Journal of Macromolecular Science, Part A
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597274

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To cite this Article Khang, Do Quang , Starke, L. and Funke, Z.(1996) 'Enhancing Polyethylene-Elastomer Compatibility by Surfactants', Journal of Macromolecular Science, Part A, 33: 12, 1973 — 1980
To link to this Article: DOI: 10.1080/10601329608011022
URL: http://dx.doi.org/10.1080/10601329608011022

J.M.S.—PURE APPL. CHEM., A33(12), pp. 1973–1980 (1996)

ENHANCING POLYETHYLENE-ELASTOMER COMPATIBILITY BY SURFACTANTS

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ABSTRACT

Some polyethylene-elastomer blends have been investigated by means of measuring their surface tension, rheology, morphology, and scanning electron microscope (SEM). The interface of their intercomponents (PE with PUR and CPE) was studied by torsion pendulum. It was found that the use of suitable amounts of surfactants could modify the morphology and polymer chain orientation of some incompatible polymer blends.

The modification of plastics by many kinds of elastomer for improving their technical properties as well as their applications has taken an important role. The main task of the modification in the blends has been studied—the influence of processing factors on the structure and properties of materials [1]. So far, the use of surfactants for polymer blends has not been investigated in detail; in particular, there has been no systematic research in using surfactants for incompatible blends from polyethylene and elastomers.

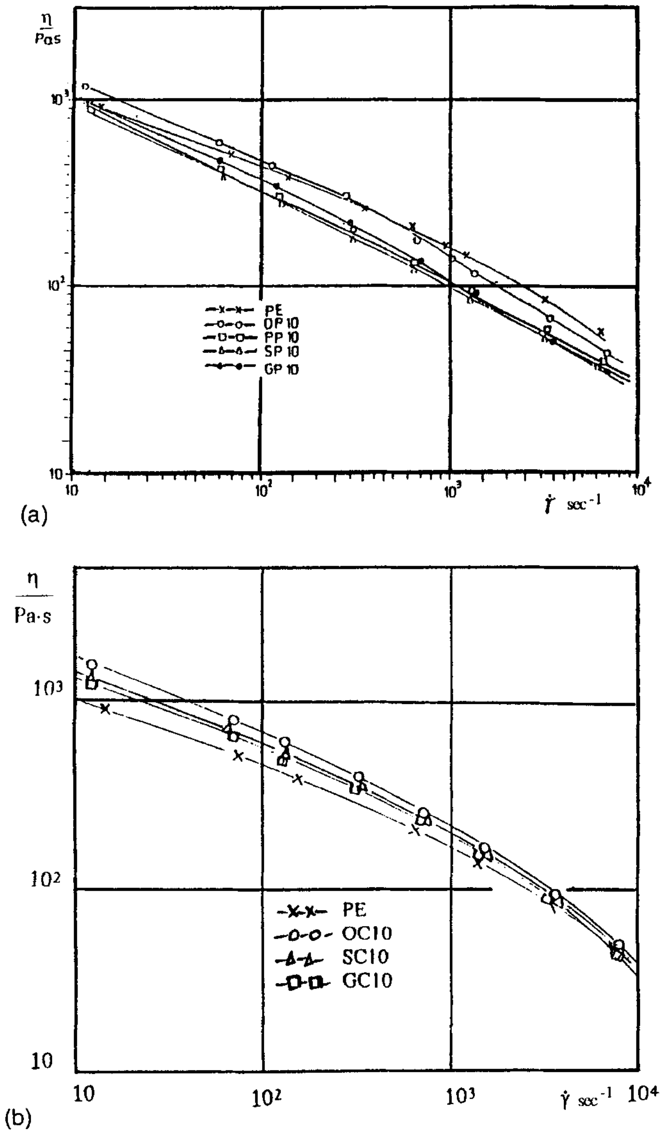


FIG. 1. (a) The flow curve of PE, PE/PUR, and PE/PUR/surfactant blends (PE: pure PE; OP 10: PE + 10% PUR; PP 10: PE + 10% PUR + 1% Präwozell; SP 10: PE + 10% PUR + 1% silicone oil; GP 10: PE + 10% PUR + 1% Genapol). (b) The flow curve of PE, PE/CPE, and PE/CPE/surfactant blends (PE: pure PE, OC 10: PE + 10% CPE; SC 10: PE + 10% CPE + 1% silicone oil; GC 10: PE + 10% CPE + 1% Genapol).

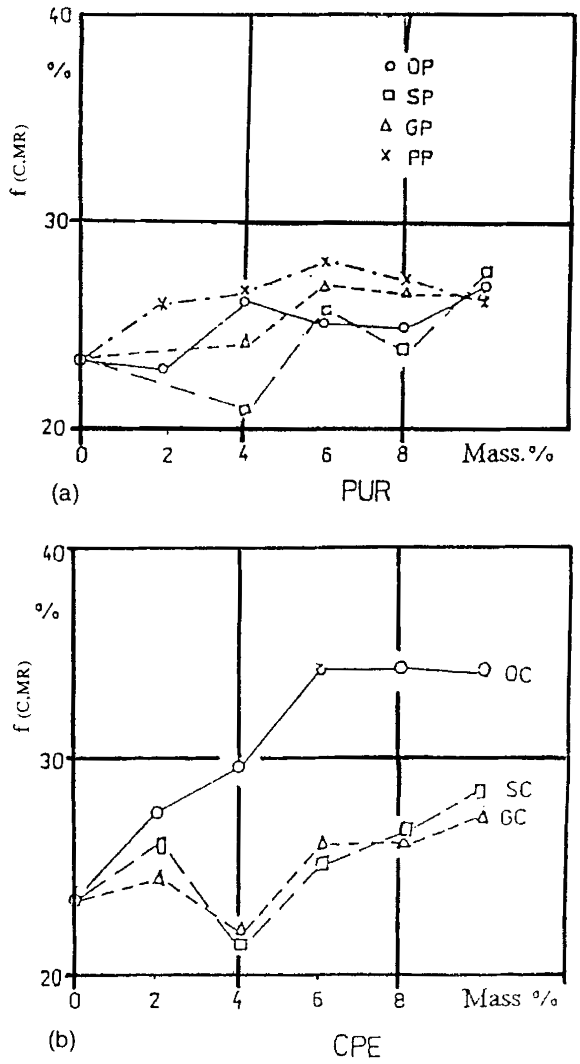


FIG. 2. (a) Dependence of the orientations along the *c* axis *f* (c,MR) on the PUR content (OP: blends with nonsurfactant; SP: blends with silicone oil; GP: blends with Genapol, PP: blends with Präwozell). (b) Dependence of the orientations along the *c* axis *f*(c, MR) on the CPE content (OC: blends with nonsurfactant; SC: blends with silicone oil; GC: blends with Genapol).

We have studied the compatibility of polyethylene with some elastomers by using surfactants. Materials for research are: high-density polyethylene A76 MA (PE); polyurethane elastomer SYS PUR T 8357/1 (PUR); and chlorinated polyethylene, Bayer CM 360 (CPE).

Our aim in using the surfactants was to diminish the surface tension of the interface of the two phases, thereby increasing the distribution and interaction of the components, which would then spontaneously make well-oriented structures.

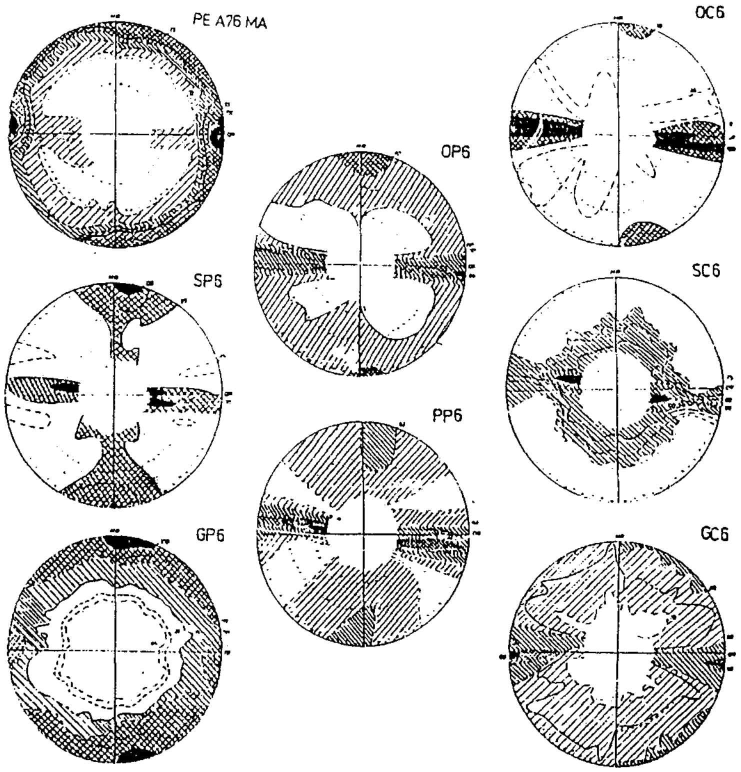
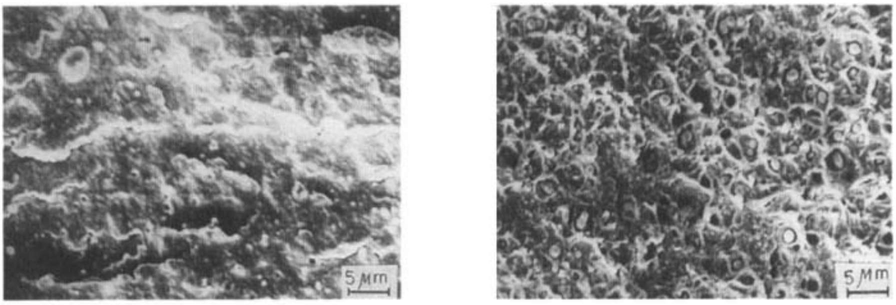


FIG. 3. 200-Polfigure of some polymer blends (OP 6: PE + 6% PUR; SP 6: PE + 6% PUR + 1% silicone oil; GP 6:PE + 6% PUR + 1% Genapol; PP6: PE + 6% PUR + 1% Präwozell; OC 6: PE + 6% CPE; SC 6: PE + 6% CPE + 1% silicone oil; GC 6: PE + 6% CPE + 1% Genapol).

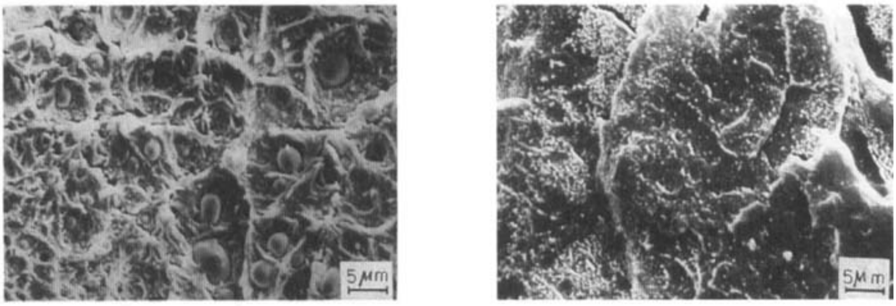
Based on the PE, PUR, and CPE chemical structures in our preliminary tests, we used these surfactants: Genapol PE 40 (Hoechst), silicon oil NM 4207 (Nünchritz), and Präwozell N9 (Buna). These are nonionic surfactants.

ESTIMATING THE SURFACTANT APPLICATION AND THE SUITABLE CONCENTRATION FOR POLYMER BLENDS

We have estimated the surface tension of the polymers and their variation in the cases using the surfactants by the hanging drop method and contact angle [2, 3]. It was considered that when a small amount of surfactant was added, the surface tension of the melted polyethylene in the nitrogen atmosphere decreased. When the surfactant content was augmented, the surface tension was still decreased but only up to a certain content of the surfactant; then surface tension no longer decreased (this was called the "limited content"). The limited content of Präwozell and silicon oil in PE is about 1%, and of Genapol is 1.25% related to PE. In these three surfactants, Präwozell gives the best effects.



PE+6%PUR PE+6%PUR+1%Prawozell



PE+6%CPE PE+6%CPE+1%Genapol

FIG. 4. SEM of some polymer blends.

For determining the optimum surfactant content in the blends, we have investigated the variation of the surface tension on the material interface in the solid state by measuring the contact angle. It was considered that with increasing surfactant content, the surface tension of the PE interface was increased, but the interfaces of PUR and CPE were decreased. The content of the surfactant at the point where the interfacial tensions of the polymers in the blends were equal, is the optimum content. The optimum content of silicon oil in the PE/PUR blends is 1.2%, of Präwozell in PE/PUR about 0.95%, and of Genapol in PE/CPE it is 0.89%. In order to combine the above-mentioned results and ease the comparison, we have chosen a common surfactant content for all blends: 1% by weight.

INFLUENCE OF THE MODIFICATION ON THE RHEOLOGY OF THE MATERIAL

The rheology of material demonstrates the distribution degree of all components in the blends; this plays a decisive role in the choice of processing regime of polymer materials, and particularly for polymer blends [4, 5]. We have used high-

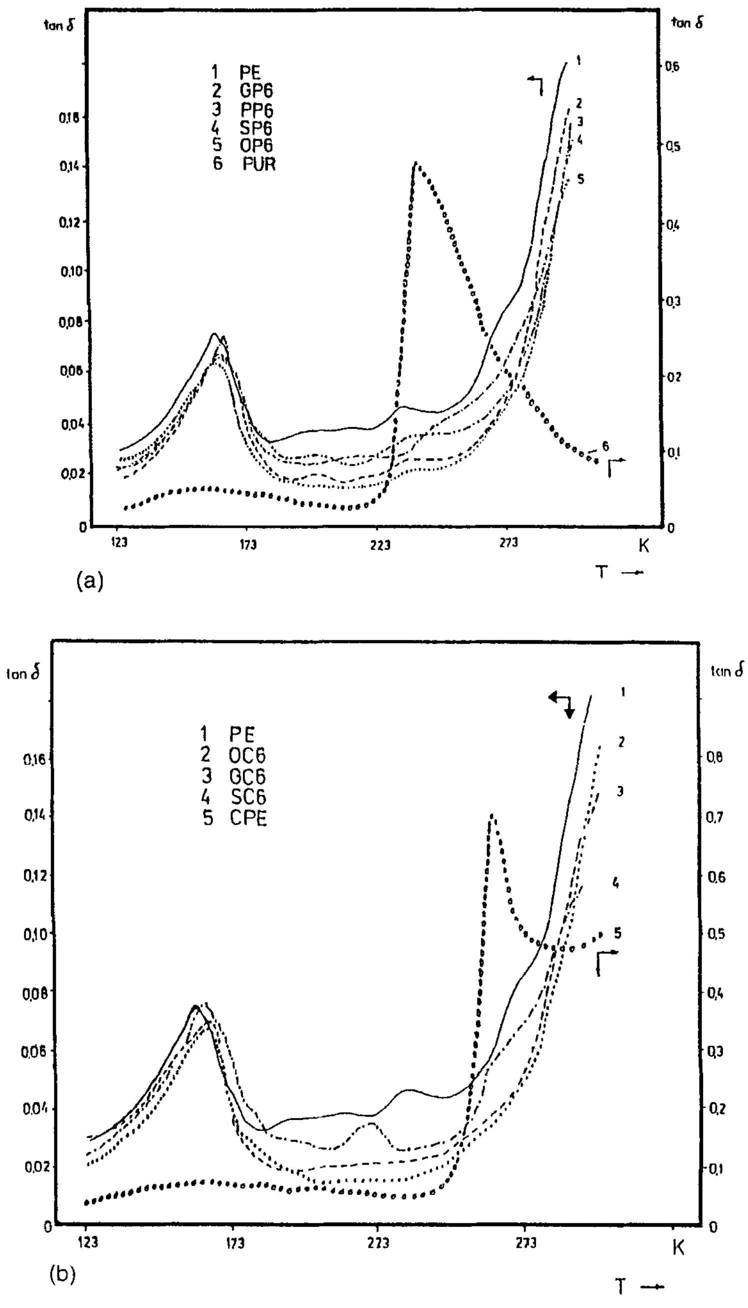


FIG. 5. (a) Temperature dependence of loss tangent δ of PE, PUR, and blends of PE, PUR with and without surfactants. (b) Temperature dependence of loss tangent δ of PE, CPE, and blends of PE, CPE with and without surfactants.

pressure capillary viscosimeter to investigate the rheology of the polymer blends. The flow curves of some typical samples are shown in Figs. 1(a) and 1(b).

It has been shown that the rheology of the materials was not changed significantly by PE modification with small elastomer amounts (up to 10%), as well as by small elastomer amount with 1% surfactants. Therefore, the processing technology of these blends could be the same as that for pure HDPE.

INFLUENCE OF THE MODIFICATION ON THE MACROMOLECULAR ORIENTATIONS OF PE–MATRIX AND MORPHOLOGY OF THE BLENDS

The orientation of the macromolecules in the blends was estimated by x-ray diffraction and the calculation of their data according to Refs. 6 and 7. In Figs. 2(a) and 2(b), the dependence of the orientation along the *c* axis on the elastomer content (with or without the surfactants) is shown.

In modifying the PE by the elastomer (up to 10%), the degree of orientation along the axis was increased, especially in the PE/CPE and PE/PUR/Präwozell blends. Similar results were observed also in the 110- and 200-nets plane as well as in the diagram of 200-Polfigure of the blends (Fig. 3).

We considered the pure PE to have a complex of A- and C-textures. In the blends from PE/PUR with Präwozell, and especially in the blend of PE with CPE, the C-structure was superior.

Investigation of the polymer blend structure by scanning electron microscope (SEM) showed that the distribution of the small elastomer particles on the PE–matrix is better in the cases using surfactants than in cases without surfactant (Fig. 4).

INTERACTION OF THE COMPONENTS IN THE PE–ELASTOMER BLENDS

The interaction of the components in the PE–elastomer blends was investigated by measuring the torsion pendulum. From the experimental data we found that the γ-relaxation maximum of PE, at 161 °K, in the PE/PUR blends was not changed, but that in the PE/CPE blends this maximum was shifted strongly on the side of the CPE maximum. This proved that PE was not compatible with PUR and only partly compatible with CPE. Mixing the surfactant into PE/PUR blends also caused this shift, especially in the PE/PUR blend having 1% Präwozell; the maximum was shifted to 165 °K [see Figs. 5(a) and 5(b)].

So it could be concluded that the surfactants have increased the interaction of the PE and PUR components in the blends.

CONCLUSION

The above-mentioned results, confirm the important role of surfactants in polymer chain orientation and the amelioration of compatibility of noncompatible polymer blends. This is a promising field of research, giving us hope of many successes.

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