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MECHANICAL BEHAVIOUR AND STRUCTURE OF IRRADIATED AND UNIRRADIATED COPOLYMERS OF ETHYLENE AND VINYL CHLORIDE*

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IN RECENT years considerable interest has been shown in the modification of polymers by means of irradiation. The major structural changes occurring in polymer molecules in the course of irradiation cause changes in physicochemical behaviour, so that improvements in the properties of polymeric materials are obtainable in this way. The modification of polyethylene by irradiation has been dealt with in some detail in the literature [1–4], and papers have also been published by authors studying the effect of ionizing irradiation on polyvinyl chloride [5, 6].

The aim in the present investigation was to study structural changes in relation to the mechanical behaviour of copolymers of vinyl chloride and ethylene exposed to the effects of ionizing radiation. Ethylene–vinyl chloride copolymers differing in composition were used in the experiments.

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EXPERIMENTAL

The substances investigated were ethylene copolymers containing 15·6; 52; 61·5 and 77 mole % vinyl chloride (VC) units. The copolymers were obtained by copolymerizing these monomers in the presence of the dinitrile of azoisobutyric acid at 70°, at a pressure below 300 kg/cm². Low density polyethylene (l.d. PE), C5 grade suspension polyvinyl chloride (PVC) with mol. wt. 77,000 and bulk PVC were taken for comparison. Ethylene–vinyl chloride copolymer (EVCC) films of different thicknesses (0·03–0·3 mm) obtained by casting were irradiated at 20° under helium with a ^{60}Co γ-ray source over a dose range of 1–1000 Mrad with dosages of 0·36–2·5 Mrad/hr. The IR spectra were recorded on a UR-10 spectrophotometer in the region of 4000–400 cm^{-1}. The optical density of the bands was calculated using the base line method. The solubility determination was conducted in a Soxhlet apparatus in an atmosphere of purified dry nitrogen. Tetrahydrofuran, *o*-xylene and toluene were used as solvents; extraction time 40 hr. After extraction the samples were vacuum-dried to constant weight at 40° under a residual pressure of 10^{-4} mm. The thermomechanical tests were carried out on a general-purpose deformometer made at the Karpov Physicochemical Research Institute. The relative characteristic selected in the thermomechanical investigations was the temperature at which there is 50% relative strain. This is conventionally referred to as the heat resistance. The load on the sample was ~7 % on the breaking load. The mechanical properties were determined on a D-4 general-purpose dynamometer.

DISCUSSION OF RESULTS

Figure 1 shows curves of the strength properties of unirradiated ethylene–vinyl chloride copolymers (EVCC) and changes in these properties during the course of irradiation. The copolymer of ethylene with 15·6 mole % VC has rubber-like properties: tensile strength 73 kg/cm², breaking elongation >2000%. A rise in the number of VC units is accompanied by reduction in the breaking elongation: a sample with 61·5 mole % VC has a breaking elongation of 200%; PVC has a breaking elongation of only 10%. The lowest tensile strength is observed with the rubber-like sample containing 15·6 mole % VC units. On increasing the number of VC units to 61·5 mole % the tensile strength rises to 230 kg/cm². The tensile strength of pure PVC is 462 kg/cm².

Study of the thermomechanical behaviour of the unirradiated EVCC (Fig. 2) showed that in the case of those containing 61·5 mole % VC the glass transition temperature (T_g) falls to 50–60° compared with T_g=80–90° found with PVC. The presence of 15·6 mole % VC reduces the melting point from 80–110° characteristic of l.d.PE down to 60°. X-ray pictures* of the EVCC samples show that the crystalline portion of those containing 15·6 mole % VC is preserved, but with higher contents of VC units the copolymers have an amorphous structure.

Irradiation of the EVCC samples of different compositions resulted in the tensile strength increasing with the irradiation dose (Fig. 1); it has a maximum in the region of 100–130 Mrad. Further irradiation reduces the tensile strength. A considerable rise in the latter is seen with EVCC containing 15·6% VC. The

* X-ray pictures of the EVCC samples were recorded on a URS-50I diffractometer by B. I. Zverev.