

Preliminary Studies on the Morphology of Natural Rubber-Polypropylene Blends Using Scanning Electron Microscopy

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ABSTRACT

The morphology of natural rubber/polypropylene (NR/PP) blends were studied using scanning electron microscopy (SEM). The NR/PP blends were produced in varying compositions of NR/PP ratios of 80:20, 70:30, 60:40, 50:50, 40:60 and 30:70. The NR/PP blends were sputter coated with gold and observed under a Phillips 500 SEM at magnifications of 0.326K and 25K respectively. Micrographs showed the blends as incompatible polymers with NR domains embedded in a continuous PP matrix. At higher NR loadings, the NR domains were observed to be fibrils interspersed continuously in the PP matrix whilst at lower loadings the NR phase was scattered in distinct granular domains. Models of the NR/PP blends were postulated from the micrographs obtained.

ABSTRAK

Morfologi adunan getah asli/polipropilena (NR/PP) telah dikaji dengan teknik kemikroskopian imbasan elektron (KIE). Adunan NR/PP telah dihasilkan sebagai adunan pelbagai komposisi dengan nisbah NR/PP seperti berikut : 80:20, 70:30, 60:40, 50:50, 40:60 dan 30:70. Adunan NR/PP tersebut telah disalut secara percikan dengan emas dan dikaji dengan alat mikroskop elektron Phillips 500 pada pembesaran 0.326K dan 2.5K masing-masing. Cerapan daripada mikrograf menunjukkan adunan sebagai polimer tidak cocok dengan domain NR terbenam di dalam matriks PP selanjar. Pada komposisi NR yang tinggi, domain NR telah diceraap berada sebagai fibril bercampur secara selanjar di dalam matriks PP. Pada komposisi NR yang rendah pula fasa NR terserak dalam domain yang khusus. Model NR/PP telah dipostulat berdasarkan mikrograf yang telah dihasilkan.

INTRODUCTION

Thermoplastic natural rubbers (TPNR) belong to the class of materials known as thermoplastic elastomers (TPE) which are capable of being moulded like plastics at suitable processing temperatures but also possess the resilience, recovery and flexibility associated with rubbers at the normal temperatures of use. TPNR is based on high quality natural rubber (NR) with polyolefins such as high density polyethylene (HDPE) and/or isotactic polypropylene (PP). The NR can be blended to the polyolefins in different ratios thus producing materials with a wide range of properties.

Most polymer blends are immiscible and form multiphase systems and since TPNRs are essentially blends it is therefore important to study their morphology. Several reasons may attest to the importance of TPNR morphology studies such as nature of polymer domains, phase continuity and correlations between morphology-mechanical properties or morphology-rheological properties.

Electron microscopy (EM) has been reported to be an effective tool in studying the morphology of TPNR. Both techniques of EM such as scanning electron microscopy (SEM) and transmission electron microscopy (TEM) has been compared for TPNR morphology studies [1].

Both techniques may be used satisfactorily. Several workers have also used EM for studying TPNR morphology and deducing morphology-property relationships, specifically mechanical properties [1,2,3]. The morphology of failure surfaces were studied and the authors were able to correlate mechanisms of failure to failure data. Rheology-morphology studies were also carried out by several researchers [3,4] using EM to correlate flow properties with morphology.

In this study NR/PP blends of differing ratios were studied using EM in the scanning mode so as to obtain an assesment of its morphology. The model of its morphology will help to explain other properties such as thermal, mechanical and rheological.

EXPERIMENTAL

High quality natural rubber (SmR-L) obtained from RRI (Sungai Buloh) was blended in differing ratios to isotactic PP (Union Carbide J600). The blending data is detailed as follows:

Blends (NR/PP)	: 80/20, 70/30, 60/40, 50/50, 40/60, 70/30.
Starting temperature	: 140 °C.
Dumping temperature	: 180 °C.
Blending time	: 5 min.
Equipment	: Francis Show K2 intermix, 12 litre capacity.

The TPNR was then sheeted and granulated.

Samples for EM were prepared by taking sheets measuring 5 × 5 × 2 mm and mounted on sample holders using sellotape. The samples were then sputter coated with gold for 120 seconds (Polaron SEM. Sputter Coater E5100). Micrographs were obtained at magnifications of 0.326K and 2.5K respectively using a Phillips 500 Scanning Electron Microscope.

RESULTS AND DISCUSSION

The micrographs obtained are as shown in Figures 1a-1f (for 0.326K magnification) and in Figures 2a-2f (for 2.5K mag). The morphology and dispersion of phases can be observed from Figs 1a-1f (at a magnification of 0.326K). Micrographs shown in Figs 2a-2f (at higher magnifications)

does not reflect the dispersion of phases very well but would be useful for adhesion studies between binders/fillers and the polymer phases.

It can be observed that the polymers form immiscible blends, with the NR dispersed in the PP continuous phase. The same observation has been reported for NR/HDPE blends [2,6]. Other studies on TPNR blends [3,4,7] reported that using SEM both the NR and thermoplastic phases form continuous phases leading to an inter penetrating two-phase system. Essentially the two observations could mean the same thing. From our work we observed that at lower NR loadings, the NR phase appeared as long fibrils dispersed in the PP matrix. At lower NR loadings, NR phase appeared as spherical particles dispersed in particular domains. At intermediate loadings, intermediate structures appeared. At the lower NR loadings, the particles in the domains measured an average of 70 nm in diameter. This value is large compared to the value of 1.2 nm obtained by Choudhary and Bhowmick for their NR and PE blends. Choudhary and Bhowmick reported that the domain size was reduced by the addition of a third component such as a promoter. This remains to be confirmed in our own studies.

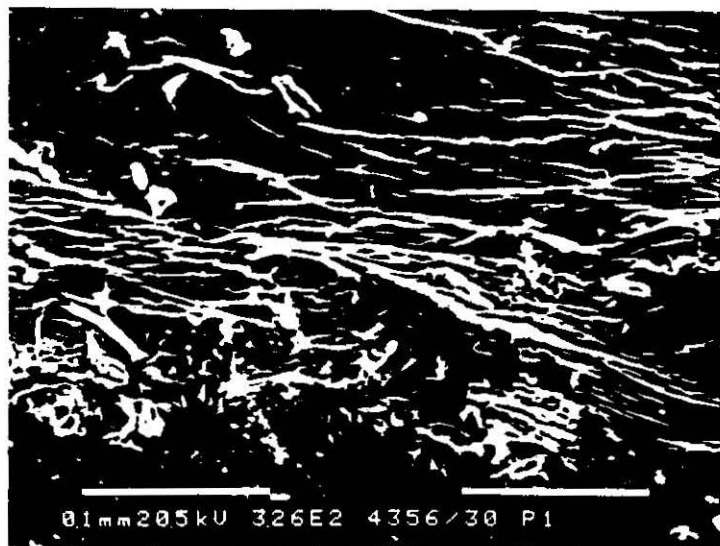


FIGURE 1a. 80 NR at 0.32 K magnification

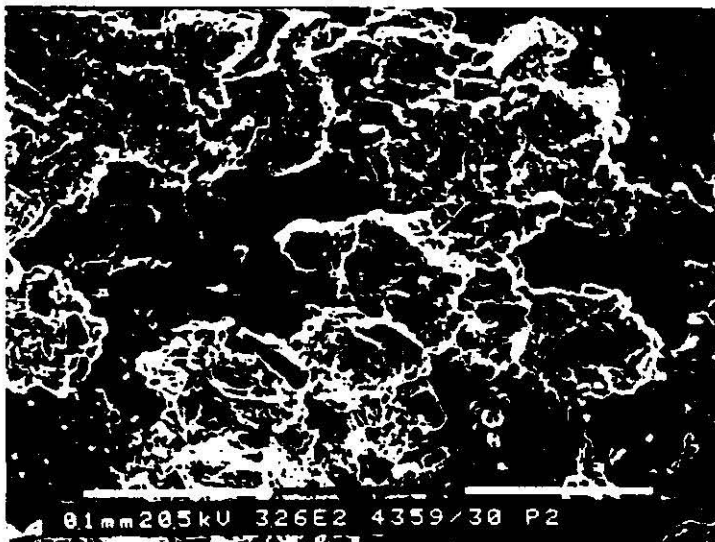


FIGURE 1b. 70 NR / 30 PP at 0.32 K magnification



FIGURE 1c. 60 NR / 40 PP at 0.32 K magnification

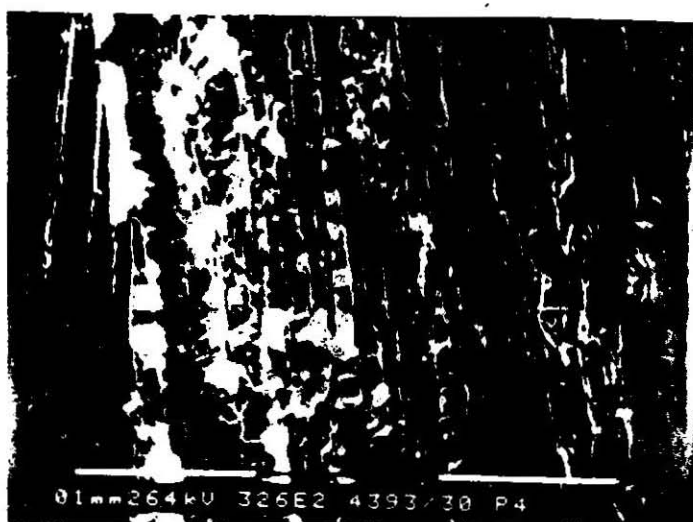


FIGURE 1d. 50 NR / 50 PP at 0.32 K magnification



FIGURE 1e. 40 NR / 60 PP at 0.32 K magnification

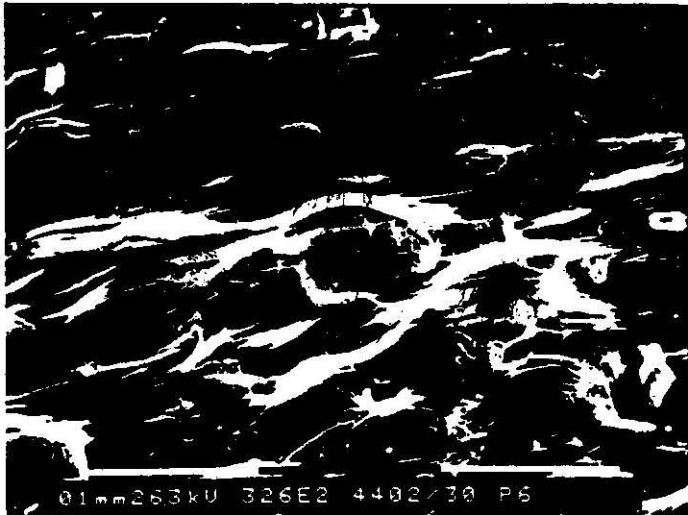


FIGURE 1f. 30 NR / 70 PP at 0.32 K magnification



FIGURE 2a. 80 NR / 20 PP at 2.5 K magnification

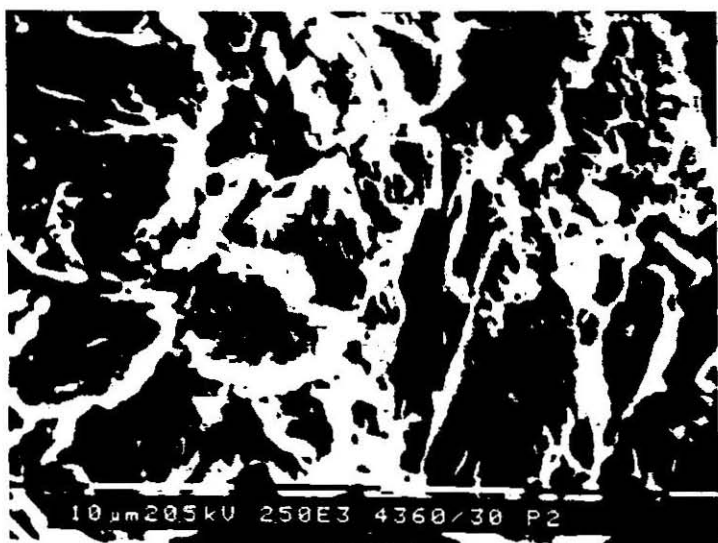


FIGURE 2b. 70 NR / 30 PP at 2.5 K magnification



FIGURE 2c. 60 NR / 40 PP at 2.5 K magnification



FIGURE 2d. .50 NR / 50 PP at 2.5 K magnification



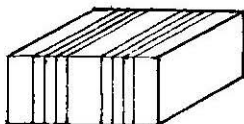
FIGURE 2e. 40 NR / 50 PP at 2.5 K magnification



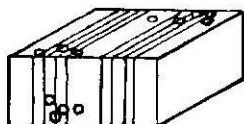
FIGURE 2f. 30 NR / 70 PP at 2.5 K magnification

CONCLUSION

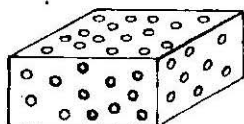
Several TPNR (NR/PP) blends were characterised for morphology studies using electron microscopy (SEM). Results obtained showed the blends to be immiscible polymers with the NR interspersed in a continuous PP matrix. The dispersion as well as nature of domain varied with the NR/PP ratios. From the micrographs as well as rubber morphology theory [5] we therefore postulate the TPNR morphology to be :



For the 80-70 NR/PP. In this model the NR domains appeared as fibrils interspersed in the PP matrix, and



For the 50-40 NR/PP. Intermediate structures appeared.



The third structure is for the < 30 NR/PP matrix. The NR domains existed as discrete spherical particles measuring an average of 70 nm across.

We hope that this study would contribute towards understanding the structure of this interesting material.

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