EFFECT OF γ —RADIATION ON PROPERTIES OF CHLORO—SULFONATED POLYETHYLENE

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ABSTRACT

The effects of γ-radiation on three chloro-sulfonated polyethylene (CSM) with different chlorine content have been investigated, the effects of γ-radiation on some physical properties of CSM have been discussed. The results showed that three CSM can be easily crosslinked by irradiation, the crosslinking degree related to chlorine content, at the same radiation dose, the more the chlorine content in CSM, the easier the CSM to be crosslinked, unirradiated CSM has good mechanical properties (tensile strength and elongation), the effect of irradiation dose on dielectric properties was insignificant.

Keywords: CSM Radiation crosslinking of polymer Dielectric property Thermal property

1 INTRODUCTION

Chloro-sulfonated polyethylene (CSM) has very high elongation (E) and suitable tensile strength (T_s). It is a polar polymer, but it has the resistance to burning and aging. CSM can be crosslinked by chemical method as well as by radiation. Most information belongs to chemical crosslinking[1-5]. In this paper, γ-radiation crosslinking of three CSM with different chlorine contents is reported. The radiation crosslinking mechanism is discussed briefly. Some physical properties of CSM, such as the mechanical, dielectric and thermal properties, were studied. The effects of radiation dose and chlorine content on these properties were investigated. The results showed that the effect of radiation dose on T_s and E is large, however, dielectric and thermal properties are insignificant in the dose range used. Dielectric and thermal properties have a bearing on chlorine content in CSM closely.

2 EXPERIMENTAL

2.1 Materials

CSM used is the product of Jilin Calcium Carbide Plant. The technical index of

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CSM is shown in Table 1.

2.2 Irradiation

The samples were irradiated with a ^{60}Co γ-source at a dose rate 10 kGy/h at room temperature in air.

2.3 Gel fraction measurement

Gel fraction of irradiated samples was determined by extraction with xylene at 130°C for 48 h, then washed with ethyl alcohol and dried in a vacuum oven to constant weight.

2.4 Physical properties measurement

The mechanical properties were determined with INSTRON. Dielectric spectra of the samples were measured with a TRS-10C dielectric measuring set. Thermograms of the samples were determined on a Perkin-Elmer DSC-2C differential scanning calorimeter with a heating rate 10 °C/min.

Table 1

The technical index of three different type CSM

Technical index	Sample type		
	20	30	40
Cl content (%)	29—33	40—45	33—37
S content (%)	1.3—1.7	0.8—1.2	0.8—1.2
Fe content (%)	0.01	0.01	0.01
Volatile matter (%)	1.0	1.0	1.0
ML viscosity	38	50	40

3 RESULTS AND DISCUSSION

3.1 Radiation crosslinking of CSM

The relationship between gel fraction and radiation dose for irradiated three CSM

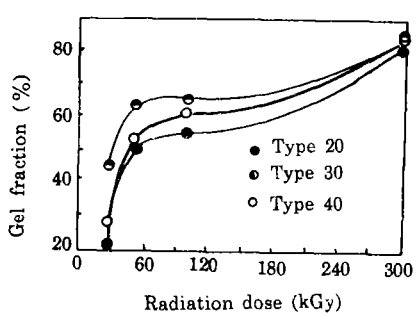

Fig.1 Relationship between gel content and radiation dose for three CSM

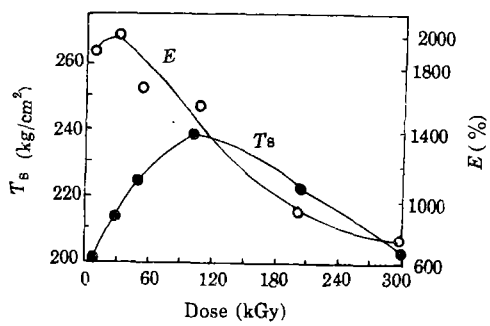

Fig.2 T_s and E dose curves for CSM

are shown in Fig.1. From Fig.1, it is seen that gel fraction for three CSM increases with increasing radiation dose. It is also observed that at same dose gel content for CSM with higher chlorine content (Type 30 in Table 1) is higher than that of lower chlorine CSM (types 20 and 40). Because the probability of dechlorination for higher chlorine CSM is larger than the other during irradiation, that is, the more free radicals is produced by irradiation, the higher probability to form crosslinking structure in that CSM. The results in Fig.1 show that crosslinking of CSM is easier

using γ-radiation.

3.2 Mechanical properties of CSM

The T_s and E of irradiated CSM were investigated. T_s and E dose curves are shown in Fig.2. From Fig.2, it can be seen that unirradiated type 40 CSM has higher elongation and suitable tensile strength. After the irradiation, T_s and E increased with dose increasing, T_s and E reached a maximum when irradiation dose is 105 and 30 kGy respectively. Afterwards T_s and E decreased with the dose increasing. These phenomena were caused by the increase of crosslinking density and the structure effect in irradiated CSM.

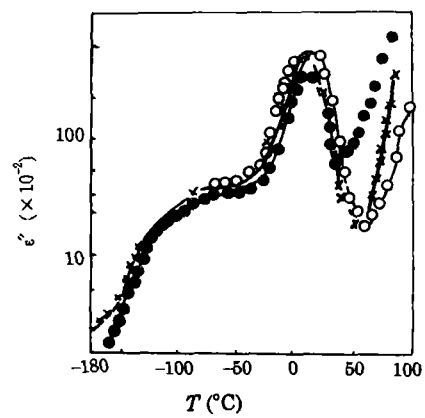

Fig.3 The temperature spectra of ε'' for CSM (type 40) at different irradiation doses

Frequency: 3kHz ● 0 kGy × 30 kGy ○ 300 kGy

3.3 Dielectric properties

Fig.3 shows the relationship between dielectric loss factor (ε'') and the temperature (°C) for type 40 CSM at different irradiation doses. A dielectric transition peak is observed over the temperature range from −180 to 100 °C. It is seen that the position for dielectric loss peak of CSM is almost not changed after irradiation. The position of the peak is about 8 °C, which is attributed to the glass transition (T_g) of CSM.

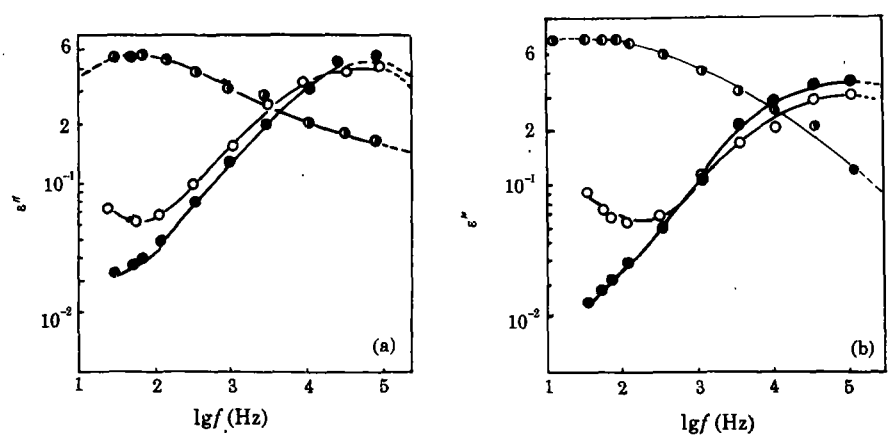

Fig.4 The frequency spectra for unirradiated CSM (a) and irradiated samples (b)

Type: ○ 20 ● 40 ◑ 30

Fig.4 (a) and (b) are the frequency spectra for unirradiated and irradiated samples. As can be seen from the figure, curves of types 20 and 40 have similar change, i.e. the

maximum loss peaks appear at 10^5 Hz. But the peak for type 30 is near 30 Hz of lower frequency. Different chlorine contents for three CSM lead to the difference of the peak position in the frequency spectra. C–Cl bond has strong polar, therefore in a sense, intermolecular tied force for higher chlorine CSM is relatively strong. As stated above, ε'' maximum loss peak on frequency spectra is at lower frequency.

3.4 Thermal behaviors

Fig.5 shows thermal analysis spectra for unirradiated three CSM with DSC. This figure clearly shows that three CSMs' transition peaks are at 17, 16 and 6°C corresponding types 20, 40 and 30 respectively. It is also indicated by DSC that T_g of CSM increases with increasing chlorine content.

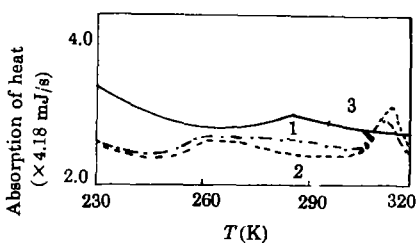

Fig.5 Thermal analysis spectra for three unirradiated CSM

Type: 1—20 2—40 3—30

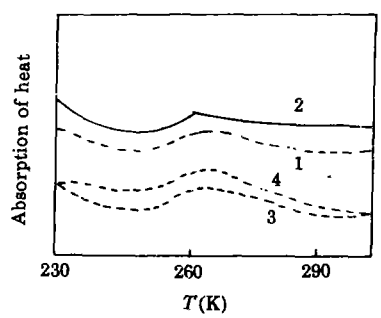

Fig.6 DSC spectra for irradiated type 40 CSM

Radiation dose (kGy):

1—0 2—10 3—50 4—300

Fig.6 shows the effect of radiation dose on T_g for type 40. As can be seen in this figure, the effect of dose on T_g of the sample is very small at the dose used, that is, the change of T_g of CSM with radiation dose obtained by DSC and by dielectric method is consistent.

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