

LETTERS TO THE EDITORS

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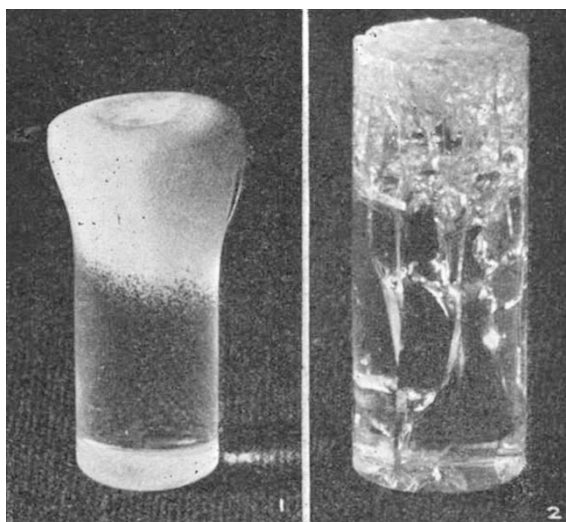
Breakdown of Methyl Methacrylate Polymer by High-Energy Radiation

THE behaviour of polymethyl methacrylate ('Perspex') when exposed to high-energy radiation is markedly different from that of many other long-chain polymers such as 'Polythene' and polystyrene¹. These latter develop cross-links forming a thermo-setting material, whereas polymethyl methacrylate shows rapid breakdown after relatively short radiation doses. The nature of the changes produced is complex, and appears to vary with the temperature as well as the radiation dose.

Most of the irradiation work was carried out in the BEPO atomic pile at Harwell, at a temperature of about 70° C. Unit radiation dose is defined as a flux of 10^{17} slow neutron/cm.² plus the associated fast neutrons and gamma-rays. After exposure to some two units of radiation 'Perspex' loses its transparent appearance, expands and forms a white brittle material, consisting of a mass of bubbles. Higher radiation doses produce a white powder. If shorter radiation doses are given, there is no obvious change in the 'Perspex', apart from a yellowish tint which occurs in many organic compounds exposed in the pile. When these specimens are afterwards heated, internal bubbling occurs and the material expands to six to eight times its original volume. The temperature at which this change occurs is determined by the radiation dose—the nearer the radiation dose approaches 2 units, the lower the subsequent temperature needed to produce bubbling. Thus a radiation dose of only 0.1 unit is needed for bubbling to occur at a temperature of 140° C. This phenomenon is ascribed to the breakdown of the side-chains, releasing mainly carbon monoxide and dioxide and hydrogen. These are maintained under pressure inside the material until the temperature rise weakens the material sufficiently to allow bubbles to form.

An interesting observation is that bubbling does not occur within a distance of about 1 mm. from the free surface of a specimen. In this region 'Perspex' remains transparent, and tough. The expanded material therefore consists of an internal network of bubbled material surrounded by a thin and tougher coat. To explain the losses of weight observed in 'Polythene' on irradiation², it was necessary to assume that certain gases produced by radiation can only escape from the polymer if they are liberated within a small distance from the surface. In the present work on polymethyl methacrylate, this assumption has been justified. Thus a specimen irradiated for 1.1 units, and afterwards heated for a short time to produce a small amount of bubbling, had a 'free zone' (without bubbles) about 1 mm. in thickness and following the surface contours. This free zone is not due to some form of low-penetrating radiation nor to the presence of oxygen. The assumption of diffusion over a limited distance must therefore be accepted.

The same effect has been produced by irradiation with pure gamma-radiation from a cobalt-60 source. Fig. 1 shows a rod of 'Perspex', irradiated in a non-uniform γ -flux, and afterwards heated to produce bubbling. The end of the rod subjected to the highest



radiation dose shows considerable expansion, whereas the opposite end is apparently unaffected. If the radiation takes place at 20° C., considerable doses can be absorbed without any obvious effects on the specimen. If it is then left standing for several months, intense cracking appears in the specimen, but no bubbling (Fig. 2). It would therefore appear that temperature above the second-order transition is needed for large-scale gas diffusion to take place.

One may perhaps envisage irradiated 'Perspex' being used as a heat-insulating material. Small blocks of the polymer can be placed inside a vessel and, by heating, expanded *in situ* to give a bubbled material filling the required volume.

Fuller details will be published elsewhere³.

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¹ Charlesby, A., *Nature*, **171**, 167 (1953).

² Charlesby, A., *Proc. Roy. Soc., A*, **215**, 187 (1952).

³ Ross, M., and Charlesby, A., *Atomics* (in the press).

'After-effect' in Aqueous Solutions of Deoxyribonucleic Acid irradiated with X-Rays

It has been known for some time that the irradiation of aqueous solutions of deoxyribonucleic acid with X-rays leads to a loss of viscosity¹. However, apart from any drop in viscosity during the irradiation, it has been observed by several workers^{1,2} that there is also an 'after-effect' in these solutions, namely, a slow decrease of viscosity which continues for some time after the actual irradiation.

Although recent work³ has to a large extent clarified the nature of this after-effect, a certain amount of confusion still exists with regard to its extent under different experimental conditions. Butler and Conway² have stated that the after-effect is only observed when molecular oxygen is present in the solution during the irradiation, and they have suggested that the effect is due to a slow decomposition of a peroxidic derivative of the deoxyribonucleic acid which is formed by the HO₂ radicals present under these conditions. At first these authors concluded that the substance formed was similar to a dialkyl-peroxide. However, in a subsequent