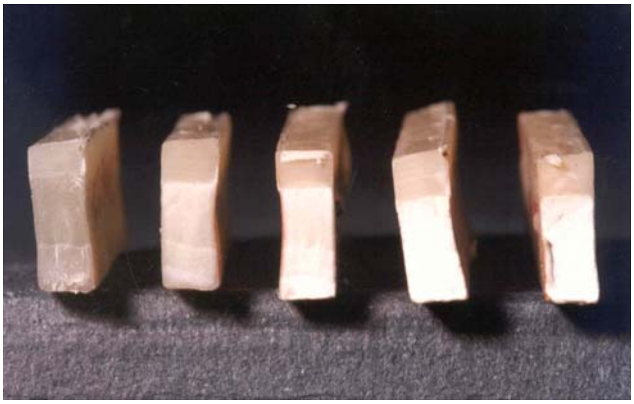


Fig. 4 Fractured surfaces of SAN/ NR-g-SAN blends at varying rubber content; From left C22/5, C22/10, C22/15, C22/20 and C22/25

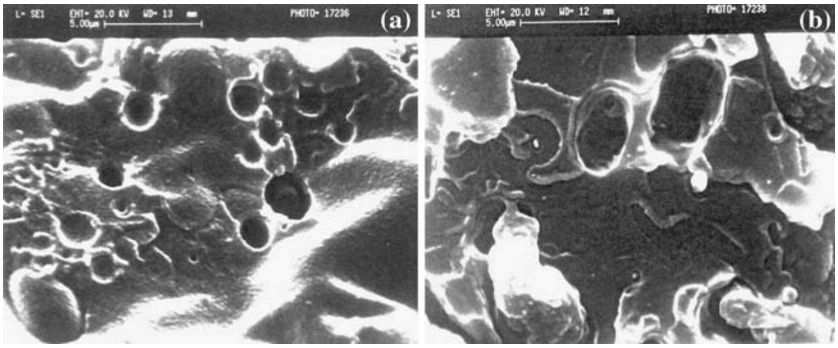


Fig. 5 SEM of the fractured surface of (**a**) SAN/NR (80:20), (**b**) SAN/NR-g-polystyrene (Rubber content = 20%)

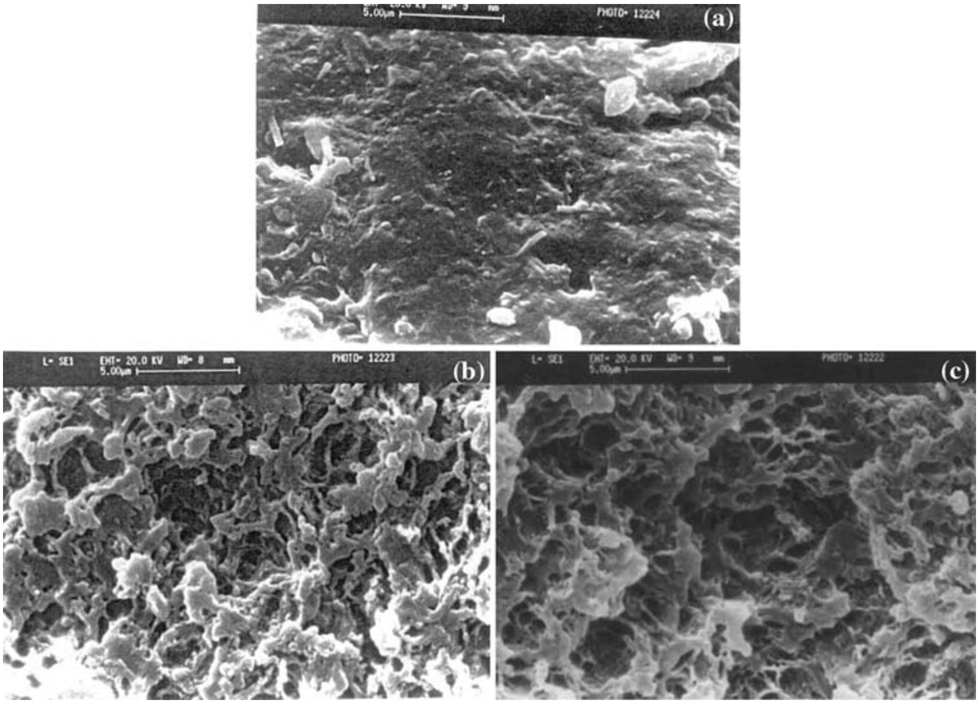


Fig. 6 SEM of the fractured surface of SAN/NR-g-SAN blends at varying percent grafting (PG) of the rubber (Rubber content = 20%): (**a**) PG = 34.2%, (**b**) PG = 49.0%, (**c**) PG = 65.02%

content is given in Fig. 5b which also shows particle agglomeration and debonding of the rubber particles.

The effect of percent grafting of the rubber in the blend on the morphological features of the fractured surface is given in Fig. 6 (a–c). The fractured surface of blends having graft copolymer with low PG (34.2%) (Fig. 6a) shows typical features of a fractured brittle surface with no or negligible plastic flow of the matrix. Since the rubber particles are not fully covered at low levels of PG, sufficient stress transfer was not possible in order to observe cavitated rubber particles. However, blends containing rubber particles having intermediate (PG = 49%) and high levels of grafting (PG = 64.3%) developed multiple rubber particle cavitation which precedes the matrix deformation possibly by shear yielding and crazing. Donald and Kramer [31] have shown that the toughening mechanism of the rubber modified SAN matrix is both by crazing and shear yielding with substantial cavitation of the rubber particles. Small particles promote shear yielding by rubber particle cavitation and large particles induce crazing. It was demonstrated by these authors that when small particles (0.1–0.5 µm) cavitate, small spherical voids of diameter 0.1–0.5 µm are formed. Large particles (0.5–1.5 µm), which initiate crazes also show internal voiding and as crazing proceeds, the size of the voids becomes larger. Similar results were also reported by Schneider et al. [20]. Thus the stress whitening and its extent observed in fractured samples in the present study may be due to crazing and cavitation of the rubber particles followed by shear yielding of the matrix.

Tensile and flexural properties

Table 3 gives the effect of percent grafting of the rubber on tensile and flexural properties. The rubber content in the blends was 20% and the S:AN ratio in the feed used for the

Table 3 Effect of percent grafting on tensile and flexural strength of SAN/NR-g-SAN blends

Sample designation	Yield stress (Mpa)	Tensile modulus (Mpa)	EB (%)	Flexural strength (Mpa)	Flexural modulus (Mpa)
A22/20	24.1	647	13	45.9	1921
B22/20	24.5	679	13	44.5	1968
C22/20	27.1	677	12	45.6	1870
D22/20	26.1	716	5.8	44.5	1865

Table 4 Effect of S: AN ratio in the feed on tensile and flexural strength of SAN/NR- g-SAN blends

Sample No.	Yield stress (MPa)	Tensile modulus (MPa)	EB (%)	Flexural strength (MPa)	Flexural modulus (MPa)
C8/20	23.5	621	15.8	40.2	1824
C15/20	23.9	649	14.6	40.4	1800
C22/20	27.1	677	11.9	45.6	1870
C30/20	30.5	670	6.4	52.8	2015

preparation of the graft copolymer was 78: 22. The results show that the PG had only marginal influence on both tensile and flexural yield stress and modulus. However, strain at break showed reduction at very high percent grafting. The results on variation of AN content in the grafted chain on the tensile and flexural strength of these blends at 20% rubber content are given in Table 4. The yield stress as well as flexural stress increased marginally with the increase in AN content. Modulus however did not show any significant variation.

The effect of rubber content on the tensile and flexural properties of these blends is given in Figs. 7 and 8. Yield stress and modulus showed a systematic reduction with increased concentration of rubber. Similar trend was observed with flexural strength and modulus. Breaking strain showed a marginal increase up to 15% rubber content and then increased considerably at 20% rubber and then it increased marginally when the rubber content was further increased to 25% (Fig. 9). The increase in breaking strain at 20% rubber content coincides with the maximum impact strength achieved.

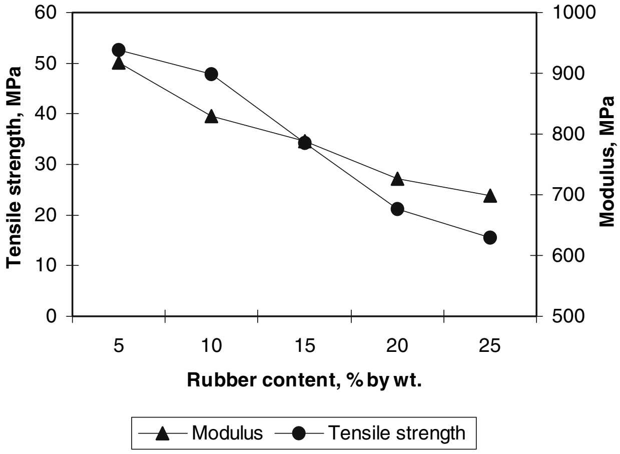


Fig. 7 Effect of rubber content on tensile strength and modulus in SAN/NR-g-SAN blends (NR: M = 40: 60; S: AN = 78: 22)

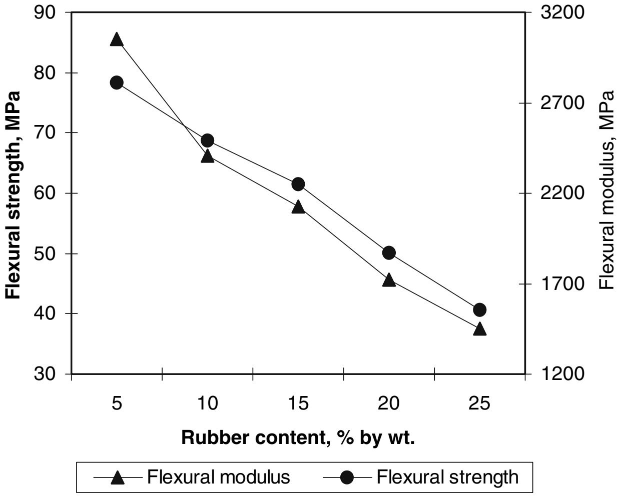


Fig. 8 Effect of rubber content on flexural strength and modulus in SAN/NR-g-SAN blends (NR: M = 40:60; S: AN = 78:22)

Comparison of mechanical properties of a few selected SAN/NR-g-SAN blends with a commercial high impact ABS sample is given in Table 5. The comparable impact and other mechanical properties with the ABS sample further confirm the efficacy of the NR-g-SAN copolymers as a toughening agent for SAN.

Dynamic mechanical properties

Figure 10 shows the dynamic mechanical properties of SAN /NR-g-SAN blend as a function of temperature. The behaviour is typical of two-phase systems showing both rubber and hard matrix phase transitions. Thus the storage modulus (E′), loss modulus (E″) and tan δ curves of these

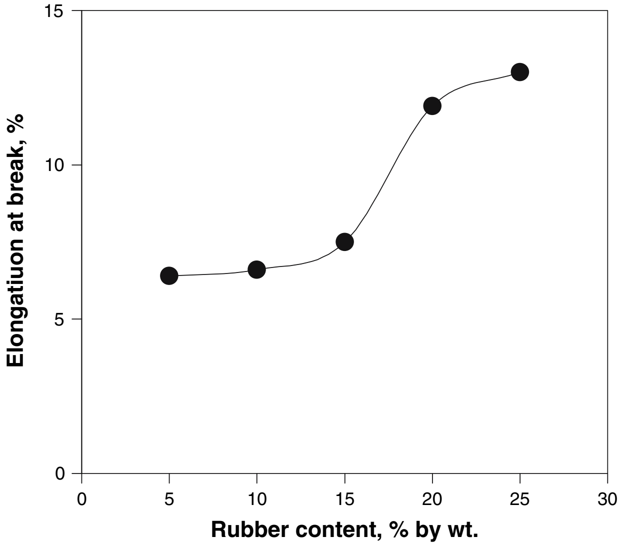


Fig. 9 Effect of rubber content on elongation at break in SAN/NR-g-SAN blends (NR: M = 40:60; S: AN = 78:22)

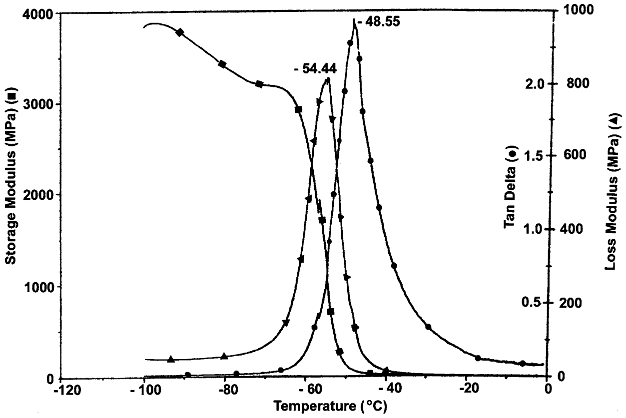


Fig. 10 Dynamic mechanical scan of SAN/NR-g-SAN blend (C22/20)

Table 5 Comparison of mechanical properties of SAN/NR-g-SAN blends with a commercial ABS sample

	ABS 100[a]	C22/20	C30/20	B30/20
Impact strength, kJ/m^2	21.2	22.7	18	20.2
Tensile strength, MPa	30.7	27.1	30.5	31
Young's modulus, MPa	705	677	690	686
Flexural strength, MPa	49.5	45.2	–	52.7

[a] Supplied by Bayer India Ltd.

blends exhibited a combination of the features of NR and SAN copolymer, explaining the high impact strength and stiffness of these blends.

Table 6 Glass transition temperature of SAN/NR-g-SAN blends

Sample No.	T_g of rubber from tan δ peak, °C	tan δ peak height
NR[a]	–48.6	–
A22/20	–52.6	0.0769
B22/20	–52.7	0.0692
C22/20	–54.7	0.0677

[a] (Cross-link density = 1.389 mole m^{-3})

Table 6 summarises the dynamic mechanical data for SAN / NR-g-SAN blends. Two observations could be made from these data; (a) a decrease in T_g of rubber in the blend compared to that obtained for NR film and a further decrease in T_g of the rubber in the blend at higher percent grafting and, (b) a decrease of tan δ peak height with the increase of PG. Thus the T_g of NR (–48.6 °C) decreased to –52.6 °C in the blend having rubber with PG of 34.2. A minor decrease in T_g to –52.8 °C was observed when the PG of the dispersed rubber was 49%. A decrease of around 2 °C was observed when the PG of the rubber in the blend was 65%. Similar results were reported by earlier workers in ABS plastics [9–11, 32]. On cooling composites having a dispersed rubber phase to temperatures well below the matrix T_g, the rubber undergoes appreciable dilatation attributed to the thermal expansion mismatch. Because of the greater thermal contraction of rubber with respect to glassy matrix, a state of triaxial tension is to be expected in each rubber particle. This leads to the increase in free volume of the rubber resulting in a decrease in T_g. As the degree of grafting increases, the coupling between the rubber and the matrix increases which further increases the triaxial tension in the rubber phase and consequent higher level of dilatation and decreased T_g value. In the present system, the lowest T_g of rubber was obtained for the blend containing rubber with PG 64 which showed the highest impact strength.

The height of the tan δ peak of a component of composite material is directly related to the relative quantity of the component in the blend [15]. Since the weight fraction of NR in the three blends studied was at 20%, the reduction of the tan δ peak height indicates the quality of the bonding at the interphase. Murayama and Lawton [33] and Chua [34] have shown that the height of the damping peak decreases when the bonding in the interfacial region increases in tyre cord/ rubber composites and glass fibre reinforced polyester, respectively. Similar results were reported by Paul and Kim in SAN/ PB-g-SAN blends. In the present studies, the rubber peak height was maximum in blends where the PG of rubber was lowest with corresponding lower impact strength and the peak height progressively reduced with the increase in PG of the rubber in the blend.

Conclusions

NR-g-SAN copolymers synthesised by copolymerisation of styrene and acrylonitrile in NR latex using γ-ray initiation can be used as efficient impact modifiers for SAN. The percent grafting of the copolymer, AN content in the grafted chain and rubber content in the blends control the toughening of SAN /NR-g-SAN blends. The impact fractured surface topography of these blends also depended on these factors. In blends having high impact strength, cavitation of the rubber particles and craze induced matrix deformation were observed. Better adhesion between the SAN matrix and the rubber particles at higher percent grafting was indicated by the height reduction in rubber damping peak. The tensile and flexural properties were mainly influenced by the rubber content in the blend.

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