

## **EFFECTS OF EPDM RUBBER ON CRYSTALLIZATION BEHAVIOUR AND MORPHOLOGY OF iPP/HDPE BLEND**

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The effects of EPDM rubber on the crystallization behaviour of isotactic polypropylene (iPP) in the ternary iPP/HDPE/EPDM blends were studied by means of DSC and X-ray diffraction. Analysis of the crystallization exotherm peaks in terms of crystallization nucleation and growth rates and crystallinity revealed variations in the morphology of the iPP component in the blends as a function of the EPDM content. The DSC and X-ray diffraction results showed that the overall crystallinity decreased as the weight percentage of EPDM was increased in the iPP/HDPE blends.

The morphology of these blends was studied by scanning electron microscopy, which revealed a random distribution of EPDM throughout the iPP matrix. The size and number of these rubber particles increased with increase of the EPDM weight percentage in the ternary iPP/HDPE/EPDM blends. The probable existence of composite inclusions of EPDM-HDPE in an iPP matrix is suggested.

Blends of PE and PP having high impact strength and low-temperature toughness have been studied for their compatibility, melt mixing and rheological behaviour [1-4] and are commercially available [5, 6]. The ultimate tensile strength and modulus of PE/PP blends has been found to depend on the blend composition [4, 7, 8].

Studies on the morphology and mechanical properties of blends of isotactic polypropylene (iPP) with elastomers (e.g. styrene-ethylene-butylene-styrene block copolymer (SEBS) [9], or ethylene-propylene copolymers (EPM) [10]) have been described in the literature. However, little information is available on the ternary blends of iPP/HDPE and elastomers.

The tensile mechanical performance of iPP/HDPE is improved by a suitable third component such as EPM [11]. Such an additive is believed to act as a compatibilizer between the two homopolymers. The effects caused by the addition of EPM copolymers having different ethylene contents to iPP/HDPE blends on the impact properties and morphology have been reported [12, 13]. The state of dispersion of poly(ethylene-co-propylene) rubber and HDPE in iPP blends has been investigated

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by using scanning electron microscopy (SEM) [14]. It would be of interest to study the effects of an elastomer on the crystallization behaviour of iPP/HDPE blends.

In this paper we present the results of our investigation of the effects of EPDM (ethylene-propylene-diene-monomer rubber) on the crystallization behaviour of the binary iPP/HDPE blend. An understanding of the crystallization behaviour of PP is of great importance for interpreting the mechanical properties of polyblends and composites containing PP as the major component.

In the ternary iPP/HDPE/EPDM blends, the iPP/HDPE ratio was kept at 9:1 and the rubber content was varied from 5 to 25 wt. %. This 90/10 ratio of iPP/HDPE was selected on the basis of a systematic study in our laboratories on the various binary blend compositions of iPP/HDPE and also from reports available in literature [15].

The morphology of these blends was studied by SEM. The crystallization behaviour and degree of crystallinity were determined by means of DSC and X-ray diffraction measurements (XRD). DSC has been widely used for study of the crystallization of polymeric materials. When recorded during the cooling cycle, using a wide range of cooling rates, the DSC traces of iPP show a well-defined crystallization exotherm. Changes in the shape and position of the exotherm are related to the changes in nucleation and growth rates, and also to the overall crystallinity and distribution of the crystallite (or spherulite) size [9].

## Experimental

Isotactic polypropylene (iPP), Koylene M 3030, from the Indian Petrochemical Corporation Ltd. (melt flow index 3.0 g/10 min), and high-density polyethylene (HDPE), Hostalene GD-7250 (melt flow index 6.5 g/10 min) and EPDM rubber, NORDEL-1560, from the DuPont Company of America, were used.

### *Preparation of blends*

In the preparation of the ternary iPP/HDPE/EPDM blends, the iPP/HDPE ratio was kept constant at 9:1 and the rubber content was varied from 5 to 25 wt. %. The compositions of the various ternary blends are listed in Table 1.

A Betol single screw extruder with  $L/D = 19.47$  ( $L/D = 370$  mm/19 mm) was used for the melt blending of the polymers. The temperatures of the four zones of the extruder were: feed zone 190°, compression zone 200°, metering zone 210° and die zone 210°. The granules of all these polymers were hand mixed prior to their feeding into the extruder hopper. The filament obtained upon extrusion was immediately quenched in water and was later chopped into small granules with a

**Table 1** Polymer blend compositions

Sample no.	Sample designation	Wt of iPP component, g	Wt of HDPE component, g	Wt of EPDM component, g
1	A'	90	10	—
2	A	85.50	9.50	5.0
3	B	81.0	9.0	10.0
4	C	76.50	8.50	15.0
5	D	72.0	8.0	20.0
6	E	67.50	7.50	25.0

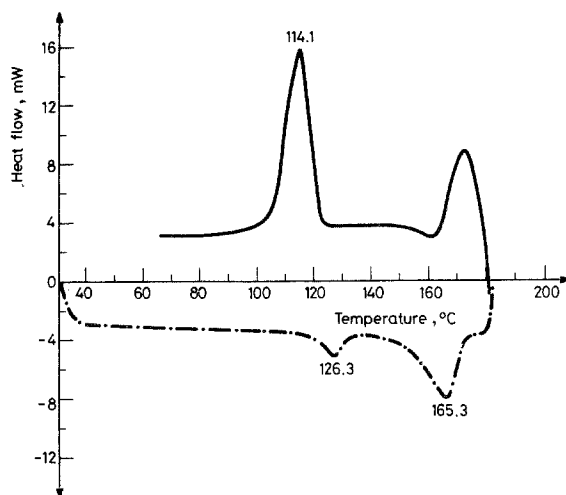
chopper. The unblended iPP and also the 90/10 binary iPP/HDPE blend were subjected to the same process of extrusion in order for them to have a similar thermal history to that of the iPP component in the various ternary iPP/HDPE/EPDM blends.

### Measurements

DSC scans were recorded on a DuPont 1090 thermal analyser with a 910 module in static air atmosphere. A sample size of  $10 \pm 1$  mg was used. The polymer sample in powdered form was heated from  $30^\circ$  to  $180^\circ$  at a heating rate of 10 deg/min and was maintained at  $180^\circ$  for 5 min to allow all the crystallites to melt. In the cooling cycle, the sample was cooled from  $180^\circ$  to  $30^\circ$  under a controlled cooling rate of 10 deg/min (Fig. 1). Once the sample had reached  $30^\circ$ , it was kept at this temperature for 10 min and the melting behaviour of the sample was then recorded by heating from  $30^\circ$  to  $180^\circ$  under the programmed rate of heating of 10 deg/min.

The X-ray diffraction measurements on the various polymer samples were performed with a Philips X-ray generator equipped with a microprocessor-controlled recorder unit. Radial scans of intensity  $I$  vs. diffraction angle  $2\theta$  were recorded in the range  $8^\circ$  to  $50^\circ$  of  $2\theta$ , using  $\text{CuK}_\alpha$  radiation of wave-length  $1.5418 \text{ \AA}$ .

Scanning electron micrographs of samples were obtained on a Cambridge S4-10 stereoscan microscope. Notched impact specimens of various ternary blends were frozen in liquid nitrogen for one hour, placed in a frame and quickly fractured in the impact mode. Fractured surfaces were etched in cyclohexane for one hour at room temperature, sprayed with fresh cyclohexane to remove EPDM and then mounted with silver paint on a base plate. The samples were next coated with silver by using the vapour deposition technique and then micrographed.



**Fig. 1** DSC trace (heating and cooling) of ternary iPP/HDPE/EPDM blend containing 10 wt.% of EPDM

## Results and discussion

### *Fusion*

The melting endotherms of iPP and HDPE were observed at 165.7 and 130.2°, respectively, and are similar to those reported previously. In the DSC scan of the 90/10 binary iPP/HDPE blend, two endothermic transitions corresponding to the two homopolymers were present at 165.3 and 127.5°. The blending of iPP with HDPE in 90/10 ratio results in only a marginal reduction in the  $T_m$  of iPP, but  $\sim 3^\circ$  reduction in the  $T_m$  of HDPE was observed. Although the melting temperature, as evaluated by DSC, is not an equilibrium value, the magnitude of the melting point depression is believed to be reasonably accurate. The melting point data on the ternary iPP/HDPE/EPDM blends are recorded in Table 2. Slight decreases in the melting points of iPP and HDPE were observed on increase of the EPDM content of the blends (Fig. 2). This depression in melting point may arise from morphological changes, such as imperfections in the crystals and a reduction in lamellar thickness. The addition of EPDM and HDPE to iPP has been reported to suppress the hexagonal phase of iPP [16, 17]. HDPE has been stated to be more effective than EPDM in reducing the hexagonal phase of iPP in binary blends, but not in ternary blends [17]. HDPE inclusions are believed to be isolated by EPDM from the iPP matrix in the ternary systems.

The decrease in the  $T_m$  of HDPE on increase of the EPDM content of ternary blends is much more than that for iPP. This behaviour can be explained in terms of

**Table 2** Results of DSC scans of ternary blends of iPP/HDPE/EPDM (heating rate 10 deg/min)

Sample designation	Transition temperatures, °C		$\Delta H_f$ , J/g	
	$(T_m)_1$	$(T_m)_2$	$x$	$y$
iPP	—	165.7 [163.0]	—	56.8 [86.3]
HDPE	130.2 [129.7]	—	84.1 [47.0]	—
A'	127.5 [128.2]	165.3 [164.1]	6.64 (8.41) [8.48]	36.7 (51.12) [52.3]
A	126.0 [126.8]	165.0 [163.0]	8.12 (7.98) [9.04]	33.7 (48.56) [56.5]
B	126.3 [126.6]	165.3 [163.4]	7.12 (7.56) [9.09]	33.6 (46.00) [48.0]
C	125.3 [125.8]	165.3 [163.4]	7.07 (7.14) [8.78]	32.7 (43.45) [47.2]
D	125.0 [125.3]	164.9 [162.9]	7.81 (6.72) [7.91]	34.7 (40.89) [45.3]
E	124.7 [124.3]	164.9 [162.0]	6.17 (6.30) [7.87]	29.6 (38.34) [43.9]

$x$  represents the heat of fusion of polyethylene (HDPE) content in the sample.

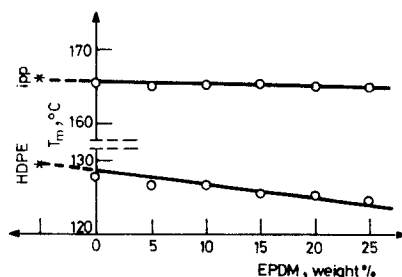
$y$  represents the heat of fusion of polypropylene (iPP) content in the sample.

$(T_m)_1$  represents the melting point of polyethylene in the sample.

$(T_m)_2$  represents the melting point of polypropylene in the sample.

Figures in parenthesis indicate the calculated values of heats of fusion.

Figures in square brackets indicate the values of second thermal cycle.



**Fig. 2** Effect of EPDM on melting point of iPP and HDPE in the 90/10 blend (\*indicates the m.p. of homopolymer)

the combination of HDPE and EPDM to form composite particles in the iPP matrix. The localized high concentration of EPDM diluent in the vicinity of HDPE (in composite particle) may be responsible for a larger decrease in the  $T_m$  of HDPE.

In order to maintain the same thermal history of the polymer blends, the samples were heated at 180° for 5 min, followed by cooling at a constant rate (10 deg/min). The melting behaviour of these samples was then studied by subjecting them to a programmed rate of heating (10 deg/min) from 30° to 180° in the DSC cell. A comparison of the results thus obtained with those found in the first heating cycle (where the samples used were prepared by extrusion blending followed by immediate cooling in water) shows a slight increase in the  $T_m$  of HDPE in these binary or ternary blends. The  $T_m$  of iPP, however, decreased in all the polymer blends (binary or ternary) (Fig. 3).

The area under the melting endotherms representing the heat of fusion ( $\Delta H_f$ ) is also reported in Table 2. The heats of fusion were much higher in the second heating cycle than in the first. The fast cooling of binary or ternary blends (by immersing extruded samples in water) may lead to imperfect crystal formation, whereas under a low cooling rate (10 deg/min), the crystallization of both iPP and HDPE may yield more perfect crystals with a narrow distribution of the crystallite size. This may be responsible for the higher  $\Delta H_f$  values observed. From a knowledge of the heats of fusion of the pure components, the heat of fusion of the blend could be

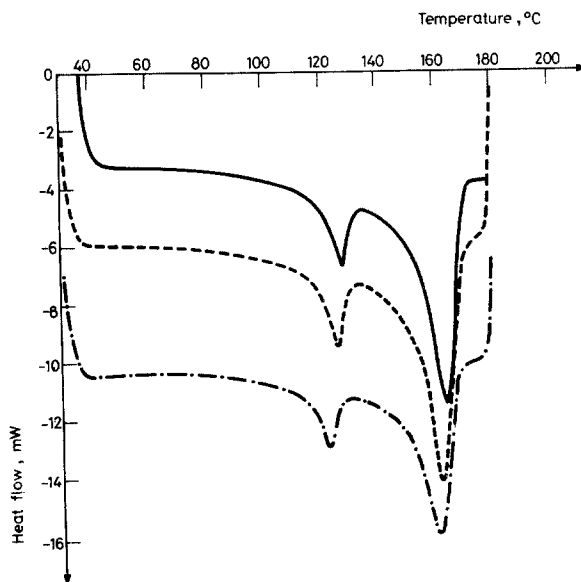


Fig. 3 DSC traces of iPP/HDPE/EPDM polymer blends after subjecting them to same thermal history (i.e. second heating cycle: — 0 wt.% EPDM; --- 5 wt.% EPDM; - · - 25 wt.% EPDM)

calculated by using the mixture rule. The calculated heats of fusion were found to be higher than the corresponding experimental values, indicating that the overall crystallinity was lower in the ternary blends (Table 2).

The relative decrease in the heat of fusion of the iPP components in the ternary blends as a function of the EPDM content could readily be ascertained by plotting the ratio of  $\Delta H_f$  for the blend and  $(\Delta H_f)_0$  for pure iPP vs. the blend composition (Fig. 4). An increase of the EPDM content resulted in a decrease in this ratio.

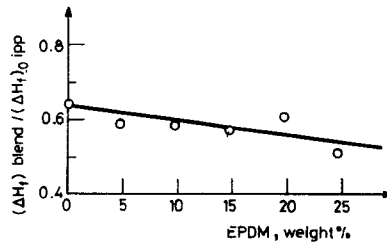


Fig. 4 Effect of EPDM on the relative heats of fusion of iPP in the iPP/HDPE polymer blends

*Crystallization*

The crystallization exotherms recorded during the cooling cycles of iPP, HDPE, the 90/10 blend of iPP/HDPE and the ternary iPP/HDPE/EPDM blends used in the present work were determined by DSC. The quantities used to analyse the crystallization exotherms are defined below and have also been used by other workers [9] (Fig. 5):

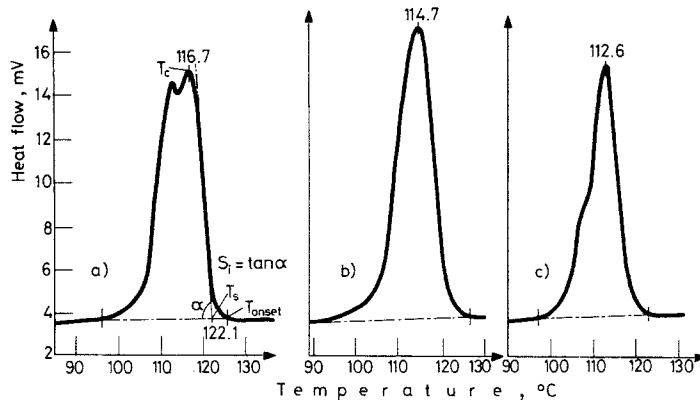


Fig. 5 Crystallization exotherms obtained during cooling cycle of. (a) (90/10) iPP/HDPE blend; (b) iPP/HDPE blend containing 5 wt. % of EPDM; (c) iPP/HDPE blend containing 25 wt. % of EPDM

- (i) The peak temperature of the crystallization exotherm,  $T_c$ .
- (ii) The temperature of onset of crystallization,  $T_{\text{onset}}$ , which is the temperature where the thermogram initially departs from the baseline on the high-temperature side of the exotherm.
- (iii) The slope of the initial arm of the exotherm,  $S_i$ , which is the slope of the tangent drawn to the initial arm on the high-temperature side of the exotherm.
- (iv) The quantity  $(T_s - T_c)$ , where  $T_s$  is the temperature at the intercept of the tangent at the baseline on the high-temperature side of the exotherm.
- (v) The heat of crystallization exotherm,  $\Delta H_0$ , J/g.

The  $T_c$  of iPP and HDPE were found to be 118.6 and 112.8°, respectively. In the DSC scan of the 90/10 iPP/HDPE blend, one prominent exothermic transition was observed with two distinct peaks at 116.7° and 112.8°, respectively, for the iPP and HDPE components. This indicates the existence of two distinct kinds of spherulites in the system, which grow at two different crystallization rates, one crystallizing at a lower temperature than the other. There was a decrease of  $\sim 2^\circ$  in the  $T_c$  of iPP on the addition of 10% HDPE in the 90/10 binary iPP/HDPE blends. In all the ternary iPP/HDPE/EPDM blends containing 5 to 25 wt.% of EPDM, only one exothermic transition was observed with a single peak ( $T_c$ ). The  $T_c$  of the iPP component decreased from 116.7° for the 90/10 binary iPP/HDPE to 112.6° for the ternary blend containing 25 wt.% of EPDM. The reduction in  $T_c$  as a function of blend composition is given in Fig. 6.

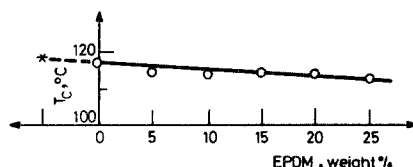


Fig. 6 Effect of EPDM on crystallisation peak position ( $T_c$ ) of iPP in iPP/HDPE blends. (\*indicates the  $T_c$  of pure iPP)

The absence of a peak corresponding to HDPE in the crystallization exotherms of various ternary blends and a reduction in the  $T_c$  of iPP clearly indicates that EPDM influences the crystallization behaviour of the homopolymers in the ternary blends.

A decrease was observed in the heat of crystallization upon the incorporation of increasing percentages of EPDM from 5 to 25 wt.% in the ternary iPP/HDPE/EPDM blends (Table 3). The heat of crystallization ( $\Delta H_0$ ) was also calculated via the mixture rule on the basis of the weights of the two crystallizable homopolymers iPP and HDPE in the binary and ternary blends (Table 3). The experimental values were found to be lower than the  $\Delta H_0$  calculated, indicating that



**Table 3** Crystallisation behaviour of ternary blends of iPP/HDPE/EPDM as evaluated by DSC (cooling rate 10 deg/min)

Sample designation	Crystallization temperatures, °C		$\Delta H_o$ , J/g	$T_s - T_c$ , °C	$T_{onset}$ , °C	$S_i$ , slope of initial arm
	$(T_c)_1$	$(T_c)_2$				
iPP	—	118.6	80.7	6.8	129.0	7.11
HDPE	112.8	—	124.0	3.3	117.0	10.38
A'	112.8	116.7	79.6	5.4	125.0	14.30
A	—	114.7	[85.03]	6.7	126.0	19.08
B	—	114.1	[80.77]	6.5	124.0	19.08
C	—	114.5	[76.52]	6.2	124.0	19.08
D	—	114.3	[72.27]	5.9	124.0	19.08
E	—	112.6	[68.02]	5.7	122.5	19.08
			[63.77]			

$(T_c)_1$  represents the peak temperature of crystallization of polyethylene (HDPE).

$(T_c)_2$  represents the peak temperature of crystallization of polypropylene (iPP).

Figures in square brackets indicate the calculated values of heats of crystallization.

the increasing EPDM content hampered the process of crystallization, thereby acting as a diluent in the ternary iPP/HDPE/EPDM blends.

The quantity  $S_i$ , which is indicative of the rate of nucleation, increased on the addition of HDPE and EPDM to iPP. The parameter  $T_s - T_c$  is a measure of the overall rate of crystallization, decreased on the addition of HDPE or EPDM to iPP. However, the decrease was maximum on the addition of HDPE (i.e. in the binary system). When 5 to 10 wt.% of EPDM was added to the iPP/HDPE blend, the difference between  $T_s$  and  $T_c$  increased and was almost comparable to that for iPP. A further increase of the EPDM content reduced the magnitude of  $T_s - T_c$ . The smaller the difference between  $T_s$  and  $T_c$ , the greater the rate of crystallization. The  $T_{onset}$  for iPP decreased on the addition of HDPE and EPDM.

Thus, these results indicate that the addition of EPDM to the binary iPP/HDPE blend results in an increased rate of nucleation ( $S_i$ ), but in a decrease in growth rate ( $T_s - T_c$ ). A high rate of nucleation may cause the formation of a larger number of spherulites, which may not grow to a large size due to the low rate of growth of crystallization. Thus, the ternary blend will contain a large number of small spherulites. The existence of such a structure is responsible for the overall reduction in the crystallinity of the ternary blend ( $\Delta H_f$ ). The growth rate increases on increase

of the EPDM content of the ternary blends, indicating an increase in the crystallite size at higher rubber contents.

### *X-ray diffraction*

X-ray diffraction patterns of iPP and various polymer blends are shown in Fig. 7. The diffractogram of iPP shows several diffraction maxima, of which the four occurring at  $2\theta$  values of  $14^\circ$ ,  $17^\circ$ ,  $18.5^\circ$  and  $21.7^\circ$  are very intense; the last of these peaks is apparently a doublet. Natta and Cordani [18] have reported similar crystalline peaks for iPP. The diffraction patterns of the binary iPP/HDPE blend and the ternary iPP/HDPE/EPDM blends display all the characteristic peaks of iPP. No additional peak was observed, implying sufficiently grown crystallinity due to iPP in the range of these blend compositions under study.

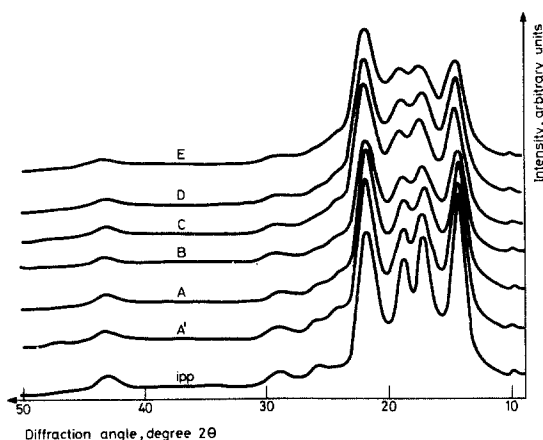


Fig. 7 X-ray diffractograms of iPP and various polymer blends

For the 90/10 binary iPP/HDPE blend, the peak heights at  $2\theta$  values of  $14^\circ$ ,  $17^\circ$  and  $18.5^\circ$  remain the same as for iPP. The height of the peak at  $2\theta = 21.7^\circ$  is increased to some extent for the 90/10 binary iPP/HDPE blend, indicating sufficiently grown crystallinity due to the ability of HDPE to reduce the average spherulite size in all the binary blends, even those containing 90% iPP, resulting in an increase in overall crystallinity and promoting the formation of intercrystalline links [15]. Due to the higher crystallization temperature of iPP, there is a possibility that iPP may help nucleate HDPE to some extent, resulting in an overall increased crystallinity for the 90/10 binary iPP/HDPE blend. However, the four diffraction maxima show the variation of the peak heights with blend composition. As the EPDM content of the blend is increased, the heights of the peaks at  $14^\circ$ ,  $17^\circ$  and  $18.5^\circ$  decrease, whereas the height of the peak at  $2\theta = 21.7^\circ$  does not decrease to the

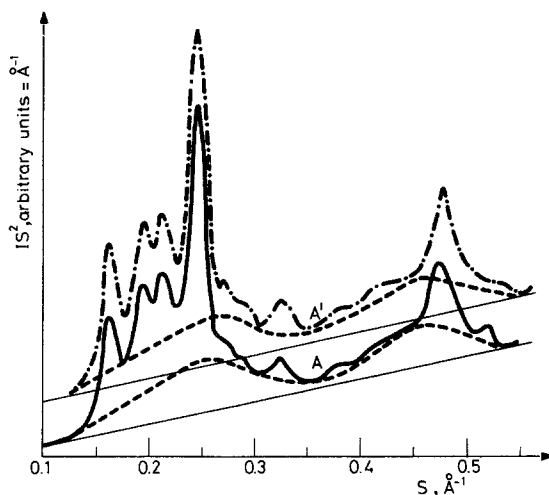


Fig. 8  $IS^2$  vs.  $S$  plots of (90/10) iPP/HDPE (---, A') and iPP/HDPE blend containing 5 wt.% of EPDM (—, A) with baseline and amorphous scattering curve [20]

same extent. Some possible causes for this kind of variation of the peak heights could be: the variation of the mean spherulite size or their distribution, deformation at the spherulite boundaries, or any long-range order induced in the structure by the dispersion of EPDM domains in the iPP/HDPE matrix.

The degree of crystallinity ( $X_c$ ) was calculated from these diffractograms by the method used in the literature [19, 20]

$$X_c = \frac{\int_0^{\infty} S^2 I_{cr}(S) ds}{\int_0^{\infty} S^2 I(S) ds} \cdot K$$

Where  $I_{cr}(S)$  is the coherent intensity concentrated in the crystalline peaks and  $I(S)$  is the total coherent intensity scattered.  $S$  is the scattering vector expressed as  $S = (2/\lambda) \sin \theta$ .  $K$  is the correction factor, which depends on the atomic scattering factor and the disorder function [19, 20]. Owing to the uncertainty [19, 20] about the value of the disorder function, this factor is ignored in these calculations by taking the  $K$  value to be equal to unity. The degree of crystallinity thus evaluated is denoted as the apparent degree of crystallinity ( $X_c$ ), which is emphasized for its comparative value alone.

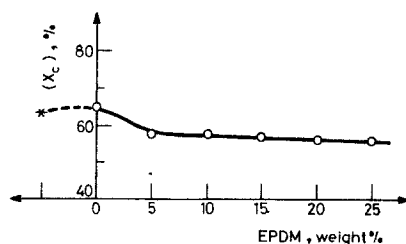
The experimental  $I$  vs.  $2\theta$  curves were converted into  $IS^2$  vs.  $S$  curves [19, 20]. The  $IS^2$  vs.  $S$  curves for iPP/HDPE/EPDM and the 90/10 binary iPP/HDPE are shown in Fig. 8 as a typical illustration of the base line and the amorphous scattering curve

used in these calculations. The resemblance between  $IS^2$  vs.  $S$  curves for these samples and those reported for iPP by other authors [19, 20] is marked.

The apparent crystallinity values obtained in this way are shown in Table 4. The  $X_c$  value obtained for the 90/10 binary iPP/HDPE blend is almost comparable with that for pure iPP; in fact, it is slightly higher than that for the pure iPP sample. This may be due to the ability of HDPE to reduce the average spherulite size in all binary compositions, even those containing 90% iPP [15]. The nucleation and growth rates are very high for HDPE, whereas the opposite is true for iPP [15]. The crystallinity of iPP decreases slightly as the EPDM content of the ternary blends is increased from 5 to 25 wt.% (Fig. 9).

**Table 4** Results of X-ray diffraction (XRD) of various polymer blends

Sample number	Sample designation	Percent apparent crystallinity ( $X_c$ ), %
1	iPP	64.0
2	A'	65.0
3	A	58.0
4	B	57.0
5	C	57.0
6	D	56.0
7	E	56.0

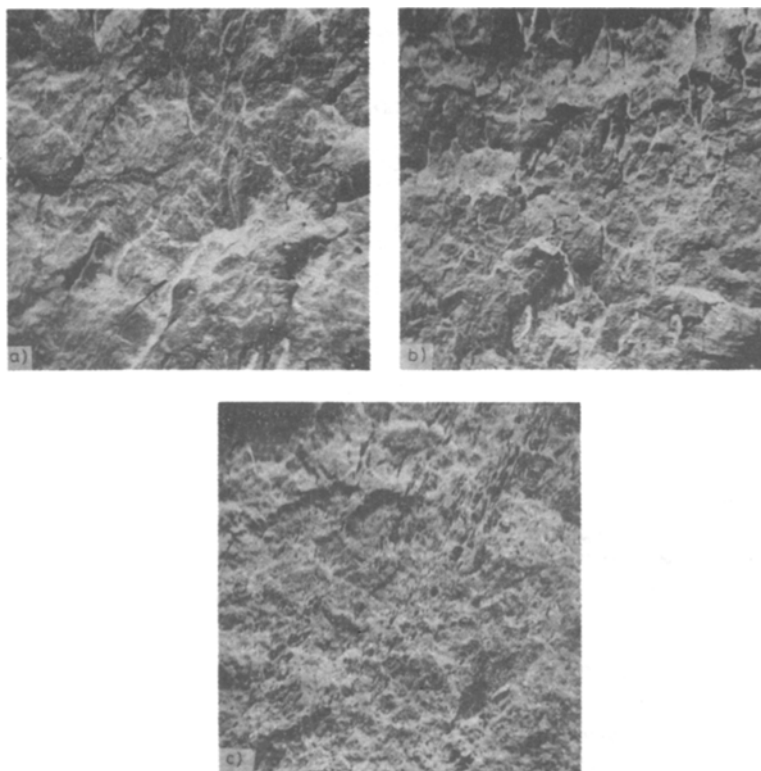


**Fig. 9** Effect of EPDM on percent apparent crystallinity of iPP/HDPE polymer blend

### Scanning electron microscopy

Microstructural details depicting the bulk morphologies of impact specimens, as revealed by fracture at liquid nitrogen temperatures and subsequent etching with cyclohexane to remove the EPDM inclusions from the surface [17], are given in Fig. 10. Scanning electron micrographs of injection molded 90/10 binary iPP/HDPE and ternary iPP/HDPE/EPDM blends containing 5 and 25 wt.% EPDM were taken perpendicular to the flow direction. As the solubility parameter and surface

tension of EPDM are intermediate between those of PP and PE, it is possible EPDM functions as an emulsifier at the surface of HDPE particles [17]. In the ternary iPP/HDPE/EPDM blends, when small amounts of EPDM and HDPE are added to iPP, the two additives have a tendency to form composite EPDM–HDPE particles in an iPP matrix [14].



**Fig. 10** Scanning electron micrographs of injection molded polymer blends; (a) (90/10) iPP/HDPE blend (580 $\times$ ); (b) iPP/HDPE/EPDM (5 wt.%) (600 $\times$ ); (c) iPP/HDPE/EPDM (25 wt.%) (570 $\times$ )

From the SEM micrographs (Fig. 10), it is evident that there is a random dispersion of droplets of EPDM mixed within HDPE throughout the iPP matrix, and the size and number of these droplets increase as the percentage of EPDM in the ternary iPP/HDPE/EPDM blends is increased. In the ternary iPP/HDPE/EPDM blends containing higher percentages of EPDM rubber, there is a possibility of finding isolated EPDM particles besides the composite EPDM–HDPE particles distributed randomly throughout the iPP matrix.

## Conclusions

The following conclusions may be drawn from the above results:

(a) The addition of elastomer (EPDM) to the iPP/HDPE blend leads to the formation of discrete rubber particles randomly distributed in the polymer matrix. An increase of the EPDM concentration results in increases in the size and number of these particles.

(b) A significant decrease in the  $T_m$  of HDPE is observed in the presence of EPDM. This may be due to the formation of composite particle of rubber and HDPE.

(c) The presence of these composite particles increases the rate of nucleation, thereby increasing the number of spherulites but reducing the spherulite size.

(d) The overall crystallinity of the iPP/HDPE blend is reduced by the incorporation of EPDM.

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**Zusammenfassung** — Die Effekte von EPDM-Kautschuk auf das Kristallisationsverhalten von isotaktischem Polypropylen (iPP) in den ternären Gemischen iPP/HDPE/EPDM wurden mittels DSC und Röntgendiffraktometrie untersucht. Die Analyse der exothermen Kristallisationspeaks mit Hinblick auf die Kristallisationskeimbildung und die Geschwindigkeit des Kristallwachstums und die Kristallinität deuten auf morphologische Varianten der iPP-Komponente in den Gemischen in Abhängigkeit vom EPDM-Gehalt hin. Die durch DSC und Röntgendiffraktometrie erhaltenen Ergebnisse zeigen, daß die Kristallinität mit steigendem Gehalt an EPDM in den iPP/HDPE-Gemischen abnimmt. Die Morphologie dieser Gemische wurde durch Scanningelektronenmikroskopie untersucht. Es wurde eine random-Verteilung des EPDM in der iPP-Matrix festgestellt. Größe und Zahl dieser Kautschukpartikel nehmen mit zunehmendem EPDM-Gewichtsanteil in den ternären iPP/HDPE/EPDM-Gemischen zu. Auf die wahrscheinliche Existenz von EPDM/HDPE-Einschlüssen in einer iPP-Matrix wird hingewiesen.

**Резюме** — Методом ДСК и рентгеноструктурного анализа изучено влияние ЕПДМ резины на кристаллизацию изотактического полипропилена (и-ПП) в тройных смесях и-ПП-ХДПЕ-ЕПДМ. Анализ экзотермических пиков кристаллизации, проведенный на основе образования центров кристаллизации, скорости их роста и степени кристаллизации, показал морфологические изменения изотактического полипропилена в зависимости от содержания ЕПДМ. Результаты измерений ДСК и рентгеноструктурного анализа показали, что полная кристаллизация уменьшается с увеличением весового процента ЕПДМ в смеси и-ПП-ХДПЕ. Морфология этих смесей была изучена методом сканирующей электронной микроскопии, показавшей произвольное распределение ЕПДМ в матрице изотактического полипропилена. При этом размер и количество частиц ЕПДМ увеличивается с увеличением весового процента этой резины в тройных смесях и-ПП-ХДПЕ-ЕПДМ. Предположено возможное существование в и-ПП матрице сложных включений типа ЕПДМ-ХДПЕ.