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Chemistry

STUDY ON PREPARATION OF BLENDS BASED ON POLY(VINYL CHLORIDE), NITRILE - BUTADIENE RUBBER, NATURAL RUBBER AND POLYETHYLENE

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Abstract. The blends based on polyvinyl chloride (PVC), nitrile-butadiene rubber (NBR), natural rubber (NR) and polyethylene (PE) were made by three different methods. The mechanical properties of these blends in dependence of mixing time and temperature were characterized. The result showed that the two-step blending method, where PVC and NBR were first mixed together and then blended with NR and PE, is the best one to prepare blends with high mechanical properties.

1. INTRODUCTION

Vietnam is one of the biggest rubber-manufacturing and exporting countries in the world. Therefore, there has been increasing concern about the blending of natural rubber with other polymers, particularly, with thermoplastics in order to improve their properties as well as to widen their applications [1-3]. Recently, we have successfully prepared PVC/NBR/NR blends, which showed high mechanical properties and thermo-oxidative stability [4-6]. In this paper, the preparation of quaternary-polymer blends PVC/NBR/NR/PE was discussed.

2. EXPERIMENTAL

2.1. Materials

Nitrile-butadiene rubber (CKH 40 type), natural rubber (SVR 3L type), high-density polyethylene and polyvinyl chloride (TH-1000 type) were purchased from Russia, Vietnam, Thailand and Japan, respectively. The other additives such as curing agent (sulfur), stabilizers (cadmium stearate, barium stearate and N-phenyl-β-naphthylamine (Neozon D, Russia), accelerator (tetramethyl thiuram disulfide (TMTD)), cure activators (zinc oxide and stearic acid) and carbon black as filler were all of commercial grades.

Four polymers were first blended in a laboratory-scale Haake PolyLab Mixer (Germany) with various mixing temperatures and mixing time at a rotor-speed of 30 rpm and a fill factor of 0.7. Then, to vulcanize the blends, the mixes were compressed in a mold by using a laboratory hydraulic hot press Toyoseiky model (Japan) for 15 min at 150°C.

There are three specific methods for making blends used in our study as follow:

- *Method A:*

All compound ingredients were simultaneously mixed at various mixing-conditions to prepare directly the blends PVC/NBR/NR/PE.

- *Method B:*

PVC/NBR blends and PE/NR blends were first made at 170^{O}C for 6 min and at 135^{O}C for 6 min, respectively. Then, these blends PVC/NBR and PE/NR were mixed together at some mixing conditions in order to obtain PVC/NBR/NR/PE blends.

- *Method C:*

PVC/NBR blends were first prepared at 170^{O}C for 6 min. Afterward, the blends PVC/NBR were mixed with NR and PE at different mixing conditions to achieve PVC/NBR/NR/PE blends.

Mechanical tests (tensile strength and elongation at break) were carried out using the WPM - 250 tensile testing machine model (Germany) under the TCVN 4509 standard.

3. RESULTS AND DISCUSSIONS

3.1. Influence of the blending temperature

Tensile strength and elongation at break of PVC/NBR/NR/PE blends are shown in figures 1 and 2, respectively.

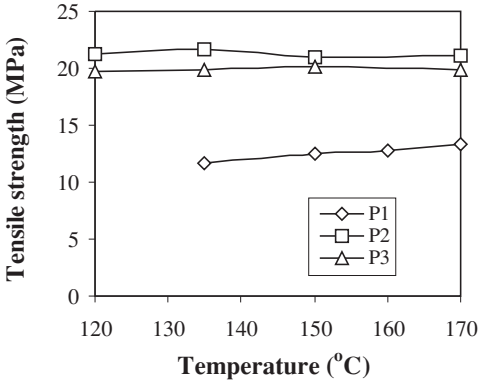

Fig. 1. Dependence of Tensile strength of PVC/NBR/NR/PE blends on blending temperatures

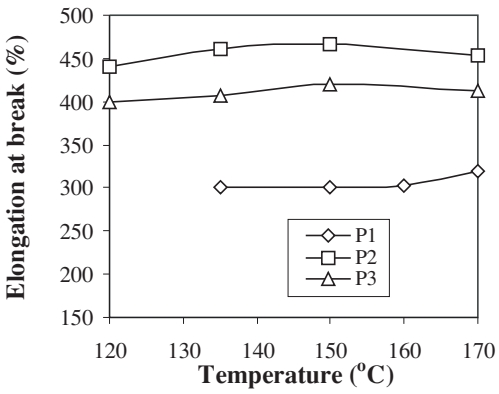

Fig. 2. Dependence of elongation at break of PVC/NBR/NR/PE blends on blending temperatures (P1, P2, P3 are Method A, B, C, respectively)

The results show that mechanical properties of the blends prepared by these methods are slightly influenced by the blending temperature. Although Method A (P1) allowed to make blends directly but the obtained blends exhibit the lowest mechanical properties. That can be explained by the weak compatibility between the polymers, for example, PVC with NR, PVC with PE, NBR with PE.

Among two remaining methods, Method C (P3) performed as the best one for making PVC/NBR/NR/PE blends not only because it had two blending steps but also

the obtained material showed the highest mechanical properties. Therefore, Method C was chosen for further study.

3.2. Influence of the mixing time

Besides the blending temperature, the mixing time is another important factor, affecting the phase morphology of blends. In this study, mixing time was varied from 2 to 8 min at 135 ^{o}C and 150 ^{o}C. The longest mixing time was confined to 8 min to avoid any possible thermal decomposition.

Figures 3 and 4 present the results of tensile strength and elongation at break of PVC/NBR/NR/PE blends. The results show that both tensile strength and elongation at break increase with increasing mixing time from 2 to 6 min. However, for the mixing time above 6 min, it does not have much influence on the mechanical properties.

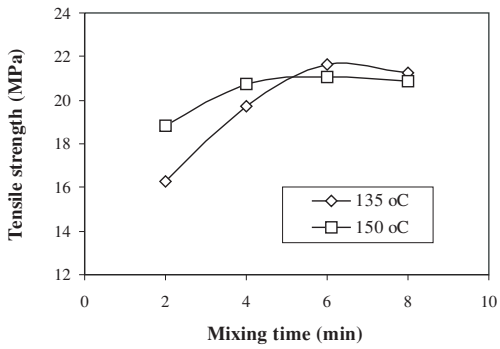

Fig. 3. Dependence of tensile strength of the PVC/NBR/NR/PE blends on the mixing time.

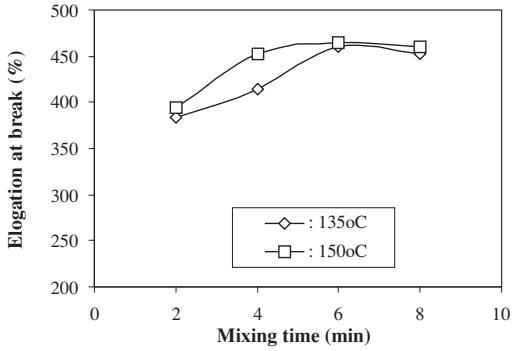

Fig. 4. Dependence of elongation at break of the PVC/NBR/NR/PE blends on the mixing time.

3.3. Influence of PVC content on mechanical properties of blends

The dependence of tensile strength and elongation at break of the blends PVC/NBR/NR/PE prepared by Method C on PVC content was shown on Figure 5. In this experiment, we fixed NR and PE contents (wt% NR + wt% PE = 35 wt% of all polymers) as well as other additive contents and processing conditions (135 ^{o}C blending temperature, 6 min mixing time), whereas PVC content in PVC/NBR blend was varied from 0% to 40%.

It is obvious to see that the elongation at break decreases gradually with increasing in PVC content because of low elongation of PVC and poor adhesion of PVC to PE and NR as well. Meanwhile, the tensile strength varies noticeably and obtains the maximum value (21.7 MPa) at about 30 % PVC. This may be explained that an increase of PVC content caused a change in strength of PVC/NBR phase, affecting the properties of the final blends.

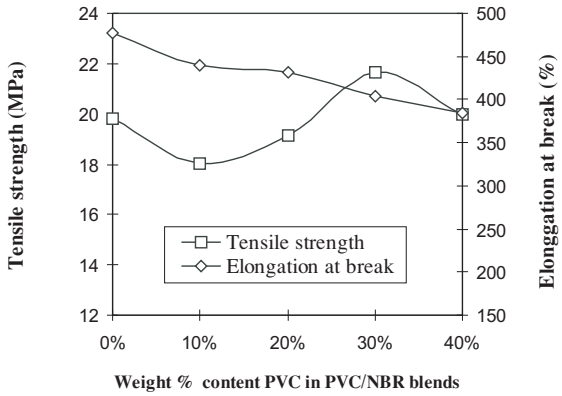

Fig. 5. Dependence of tensile strength and elongation at break of the PVC/NBR/NR/PE blends on PVC content

3.4. Influence of NR and PE content on mechanical properties

In order to study the influence of PE and NR contents on the mechanical properties of the PVC/NBR/NR/PE blends, we varied PE and NR contents (wt% NR + wt% PE = 35 wt% of all polymers) whereas PVC/NBR content (65 wt% of all polymers) and other additive contents as well as processing conditions (135 °C blending temperature, 6 min mixing time) were fixed. The results were shown in Fig. 6.

It is interesting to note that the change in mechanical properties of the PVC/NBR/NR/PE blends with the variation of PE content (Fig. 6) is similar to that with the variation of PVC content (Fig. 5). Elongation at break decreases gradually and at 8.75 % PE content (means 25 wt% of the total weight of PE and NR), the blends have the highest tensile strength. The reasons of that are the same as mentioned in Section 2.3.

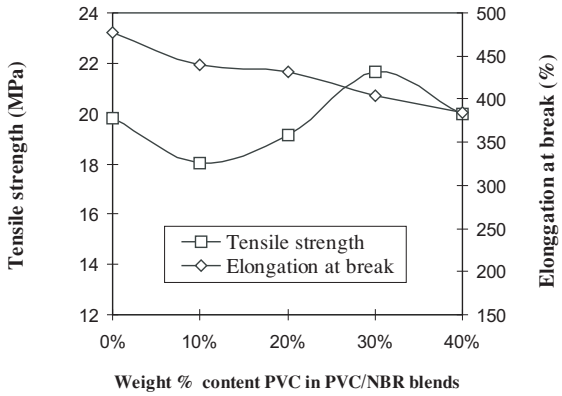

Fig. 6. Dependence of tensile strength and elongation at break of the PVC/NBR/NR/PE blends on the PE content

4. CONCLUSION

In the present paper, three different methods for preparation of PVC/NBR/NR/PE blends are discussed. Method C, where PVC/NBR blends are first prepared then mixed with both NR and PE and other additives, seemed to be the best method. The optional processing conditions for this method are 6 min mixing time, 135°C-150 °C blending temperature, 30 rpm rotor speed and 0.7 fill-factor. Polymer ratio also was investigated: (30 PVC + 70 NBR) : (25 PE + 75 NR) = 65 : 35.

The research results also show that the constituent supply order in preparing multi composition blends influence significantly the physico-mechanical and technical properties of the materials.

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REFERENCES

1. Akhtar S., Kuriakose B., De P. P., De S. K: *Plastic Rubber Process. Appl.* **7** (1) (1987) 11-18.
2. Do Quang Khang, Nguyen Van Khoi, Nguyen Quang, Tran Thi Binh, Luong Nhu Hai, *Journal of Chemistry*, **38** (1) (2000) 50 - 63 (in Vietnamese).
3. Ibrahim A., Dahlan M., *Prog. Polym. Sci.*, **23** (4) (1998) 665 - 705.
4. Nguyen Phi Trung, Tran Thanh Son, Nguyen Thac Kim, Hoang Thi Ngoc Lan: *Proceeding of the Third Internaltional Workshop on Materials Science (IWOM' 99)*, Hanoi, Vietnam, November **2-4** (1999) 809 - 812.
5. Nguyen Phi Trung, Tran Thanh Son, Nguyen Thac Kim, *Journal of Science & Technology*, V. XXXVIII, No. 3B (2000) 41-44 (in Vietnamese).
6. Nguyen Phi Trung, Thai Hoang, Vu Minh §uc, Tran Thanh Son, *Journal of Science & Technology*, V. XXXV, No. 5, 34-37 (1997) (in Vietnamese).

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