The odd ions formed in these processes should exhibit paramagnetic resonance, and this has been found to be the case[2]. These coloured plastics are therefore solid systems, in which one has some control over the nature and number of the electron trapping sites. At the same time, the velocity of the thermal back-reaction is sufficiently small to permit accurate observation. The effect may be related to the increased conductivity[3] and fluorescence of plastics under irradiation[4] previously reported. It seems, therefore, that these systems might yield useful information on electron capture processes in solids. Further experiments on the chemical and physical aspects are in progress.

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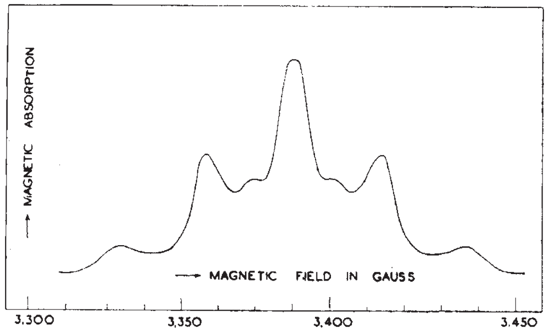
Paramagnetic Resonance

USING the sensitive micro-wave apparatus described recently[1], operating at 9,500 Mc./sec., sharp paramagnetic resonance spectra have been obtained with a number of plastics after irradiation in a 200-kV. X-ray therapy set. The main experiments have been carried out with specimens (2 cm. diameter × 0·3 cm.) of coloured polymethylmethacrylate ('Perspex')[2] and of clear uncoloured 'Perspex'. The observed intensities and widths of the resonance absorptions and their increase with X-ray dosage, which was varied between 10^5 and 10^7 roentgens, are in accordance with the assumption that the magnetic centres are electrons produced as the result of irradiation and trapped in the plastic lattice.

The structure of the resonance is the same for both types of specimen, consisting of a central peak symmetrically surrounded by a number of satellites (see graph). There is, however, a marked difference between the coloured and clear 'Perspex' in the position of the resonance spectra, providing evidence of differences in the nature of the trapping sites. In the coloured specimens the centre of the resonance lies at a magnetic field corresponding to a g-factor within 0·1 per cent of the free spin value, whereas in the clear 'Perspex' the resonance pattern is shifted down-field by some 20 gauss ($g = 2{\cdot}014$), indicating interaction of the trapped electrons with surrounding atoms. The symmetry of the resonance pattern of the dyed 'Perspex', in which no trace of the displaced clear 'Perspex' lines is detectable, suggests further that the presence of the dye molecules provides electron traps which are considerably deeper than those in the plastic host lattice. Other results point to the same conclusion, such as the stability of the trapped electrons in the dyed as compared with the undyed specimens shown by resonance experiments at long periods after irradiation, and the less severe competing effect of oxygen demonstrated by resonance observations at small X-ray doses with specimens of varying oxygen content. It should be noted that the electrons captured by oxygen molecules, and the positive holes, that is, the sites in the plastic lattice which have lost electrons during irradiation and consequently have unpaired electron spins, are assumed to produce no resonance effects detectable with the present apparatus. With this qualification the resonance experiments have gone far in supporting the arguments on the effects of X-rays on plastics presented in the preceding communication as the result of optical measurements.



Magnetic resonance spectrum of irradiated 'Perspex'

The remarkable fine structure of the paramagnetic resonance of the observed resonance spectra is of even more general interest, since it appears to reflect characteristic properties of the structure of plastics. In the 'Perspex' resonances obtained at small X-ray dosage, lines are detectable at ± 12 and ± 46 gauss from the centre, besides the main satellites at ± 25 gauss. Resonances having a similar pattern have been observed with irradiated polystyrene; here the main satellites are at ± 18 gauss. It is believed that the satellite resonances are caused by regularities in the spacing in the plastic lattice of the trapping sites for the magnetic units (electrons and possibly positive holes). Magnetic dipole interaction between neighbouring spins would thus lead to a non-random distribution of the internal magnetic field acting on the resonating electron spins. Considering only the effect of nearest neighbours and neglecting the statistics of their spatial distribution, a crude estimate of a characteristic minimum separation r_0 between adjacent spins can be obtained by identifying the field separation of the main satellites from the resonance centre with the internal field μ_0/r_0^3 produced by a single adjacent spin. The values for r_0 of 17 A. and 19 A. derived from the observed resonance spectra for polymethylmethacrylate and polystyrene respectively may be related to one of the regular 'identity periods' derived for the specific plastics from X-ray diffraction measurements[3].

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