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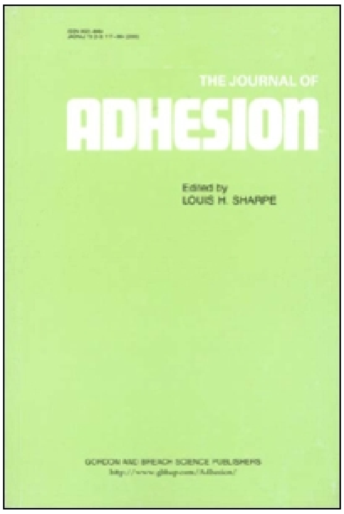

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*Study of Polymer Blends as a Vibration Damper

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ABSTRACT

Metallic materials have too small internal friction to damp vibration making noise, whereas plastics show remarkably large damping capacity in some characteristic temperature ranges where a considerable part of the vibrational energy is consumed as a result of molecular friction.

If the two kinds of materials are combined, one can expect that the vibration of the composite materials will be damped to a greater extent than that of the metal itself.

In this study dynamic mechanical properties of a variety of polymer blends were measured and those which have a broad E″ peak around 0°C were chosen from among them.

Sandwich structures of Al/polymer/Al type were then constructed and the dynamic mechanical properties of the composite systems were measured by means of a vibration reed technique. It was found that the sandwich structures with these polymer blends had larger damping capacity than that with poly (vinyl acetate) or Al itself.

INTRODUCTION

NOISE ARISING FROM vibrating parts of various kinds of machines and structures could be harmful to society. Effective expedients for preventing noise also have great industrial interest. Such noise is caused since metallic materials in general have a small internal loss and consequently their vibrations are difficult to damp. Therefore, it would be helpful to use plastics having large internal loss in order to reduce or eliminate noise. For instance, metal parts of cog wheels which are a source of noise can be substituted with plastics in order to prevent noise. However, there are many cases in which this substitution cannot be applied because of the lack of mechanical strength. Even in these cases, however, it is possible to reduce vibration remarkably by using a composite body consisting of plastics having a large loss modulus and of metals as the structural material for machine parts which are a noise source or as the surrounding material[1]. Since vibrations can be damped as a result of a partial consumption of the vibration energy added to the system due to the relaxation movement of the molecules in the plastic layer, the desired results would be obtained if plastics are chosen which have a large and broad loss modulus E″ in the audible frequency range as well as in the temperature range of use. On the basis of these ideas, Oberst *et al.*[1] investigated the dynamic viscoelasticity of various plastics-metal composite bodies. However, they did not describe in detail the compositions or the types of plastics used.

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In the present investigation we first tried to prepare polymer blends having a relatively large loss modulus E″ in a wide temperature range with the maximum in the neighborhood of 0°C. We investigated the dynamic viscoelasticity of some of these samples sandwiched between metal plates.

EXPERIMENTAL

2.1 Sample Preparation

We selected nitrile rubbers (abbreviated as NBR (30), NBR (40), etc., the numbers indicating the acrylonitrile content), polychloroprene (Neoprene), polybutadiene (PBD), polyethyl acrylate (PEA) and natural rubber for the components having a low T_g, and polyvinylchloride (PVC), vinyl acetate-vinyl chloride copolymer (PVAc:VC=50:50), polystyrene (PSt) and polymethylmethacrylate (PMMA) for high T_g components and polyvinylacetate (PVAc) for an intermediate component. These components were blended in various ratios. In blending, the polymers in the prescribed ratios were dissolved in tetrahydrofuran and then precipitated in water. The precipitates were thoroughly dried and then pressed at about 110°C to obtain a film of about 0.5 mm thickness. As for some of the benzene soluble components, the blending was also carried out by the freeze drying method. The various polymers were mixed in the prescribed ratios yielding about a 5% benzene solution. The solution was poured into a separatory funnel cooled with liquid nitrogen and frozen within a very short time, then it was transferred to a bath at 0°C and dried under reduced pressure. The samples obtained were pressed at room temperature yielding semi-transparent films. In addition to these, styrene was grafted to Neoprene and NBR (40) by a solution polymerization. The solvent was tetrahydrofuran and the initiator was benzoyl peroxide. The reaction was carried out at 70°C for 8 hours. The conversion rate was 22.5% for NBR (40)-g-St and 28.3% for Neoprene-g-St.

2.2 Measurement of Viscoelasticity

Measurements of viscoelasticity were carried out at a frequency on the order of 100 cps which is near the center of the audible frequency range on a logarithmic scale. If the temperature width of the peak of the loss modulus (E″) is broad at constant frequency, then it can generally be said that the frequency width of the peak of the E″ curve is also broad at constant temperature.

The dynamic viscoelasticity of the polymer films was measured by a direct reading type Vibron DDV-II manufactured by TOYO Measuring Instrument Co. The measurements were carried out at a frequency of 110 cps and the average rate of temperature rise was about 1°C/min.

In some cases, either 0.02 mm thick aluminum foils or 0.26 mm thick aluminum plates were adhered by the cyanoacrylate type adhesive, Aron Alpha, to both sides of a polymer film about 0.5 mm thick. The dynamic viscoelasticity of these composite bodies was measured by the vibrating reed method[2]. The measuring frequency was about 100 cps and about 200 cps for the sample with aluminum foils and the sample with 0.26 mm thick aluminum plates, respectively. The temperature was raised or lowered stepwise and the measurements were carried out after the temperature became constant. The frequencies of the device were calibrated by a synchroscope attached to the output terminal of the vibration device.

EXPERIMENTAL RESULTS AND DISCUSSION

Some typical curves of the dynamic viscoelasticity measurements for the polymer blends prepared in this study are shown in Figs. 1-4.

Fig. 1 shows samples having an extremely narrow peak in the loss modulus curves. Generally homopolymers exhibit an extremely high loss modulus at the transition region in a narrow temperature range, but it decreases remarkably outside that temperature range. The polymer blend between the polymers having an extremely good compatibility shows the same tendency. Fig. 2 shows samples having a relatively broad peak Figs. 3 and 4 show samples having a loss modulus peak which is spread over a much wider temperature range. In order not to weaken the vibration damping action even when some of the operating conditions such as temperature and frequency are changed, it is quite necessary to use polymers having a very broad peak in the loss modulus curve as shown here. Besides the systems shown here, dynamic viscoelasticity measurements were carried out for various other

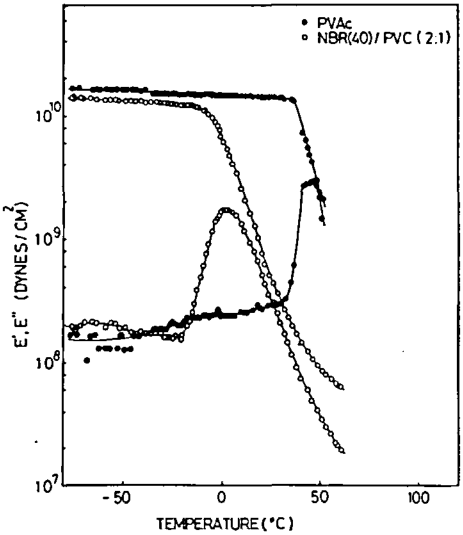

Figure 1. Temperature dependence of the complex moduli of the polymers (110 cps).

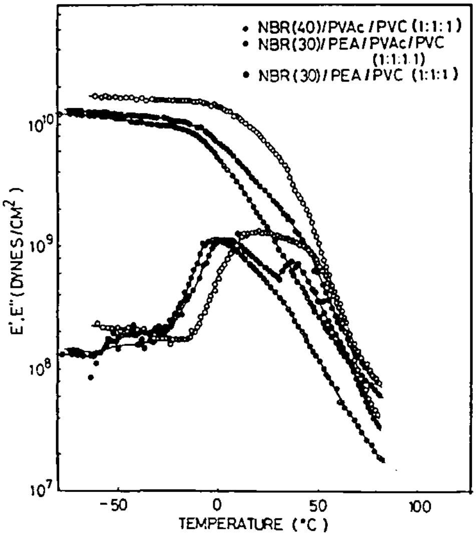

Figure 2. Temperature dependence of the complex moduli of the polymers (110 cps).

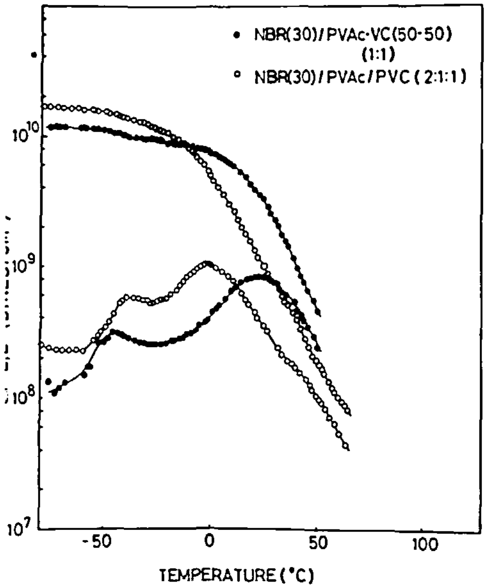

Figure 3. Temperature dependence of the complex moduli of the polymers (110 cps).

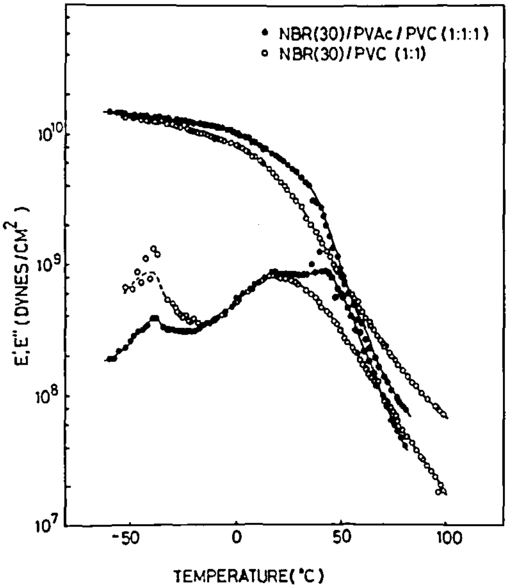

Figure 4. Temperature dependence of the complex moduli of the polymers (110 cps).

composite materials, all of which did not show a single broad dispersion peak but showed the independent loss modulus peaks characteristic of each component. Finally, among the systems studied here relatively broad loss modulus peaks having no sharp descent could be obtained from the composite materials of NBR and PVC with a third modifying component which are known to be partially compatible or a molecular mixture[3].

Hata *et al.*[4] reported that they could make molecular mixtures of the PMMA-PVAc system by the freeze drying method and that the dynamic viscoelasticity measurements showed a broad dispersion in the loss modulus curve. Also in our study the freeze drying method was applied to the mixture of Neoprene and PBD and that of PSt and PMMA in which no single broad peak of loss modulus was observed. This is probably due to the fact that the T_g of one component is much lower than the freezing temperature (0°C).

Moreover, in an attempt to increase the mutual dispersion of two polymers having no compatibility, Neoprene-g-St and NBR (40)-g-St were prepared, but only the characteristic loss moduli of both components were observed independently.

For the specimen having a broad loss modulus peak as shown in Fig. 3 and 4, sandwich type composites were made by adhering either 0.02 mm thick aluminum foils or 0.26 mm thick aluminum plates on both sides of the

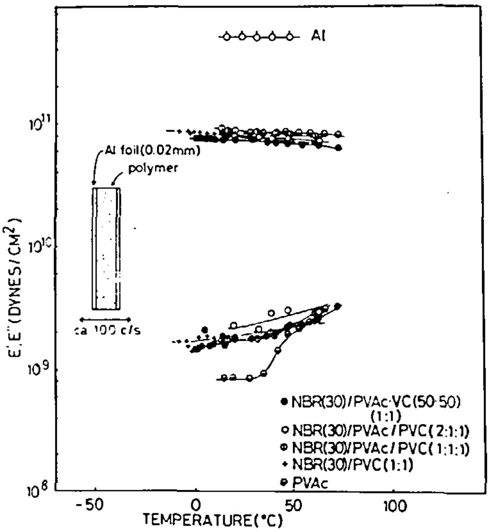

Figure 5. Temperature dependence of the complex moduli of the Al/polymer/Al type sandwiches. Al foils were used.

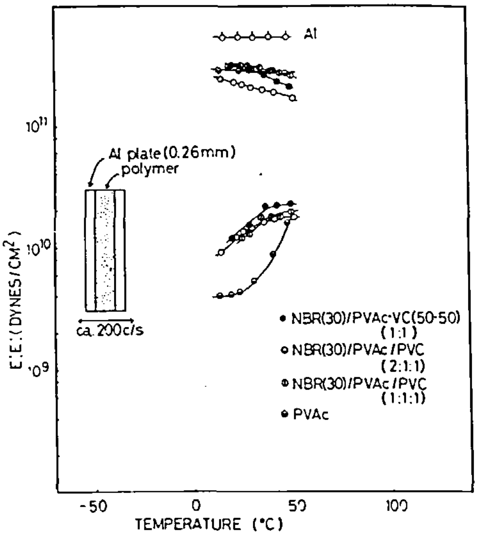

Figure 6. Temperature dependence of the complex moduli of the Al/polymer/Al type sandwiches. Al plates 0.26 mm thick were used.

polymer film. Measurements of the dynamic viscoelasticity of these composite materials were carried out and the results are given in Figs. 5 and 6. For comparison, the same measurement was carried out both on the sandwiched PVAc sample and the aluminum plate itself. The resonant vibration curve of the latter was so sharp that the loss modulus could not be estimated. Although the temperature range of the measurements was narrow, it can be said that the polymer having a large loss modulus also shows a large overall loss modulus even if it is sandwiched, indicating that it has a larger damping capacity than PVAc. Due to the bending vibration and their temperature and thickness dependence, the absolute values of E′ and E″ are more complicated than can be expected for the individual values of E′ and E″ of the polymer film and the metal using a simple parallel model[5]. In addition to these, similar experiments were carried out on PEA and natural rubber, both sandwiched between aluminum plates. The results are shown in Fig. 7. First of all, the

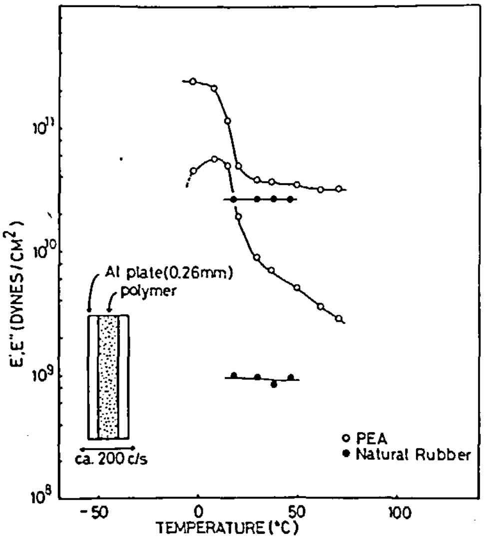

Figure 7. Temperature dependence of the complex moduli of the Al/polymer/Al type sandwiches.

most characteristic feature is that the apparent transition point of the PEA sandwich is shifted considerably to a higher temperature than that of PEA itself. Secondly, its storage modulus decreases sharply in the apparent transition region, but above that temperature it gradually approaches a certain value which is almost equal to that of the natural rubber system (yet the numerical value cannot be explained by a parallel model). In any event, it is obvious that the dynamic viscoelasticities E′, E″ of the polymer composites become almost equal when the polymer is in the rubbery state above its transition temperature.

Although it became quite clear that the dynamic viscoelasticities of the composite materials behave characteristically, reflecting the characteristic features of the components, further fundamental studies are still needed for a close analysis of their behavior.

CONCLUSIONS

In the above, a survey has been made of polymer blends having a vibration damping capacity in a relatively wide temperature range. Dynamic viscoelasticity studies were carried out on the metal-polymer-metal sandwiches made of these polymer blends. There appears to be a good possibility of finding a polymer system meeting our objectives by investigating other suitable polymer systems besides the ones used here, by developing new blending techniques and by investigating systems containing fillers. Furthermore, together with the fundamental analysis of the dynamic viscoelasticity of the composite bodies as mentioned before, it will become important in the future to solve the problem of adhesion in the sound absorbing materials.

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REFERENCES

1. H. Oberst, L. Bohn, F. Linhardt, *Kunststoffe* **51**, 495 (1961). H. Oberst, A. Schommer, *ibid.,* **55** (1965).
2. For example: "Rheological Measurement Methods", Kyoritsu Publishing Co.
3. M. Takayanagi H. Harima, Y. Iwata, *Mem. Fac. Eng. Kyushu Univ.* **23**, 1 (1963).
4. Miyata, Ichihara, Suzuki, Komatsu and Hata, 16th Meeting of the High Polymer Conference (1967).
5. Takayanagi *et al., Zairo* (*Materials*) **12**, 389 (1963).