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Note

THE EFFECT OF ELASTOMERS ON THE CRYSTALLINITY OF POLYPROPYLENE *

Y.N. SHARMA, R.D. PATEL and I.S. BHARDWAJ

Research Centre, Indian Petrochemicals Corporation Ltd., P.O. Petrochemicals, Vadodara 391 346 (India)

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It is known that polypropylene (PP) has low impact strength at sub-zero temperatures and is not easy to process by vacuum forming methods. This limits its areas of application considerably. These disadvantages can be overcome by modifying the PP by blending it with elastomers [1,2]. These modifiers do not interact chemically with PP since these systems are thermodynamically incompatible [3]. From the literature survey, it is revealed that composites based on PP and elastomers have been studied extensively and the results of evaluation of chemical properties of the composites indicate technological compatibility provided the elastomer content is below 10%. X-Ray and microscopy investigations of the above blends have been reported by Akutin et al. [4,5].

In this paper, we will discuss the thermal behaviour of PP and its blends with respect to the crystallinity of the composites by means of differential scanning calorimetry (DSC).

EXPERIMENTAL

Materials

Polypropylene (PP) Koylene grade M 5630 (IPCL, India), natural rubber (NR) RMA grade, polybutadiene rubber (PBR) Cisamer grade 1220 (IPCL, India) and EPDM 321 rubber Buna AP 321 (C.H. Huls, Germany), have been used in this study.

Methods

PP and different rubbers (NR, PBR and EPDM) were melt blended on a Brabender (Plasticorder) using a "Cam" type mixer heated by oil. The conditions of mixing were: temperature, $175 \pm 2°C$; 45 rev. min^{-1}; nitrogen flow, 5 ml sec^{-1}; and time of mixing, 10 min.

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The blends were removed after mixing, quenched in cold water, dried in vacuo and pulverised.

Thermal study

The differential scanning calorimetric studies were performed on a DuPont 990 Thermal analyser at a heating rate of 20°C min^{-1} in a nitrogen atmosphere. From the DSC curves, the values of heat of fusion (ΔH_f) were calculated.

RESULTS AND DISCUSSION

The effect of blend composition on the heat of fusion is shown in Fig. 1 and is also given in Table 1. From Fig. 1, it is observed that at 2.5% rubber concentration in PP/elastomer blends there is a decrease in ΔH_f. This decrease continued up to 5% rubber concentration in the blends. After 5% rubber concentration, there is an increase in ΔH_f which then remains almost the same up to 10%rubber concentration, except in the case of PP/EPDM blend.

From these types of behaviour, it is clear that up to 5% rubber concentration, the

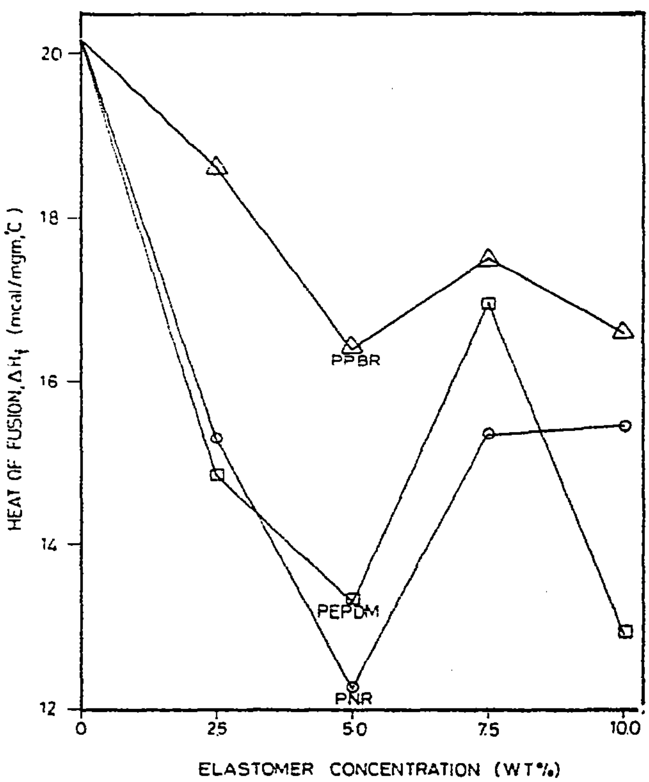

Fig. 1. The plot of heat of fusion (ΔH_f, mcal mg^{-1} deg^{-1}) vs. elastomer concentration (wt.%) for different PP/elastomer blends. ○, PP/NR; △, PP/PBR; □, PP/EPDM.

TABLE 1

Heat of fusion (ΔH_f) at 20°C min^{-1} in N_2 atmosphere for PP/elastomer blends

No.	Sample code [a]	Percent rubber	Heat of fusion ΔH_f (mcal mg^{-1} deg^{-1})
1	PP	0.0	20.0814
2	PNR-2	2.5	15.3147
3	PNR-3	5.0	12.2385
4	PNR-4	7.5	15.3697
5	PNR-5	10.0	15.9492
6	PPBR-6	2.5	18.5942
7	PPBR-7	5.0	16.3550
8	PPBR-8	7.5	17.4584
9	PPBR-9	10.0	16.5694
10	PEPDM-10	2.5	14.8624
11	PEPDM-11	5.0	13.2632
12	PEPDM-12	7.5	16.9885
13	PEPDM-13	10.0	12.9197

[a] PNR=PP+NR; PPBR=PP+PBR; PEPDM=PP+EPDM.

PP/elastomer blends show the maximum compatibility; this can also be correlated with our research data based on melt flow index and impact strength measurements [6]. At this concentration, PP/elastomer blends show a rise in melt flow index and impact strength. From the table, it is also seen that at above 7.5% rubber concentration in the PP/elastomer blends, continuous phase separation occurs and the blends are considered to be incompatible.

Heat of fusion is the real measure of crystallinity in a polymer. A high value of ΔH_f indicates the high crystallinity of PP. The effect on the crystallinity by different elastomers is different in all PP/elastomer blends. Generally, the elastomers in the composites reduce the crystallinity of PP. NR and EPDM reduce the crystallinity of PP considerably, while PBR produces a marginal effect at 2.5% rubber concentration. The trend in decreasing crystallinity with different elastomers at 5% is NR > EPDM > PBR. PP has the disadvantage of being more susceptible to crystallization and this leads to lower impact strength and to poorer low temperature brittleness characteristics. This tendency to crystallize can be reduced by the addition of an amorphous material, such as NR, EPDM and PBR. The structures of the amorphous materials are very important in reducing the crystallinity of PP. The branched elastomer reduces considerably the crystallinity shown in PP/NR and PP/EPDM blends, while PBR is not so effective in reducing the crystallinity because of very high *cis* isomer content.

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