NOTE

Morphology and Properties of Polyblend PVC/PBSM

In this study the polyblend (LIPN PBA/PS/PMMA) was prepared by blending PVC and PBSM. The morphology and properties of the polyblend have been studied. Experimental results have shown that the processability and impact resistance of PVC can be enhanced considerably by means of blending 6–20 phr PBSM. PBSM is a promising modifier for rigid PVC manufactures.

At present, the amount of PVC used for rigid PVC (RPVC) manufactures is more than 60% of total PVC amount. Polyblends PVC/EVA, PVC/CPE, PVC/MBS, PVC/ACR, and the like[1-3] have been developed to enhance the impact strength and to improve the processability of RPVC. In this study the three-stage latex interpenetrating polymer network (LIPN) PBA/PS/PMMA (PBSM) was prepared by multistage emulsion polymerization,[4,5] and it was used to make polyblend PVC/PBSM. The morphology and properties of the polyblend have been studied. Experimental results show that PBSM is a promising modifier for rigid PVC manufactures.

EXPERIMENTAL

PBSM (LIPN PBA/PS/PMMA) was prepared by three-stage emulsion polymerization.[4] The three-stage emulsion polymerization was carried out in a 1000-mL tetraneck bottle. The reaction temperature change was no more than ±0.2°C and the agitation speeds were 250 ± 5 rpm. In the first stage, deionized and deoxidized water was placed into the tetraneck bottle and then emulsifier, sodium dodecylsulphonate, PH modifying agent, sodium borate was added to the bottle. After being mixed and resolved thoroughly, the polymerization was carried out by adding the monomer, *n*-butyl acrylate (BA), together with the crosslinker, ethylene glycol dimethacrylate (EGDM), under purging with nitrogen and then adding $K_2S_2O_8$ water solution. As the first-stage polymerization was completed, styrene and crosslinker, divinyl benzene (DVB), and initiator $K_2S_2O_8$ were added to the bottle; then the second-stage polymerization was carried out under a definite temperature. For the third stage, the monomer MMA and initiator $K_2S_2O_8$ were charged to practice the third-stage reaction. Then the latex particle having three-layer structure[6] was produced. The latex particle diameter and its distribution were determined by electron microscope H-600 and photograph analysis instrument, type IBASI/II. The weight-average and number-average diameter are 0.088 and 0.084 μm, respectively, and the distribution width is 1.05.

The emulsion obtained by the three-stage emulsion polymerization was coagulated with aluminum sulfate, filtered and cleaned up to neutrality and then stove-dried under 80°C and white powder PBSM was obtained. The powder obtained was then hot-pressed at 180°C, and the wafer of 0.20–0.30 mm in thickness was formed. Take the wafer as sample for dynamic mechanical analysis using DDV-II-EA type dynamic viscoelastomer. The measuring frequency is 110 Hz and the heating rate is 2°C/min. PVC and PBSM knead with additives (calcium stearate, organotin stabilizer, and the like) in kneader GH-1000 and mixed in mixing roll to prepare homogeneous mixture (dry-blend). Polyblend PVC/PBSM specimen can be made through heat pressure molding or extrusion.

The plasticizing behavior of the dry-blend was determined using a Brabender plastic-corder PLE-330. To determine the rheological properties, PVC/PBSM dry-blend is added to mixing head at 160°C and 30 rpm and mixed thoroughly and cut to make granulates. Then the rheological behavior was determined with rheometer type 301

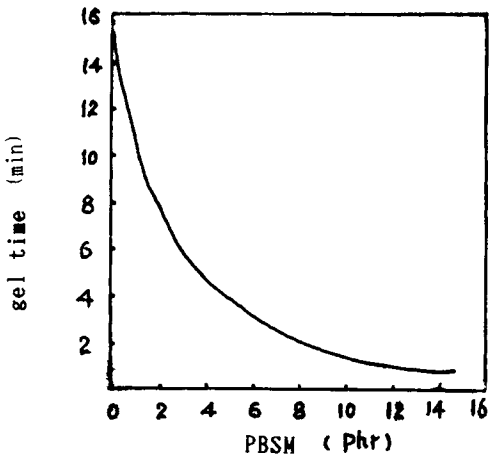

Figure 1 The influence of PBSM dose on the gel time of polyblend PVC/PBSM.

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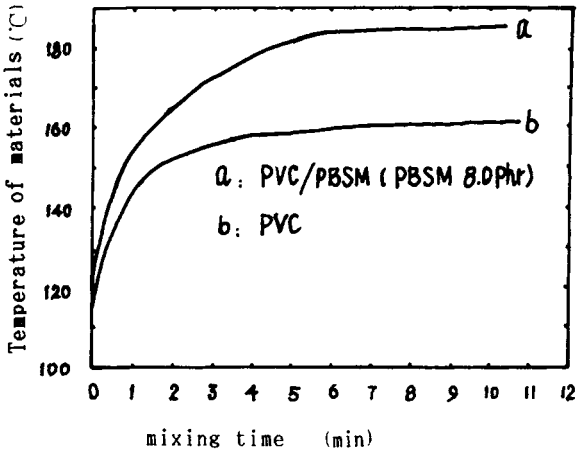

Figure 2 Temperature increase of materials in plasticizing process.

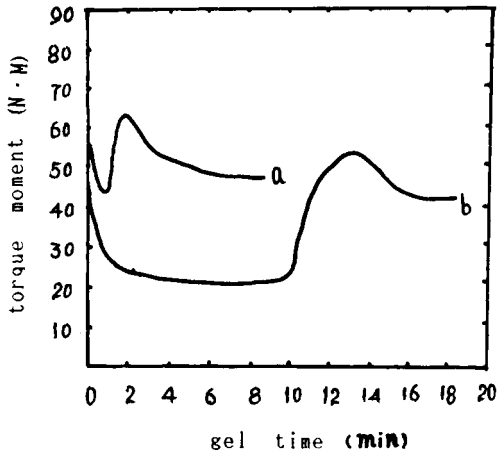

Figure 3 Curve of plasticization: (a) PVC/PBSM (PBSM 8.0 phr); (b) PVC.

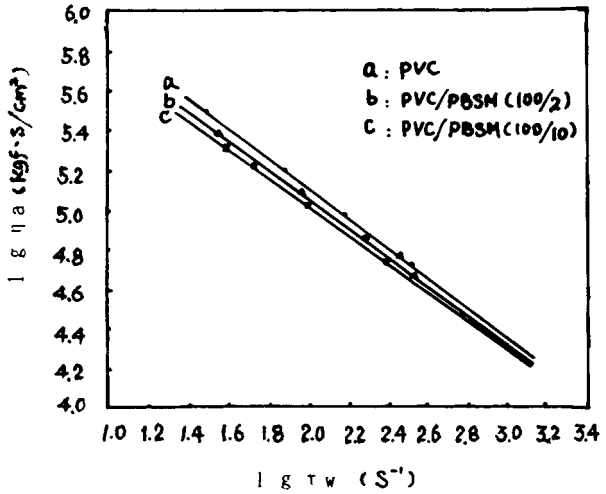

Figure 4 Viscosity–shear stress curve of polyblend PVC/PBSM.

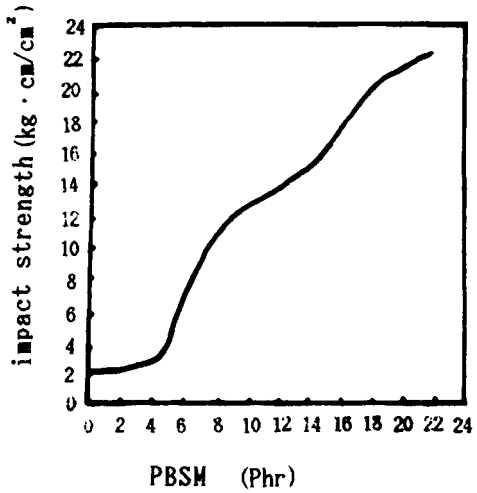

Figure 5 Effect of PBSM on the impact strength of polyblend PVC/PBSM.

(Shimadzu Comp. Japan) at 185°C and loaded with 70, 75, 90, 95, 110, 115, and 125 kg, respectively.

The wafer of 0.2–0.3 mm in thickness was made from polyblend PVC/PBSM through hot-pressed at 180°C for determination of the dynamic mechanical properties using DDV-II-EA type dynamic viscoelastometer at measuring frequency 110 Hz and heating rate 2°C/min.

The specimen of 120 × 50 × 40 mm was made for measuring impact resistance. The morphology of polyblend PVC/PBSM was characterized using gold-plating specimen by Hitach X-650 scanning electron microscope. The morphology of the three-stage latex particle was observed by Hitachi EM-H-800 transmission electron microscope in conjunction with RuO_4-staining method.[6]

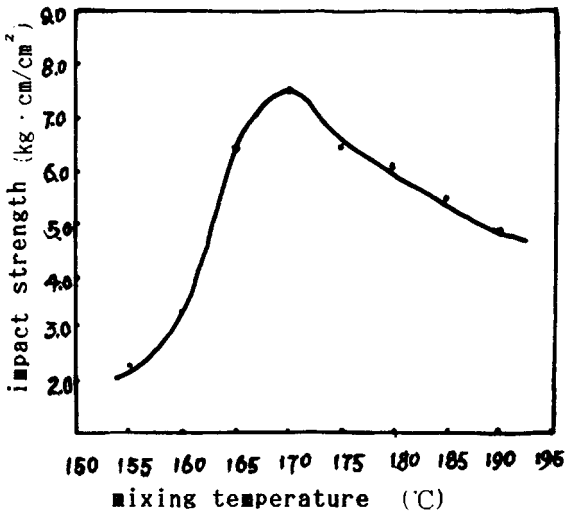

Figure 6 Effect of mixing temperature on the impact strength of polyblend PVC/PBSM. (100/8).

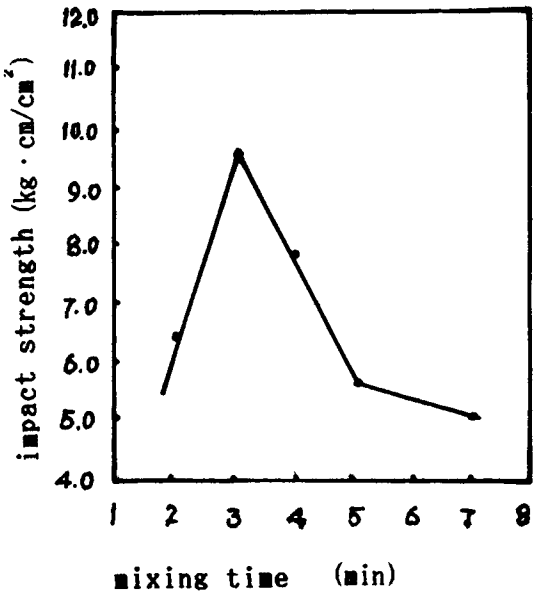

Figure 7 Effect of mixing time on the impact strength of polyblend PVC/PBSM.

RESULTS AND DISCUSSION

1. The plasticizing behavior and rheological properties of polyblend PVC/PBSM are shown in Figures 1, 2, 3, and 4, respectively.

It can be seen from Figure 1 that PBSM can shorten the gel time a great deal. The gel time is 15.3 min for pure PVC and 2.0 min for PVC/PBSM (8.0 phr PBSM). At the same time, the temperature increase of the material in the mixing process is higher by about 10°C as compared with pure PVC (Fig. 2). The plasticization curves of PVC and PVC/PBSM are shown in Figure 3.

These plasticing behaviors stem from the PBSM being filled to the interval and gaps among PVC particles and owing to the compatibility between PVC and PBSM. Thus the total touched area among the PVC particles was increased and the frictional force between particles was enhanced.[7,8-10]

The rheological curves of PVC/PBSM and PVC are shown in Figure 4. It can be seen from Figure 4 that the fluidity of PVC melt was increased by blending with PBSM. Experimental results indicate that the external appearance of the RPVC articles was improved by PBSM.

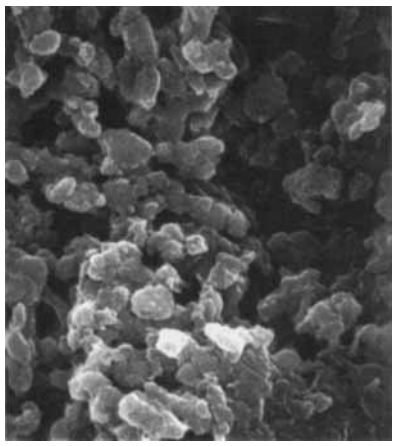

Figure 9 Scanning electron microscope of polyblend PVC/PBSM (100/8), mixing temperature 150°C, mixing time, 5 min; magnification ratio: 10^4.

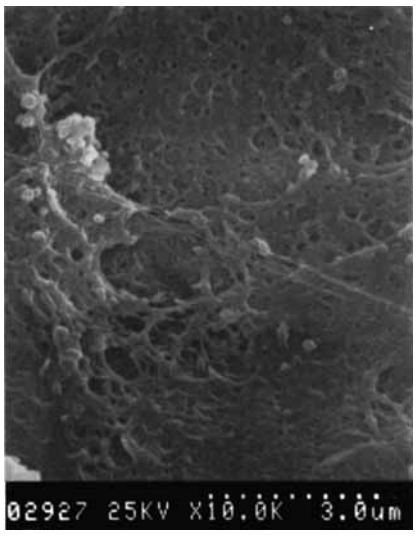

Figure 8 Scanning electron micrograph of polyblend PVC/PBSM; magnification ratio: 10^4.

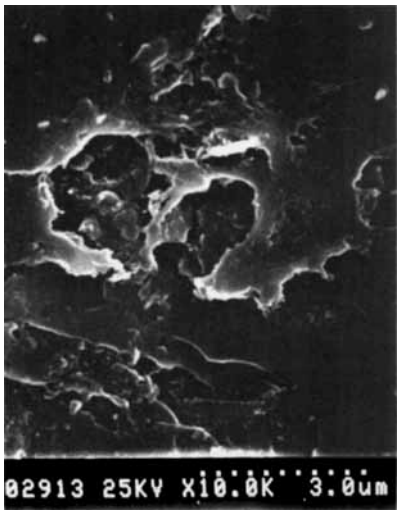

Figure 10 Scanning electron microscope of polyblend PVC/PBSM (100/8), mixing temperature 175°C, mixing time 7 min; magnification ratio: 10^4.

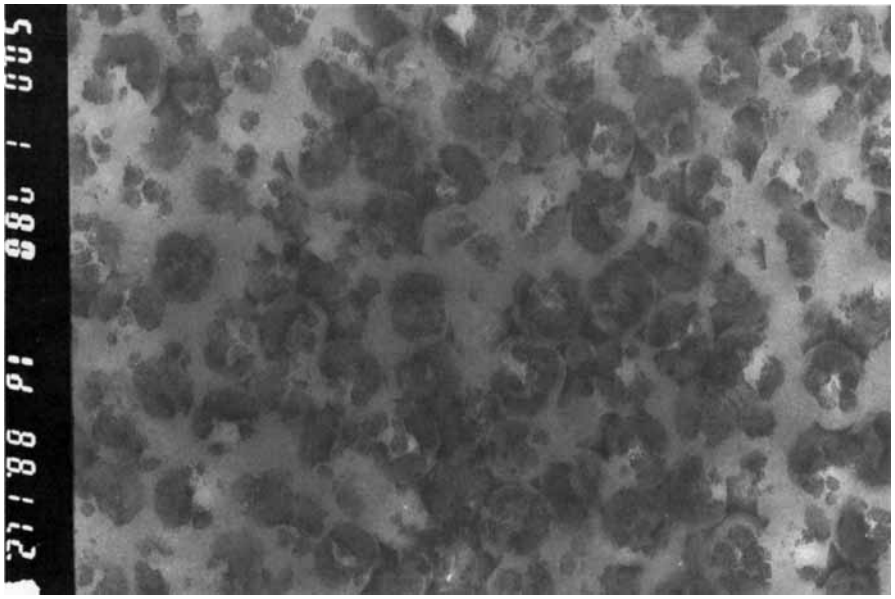

Figure 11 Transmission electron microscope of PBSM; magnification ratio: 7.5×10^4.

2. Effect of PBSM on the impact resistance of polyblend PVC/PBSM is indicated in Figure 5. The technological process conditions have distinct influence on the impact resistance of PVC/PBSM as shown in Figures 6 and 7. It can be seen from Figures 6 and 7 that the optimal conditions correspond to mixing temperature of 175°C and mixing time of 3–5 min. The reason probably is as follows: blending of PVC with PBSM is a cooperative process of PVC particles breaking, dispersion and deformation of PBSM particles and adhesion of interphase surface; the process reaches a synergetic state only at the condition of specified temperature and time. This case bears relation with the morphology of polyblend PVC/PBSM. Experimental data has shown that when PBSM does more than 8 phr, the PBSM in PVC/PBSM has network morphology at optimal mixing temperature and mixing time, as shown in Figure 8. Such morphology corresponds with maximum impact resistance of polyblend PVC/PBSM (100/8).

If the mixing temperature and mixing time were not optimal, then the network morphology did not produce (Figs. 9 and 10), and the impact resistance was lower. The network morphology of the polyblend is correlated with the morphology of the PBSM (Fig. 11). The first and second layers have crosslinked structure, and the third-layer PMMA is compatible with PVC.[11,12]

3. The dynamic mechanical spectra of PBSM, PVC, and polyblend PVC/PBSM are shown in Figure 12. For PBSM, there are two distinct spectra peaks corresponding to −31.2 and 148°C, respectively; polyblend PVC/PBSM has two glass temperature (97.2 and −31.3°C), the higher glass temperature (97.2°C) close to the T_g of pure PVC.

Experimental data indicated polyblend PVC/PBSM has dual-phase structure and PBSM has good compatibility with PVC.

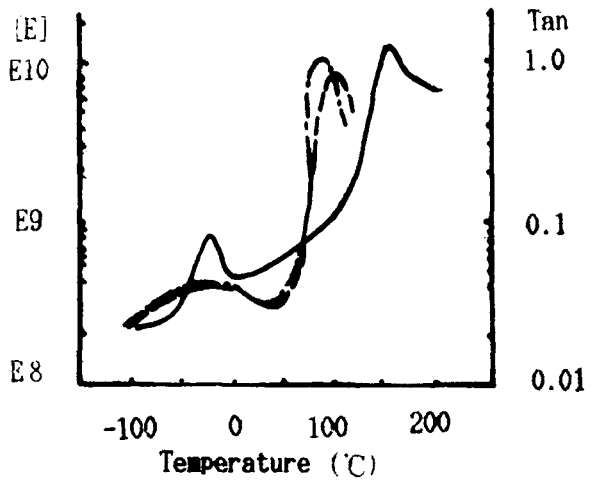

Figure 12 Dynamic mechanical spectrum: (———) PBSM; (– · –) PVC; (– – –) PVC/PBSM.

CONCLUSIONS

1. PBSM can considerably improve processability and impact resistance of RPVC. According to the experimental data, the notched impact strength can be increased by 3–10 times by blending with 6–20 phr PBSM.

2. Blending conditions have obvious influence on the impact strength of polyblend PVC/PBSM. The optimal mixing temperature and mixing time are 160–185°C and 3–5 min, respectively. Experimental data has shown that when PBSM possess network morphology, the polyblend PVC/PBSM has the best properties.

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