Morphological Analysis of Tiger-Stripe and Striped Pattern Deterioration on Injection Molding of Polypropylene/Rubber/Talc Blends

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Abstract
Tiger-stripe of injection molding of Polypropylene (PP)/rubber/talc blends was analyzed in terms of morphologies of dispersed phase comprising rubber components by using gloss, scanning electron microscopy (SEM). Tiger-stripe became inconspicuous with decreasing degree of orientation of the dispersed phase along flow direction. However, unique striped pattern deteriorations occurred after aging under ultra-violet (UV) irradiation with/without rain and thermal annealing although any conspicuous tiger-stripe was not observed on the initial specimen. These deteriorations were caused on the basis of morphological changes dependant on aging conditions.

1 Introduction

In recent two decades, PP/rubber/talc blend has grown as a main material for automotive parts: bumper facia and instrument panel which require not only mechanical properties but also surface finishing. Tiger-stripe is one of severe defects for bumper facia, and the stripe becomes conspicuous due to deterioration during practical use of automotive for several years and more (see *Figure 1* as an example). In this paper, the stripe and its deterioration are discussed in terms of morphological analysis.

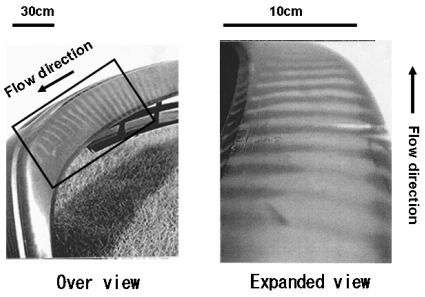

Figure 1: Typical tiger stripe and its deterioration.

2 Experimental

PP/rubber/talc blends were prepared by using mechanical blending with twin extruder. Material formulation was controlled depending on purpose. Plates having 420 mm length, 100 mm width and 3 mm thickness in dimensions were molded by injection molding. Analyses (gloss, SEM, TEM etc) were performed using these plates.

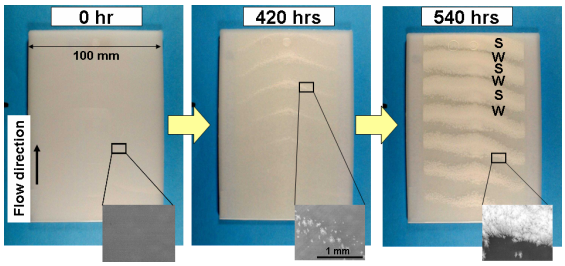

Figure 2: Striped deterioration with UV irradiation.

3 Results and Discussion

3.1 Morphology of tiger-stripe

Tiger stripe on the plate was obtained same as real parts. Previous studies have reported that the stripe consists of the alternation of glossy and cloudy parts corresponding to higher and lower degrees respectively in the orientation of dispersed rubber phases caused by a snake-like asymmetric flow during injection stage [1]. We described inconspicuous tiger stripe is controlled by polymer designs of the based PP involving narrower molecular weight distribution of homo PP portion and higher intrinsic viscosity of co-synthesised ethylene-propylene rubber portion[2]. Even thought tiger stripe is inconspicuous for initial state due to these designs, in some case the stripe becomes severely conspicuous by exposing under weather for long time (*Figure 1*).

3.2 Stripe type deterioration of PP/rubber binary blend as model blend

PP/rubber binary blend was examined as a model for the deterioration by irradiation with UV. Severe striped deterioration was observed with the irradiation (*Figure 2*) [2]. Strongly (*S*) and weakly (*W*) whitened parts corresponded to cloudy and glossy parts respectively. The chemical deterioration (C=O produced by oxidation) could not provide this striped deterioration because significant difference of C=O contents was not observed in both *S* and *W* through the depth (*Figure 3*). SEM photographs of the cross sections showed that numbers of micro voids occurred in c.a. 20-140 μm depth from the surface (*Figure 4*). Thus, it was clarified that the striped deterioration was not dependent on the chemical deterioration but on the physical one with the micro voids caused by UV. Induction depths of the voids were especially shallow in strongly whitened part (*S*) compared with weakly one (*W*). Then, it was very important where the micro voids occurred in terms of both morphology and deterioration mechanism of polymer blend. TEM photographs of the cross sections confirmed that the micro voids existed just inside the domain comprising rubber portion (*Figure 5*). These voids inside the domain were observed frequently in lower orientation domains under the shear zone in which the domains were highly oriented. As mentioned above, the induction depths were shallow and deep corresponding to *S* and *W* parts respectively. Consequently, a schematic model for the striped deterioration of the PP/rubber binary blend was proposed in *Figure 6*. Incidentally, UV irradiation up to 4000 hr could not cause any voids inside the plate with carbon black as a UV absorber. Real automotive parts probably have complicating mechanism for deterioration against weathering.

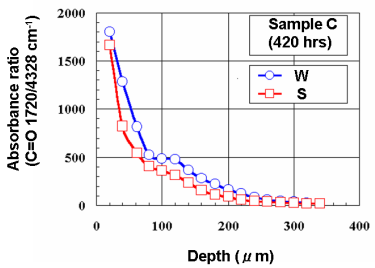

Figure 3: Depth profile of C=O caused by UV irradiation.

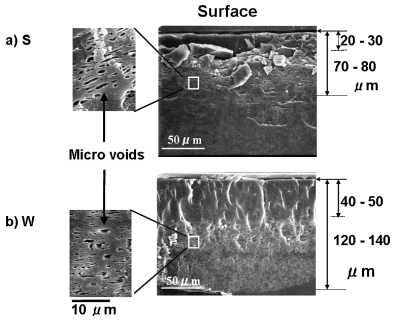

Figure 4: SEM photographs of the cross sections.

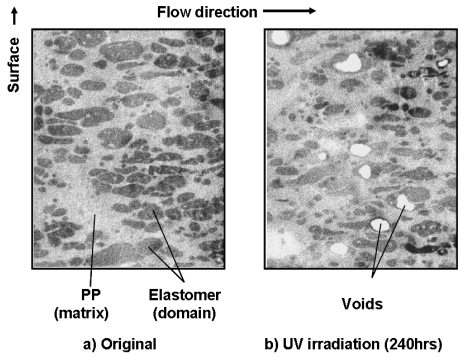

Figure 5: TEM photographs of the cross sections with/without UV irradiation

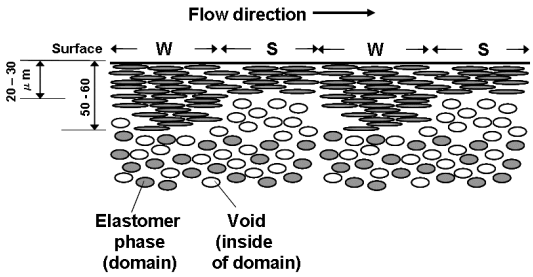

Figure 6: Schematic image for the striped deterioration of PP/rubber blend.

4 Conclusions

Tiger stripe and its deterioration were strongly influenced by morphologies formed inside the injection molding of PP/rubber/talc blend.

5 References

1. K. Hirano, Y. Suetsugu and T. Kanai, *Morphological Analysis of the Tiger-Stripe on Injection Molding of Polypropylene/Ethylene-Propylene Rubber/Talc Blends Dependent on Based Polypropylene Design*, submitting to J. Appl. Polym. Sci.
2. K. Hirano, S. Tamura, O. Isogai, S. Ikeuchi and A. Torikai, *Deterioration of Tiger stripe on Automotive Bumper Face Consisting of Polypropylene Composite*, PMF-11 (Polymer Material Forum 11th, Polymer Society of Japan), Preprints, pp.131-132 (2002)