NEW DAMPING MATERIALS COMPOSED OF LIQUID CRYSTAL POLYMER AND CARBON BLACK

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ABSTRACT

New damping materials consist of liquid crystal polymer and carbon black. The vibrational energy is converted into electrical potential energy and then is changed into Joule's heat.

INTRODUCTION

Damping materials are very important materials. They are used in many fields to control the vibrations and sounds. Rubber and foam plastics are excellent damping materials[1]. Recently, there have been many efforts to control the vibrations and sounds caused by machines and other devices. Many conventional damping materials composed of polymeric composites are based primarily on the mechanism of mechanical vibration energy dissipated to heat energy through the viscoelastic properties of polymer[2]. In the present study, we tried to make a new mechanical damper based on a new mechanism. Liquid crystalline polymer Vectra™ was doped with conducting particle carbon black. Mechanical vibration energy that transmitted to the Vectra™ then polarized it and in this way the vibration energy was converted into alternating electrical potential energy and was further converted into Joule's heat through the conduction paths which were formed by the carbon black in the polymeric matrix. In this study, we discuss how the carbon black distributes in the matrix and the relation between the damping efficiency and the conductivity of composites.
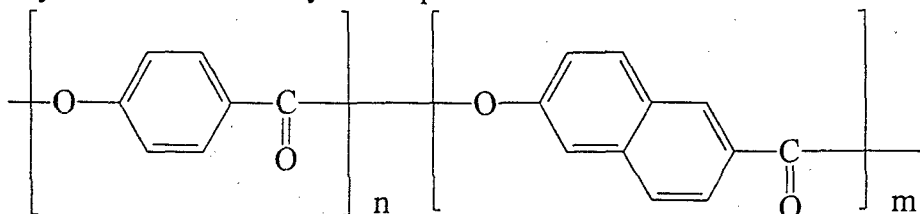
Poly(hydroxybenzoate-co-hydroxynaphthoate)
Vectra™

EXPERIMENTAL

Composite Sample Preparation: The Vectra™ was used as a matrix polymer, Carbon black, 300 Å in diameter, was used as an electrical-conductive filler[3]. The liquid crystal polymer, Vectra™ was mixed with a given amount of carbon black by a mixing roller. The mixed samples of Vectra™ and carbon black were kindly supplied by Polyplastics Co. Ltd. The content of CB in the samples was in the range of 0-10 weight %. The samples were compression-molded to make the films of about 0.5mm thickness. The temperature was 315°C, maximum pressure was 200 kgcm^{-2}.

Table 1   Composites of Vectra™ and Carbon Black

Number of Sample	1	2	3	4	5	6	7
Content of CB (weight %)	0	0.4	0.8	1.2	1.6	1.8	2.0

Number of Sample	8	9	10	11	12	13
Content of CB (weight %)	2.4	3.2	4.0	6.0	8.0	10.0

One side of the sample of 60mm length and 15mm width, was clamped in a vice, and vibration was given by a plus-driving motor. After a given vibration, the residual vibration was detected from the measurement of the displacement in the oscillated sample by a non-contact sensor, Kaman KD-2300. Fig.1 shows the system of the vibration measurement apparatus. The damping time constant τ is defined as the time after the vibration amplitude becomes 1/e of the initial value. It is shown in Fig.2
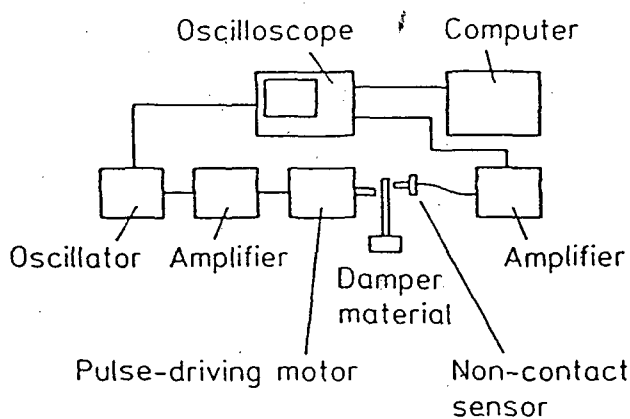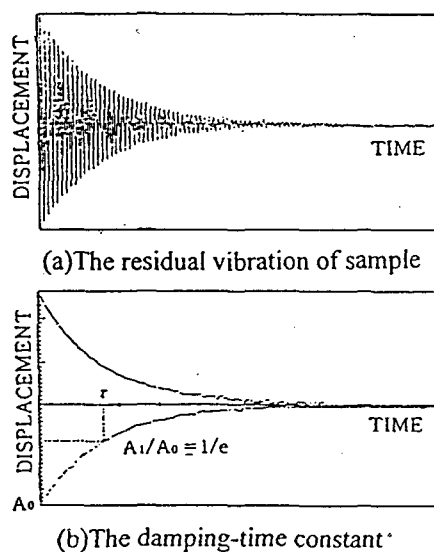

Fig. 1. Mechanical-
vibration measuring system

(a)The residual vibration of sample

(b)The damping-time constant

Fig.2 The measurement
of damping time

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The electrical conductivity was measured from the vertical thickness of the composite films.   Silver paste was used to ensure good contact of the sample surface with the electrodes of the conduction tester.   The electrical conductivity of samples varied over the interval of 10^{-14}-$10^{-4}\Omega^{-1}cm^{-1}$.

The electrical conductivity of a composite conducting polymer depends critically on the weight fraction of the carbon black.   It is shown in Fig.3.   For low content of carbon black the conductivity of the composite is basically that of the polymer matrix, at some content, however, the conductivity increases precipitously by many orders of magnitude.
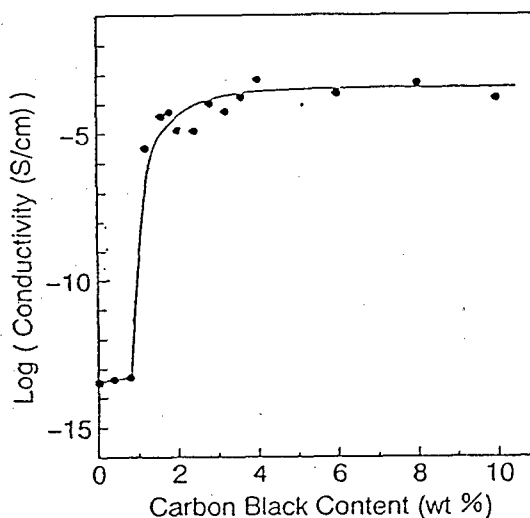

Fig.3 The electrical conductivity of the composite

RESULTS AND DISCUSSION

Vectra™ is a liquid crystalline polymer.   According to the results of the Differential Scanning Calorimetry (DSC), the temperature at which Vectra™ changes its state from crystal to liquid crystal is about 285°C-295°C. At room temperature, Vectra™ consists of both crystalline and liquid crystalline parts[4].   Carbon black particles cannot penetrate the crystalline region, and disperse in the liquid crystal region.
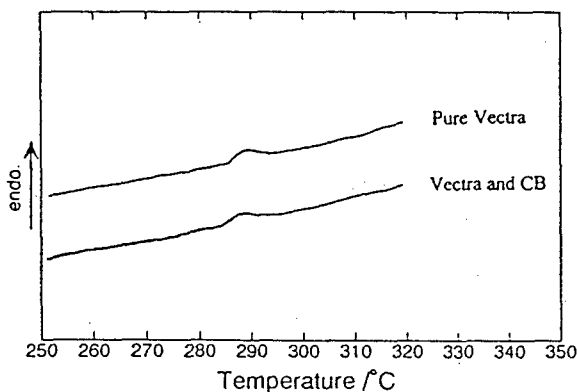

Fig.4 The DSC curve of pure Vectra and composite (CB content is 4.0%wt.)

From Fig.4 we find that the composite (CB 4.0% and Vectra™) and pure Vectra™ change their states at almost the same temperature.

Fig.5 shows the relation between the damping time constant τ and the carbon black weight fraction.   When the content of carbon black is lower than 1.2%, the mixed material is an insulator, that is ,the average distance between carbon

black particles is large. With the increase of carbon black content, the average distance becomes smaller. When the content of carbon black is about 1.2% the electrical conductivity jumps precipitously[5]. Comparison with Fig.3. we find that at around 1.0% carbon black content, the damping time is the shortest. At same content, the electrical

Fig.5 The variation of damping with weight% of CB

conductivity jumps. We could conclude that if the content of carbon black is over 1%, it is possible for electrical charge which is produced by polarization of Vectra™ to move in the mixed polymers. So the damping time becomes shorter, and the damping efficiency is higher.
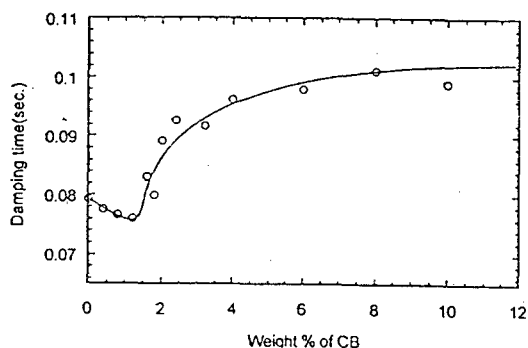
CONCLUSION

A new mechanical damper was made from Vectra™ [poly(hydroxybenzoate-co-hydroxynaphthoate) liquid crystal polymer], composite filled with electrical conductive particles. Mechanical vibration energy is transformed through the polarization of Vectra™ into electrical energy which is dissipated through the conduction paths of the conductive particles. As a result, the following points were classified:

1) The degree of vibration (damping-time constant) could be varied continuously by changing the weight fraction of the conductive particles.

2) The damping-time constant was a minimum if the content of carbon black was about 1.0%.

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