tween elements increases the concentration both of the normal stresses in fibers surrounding a fractured fiber and of the equivalent shear stresses. Here, within the investigated range of bond stiffness, the maximum shear stresses increase considerably more rapidly than do the normal stresses, i.e., the shear stresses will play the deciding role in the fracture of maximally reinforced organic-fiber composites. This finding must be taken into consideration when selecting production regimes for the manufacture of MROC's, so that the increase in the strength of the bonds between fibers will be greater than the increase in the shear stress concentration.

LITERATURE CITED


NEW ASPECTS OF THE KINETICS OF FAILURE OF POLYMERIC AND COMPOSITE MATERIALS IN ULTRAVIOLET IRRADIATION*

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Fatigue phenomena, whose nature is explained by the kinetic thermal fluctuation theory of accumulation of defects and ruptures, are the basis of many processes of failure of solids. For this reason, studies of the generation of failure of solids. For this reason, studies of the generation of defects have become very important in estimating the longevity of polymeric materials, especially when they interact with one destructive factor: ultraviolet (UV) solar radiation.

There is a large number of studies on photodecomposition, photooxidation, and failure of polymers under the effect of UV radiation [cf. 1]. However, the mechanism of the reaction of the polymer with UV radiation has not yet been adequately established, and the processes which cause rupture of weak bonds and the formation of defects are not clear. The changes in the properties of polymeric materials under the effect of UV radiation were investigated in the present article; the correlation between the longevity of the material in conditions of exposure to UV radiation and the physical structure of the polymer was established; the mechanism of defect formation was determined. The process of the interaction of UV radiation with polymeric material was studied with the integral [2] and differential [3] effect of UV radiation and force fields.

The analysis of the processes of failure indicates that a volumetrically stressed state of the material, indicated by the deformation of polymer films and coatings on flexible substrates (model systems), arises in composite materials based on polymers under the effect of UV radiation. The quantitative evaluation of the strains arising in the polymer was determined with a special instrument which ensures a precision of measurement of strains of up to 0.01 μm [3, 4].

Film samples exposed to extension stresses were irradiated with a PRK-2 mercury-quartz lamp (irradiation in the 248-300-nm wave range, intensity of 2 W/cm²). To obtain comparative data, the same film samples were irradiated with infrared (IR) light (λ = 300-1000 nm).

It was shown that the films were lengthened by a value of ΔLUV under the effect of UV radiation. After UV irradiation stopped, the deformation of the films decreased by the same value of ΔLUV. In the absence of irradiation, the size of the films subsequently remained constant if the applied tensions has not created stresses exceeding the limit of proportionality in the films. The process is repeated during repeated periodic UV irradiation; the length of the films increases or decreases corresponding to the periodicity of the UV radiation. As Fig. 1 (curve 2) shows, deformation is accompanied by a change in the temperature

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Fig. 1. Microstrains of polycarbonate films during periodic UV irradiation: 1) microstrain of the film; 2) temperature generated in the film. The arrows pointing up indicate when the radiation was switched on and the arrows pointing down indicate when it was switched off.

Fig. 2. Deformation of polymer films in periodically switching UV (1) and IR (2) radiation on and off. The arrows pointing up indicate when the radiation was switched on and the arrows pointing down indicate when it was switched off.

Based on the existing concept, elongation of the film sample should correspond to the thermal expansion coefficient and the fixed temperature. However, in comparing the elongation of the film from exposure to UV light $\Delta l_{uv}$ with the thermal elongation $\Delta l_{ir}$ which occurs on heating with an IR emitter at a fixed temperature, a difference was found between these values.

A difference in the absolute values of $\Delta l_{uv}$ and $\Delta l_{ir}$ by the value of $\delta$ was observed for all of the films of the materials studied without exception (Fig. 2). The significant difference between $\Delta l_{uv}$ and $\Delta l_{ir}$ indicates that the effect of UV radiation on polymeric materials prevents expansion of the material and a "thickening" effect (compression) of the material in the microvolumes is manifested. The value of $\delta$ is a function of the nature of the material and its chemical and physical structure (Table 1). The experimental data reported in Table 1 also indicate that the absolute value of the reversible microstrains $\delta$ for a given material remains constant in a wide range of elastic strains on extension and during creep of the films. We call the observed phenomenon the photodeformation effect, and it can probably be explained as follows. Nonradiating processes of internal and intercombination conversions take place in the interaction of UV radiation with the polymeric material, and the vibrational energy of the molecules and temperature of the sample increase as a result. However, modulation of the intramolecular vibration spectra takes place under the effect of the light field, and a decrease in the expected thermal expansion and "thickening" of the material in the microvolumes are observed as a consequence.

The studies conducted indicate the complex processes which take place in solid polymers on exposure to UV radiation. In these processes, the mechanical effect of electromagnetic radiation, previously observed in [5], is very significant.

It thus follows from the above that reversible deformation caused by a change in the temperature in the sample is observed during periodic UV radiation in polymer films under a load. The elongation strains of polymer films heated to the same temperature are smaller with UV radiation than with IR radiation. The difference between the elongation of polymer films with UV and IR radiation at the same heating temperature is not a function of the value of the stress from uniaxial extension. The reversibility of the strains and the existence of a "compression" effect in the polymer during UV radiation permitted considering the processes of failure of the materials differently and assessing the kinetics of generation of defects and crack development.

The process of generation of defects in the polymer matrix under the effect of UV radiation can apparently be represented as follows.