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Radiation Effect in Conducting Polymers

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RADIATION EFFECT IN CONDUCTING POLYMERS

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Abstract By the irradiation on conducting polymers under the coexistence of various substance like SF_6 and freon, electrical conductivity increases by many orders of magnitude, optical absorption spectrum changes drastically and also ESR linewidth decreases remarkably, which can be explained by radiation induced doping.

INTRODUCTION

We have already reported radiation effects on conducting polymers.[1,2,3] Conducting polymers are generally resistive to radiation. However, remarkable increase of conductivity is found by the irradiation on conducting polymers under the coexistence of SF_6 which is not effective as dopant by itself. In this paper, we will mainly discuss on this effect.

EXPERIMENTAL

Polyacetylene and polythiophene were prepared by methods already reported.[4,5] As radiation source, 1.8 MeV electron beam and γ-ray from ^{60}Co source were used. Details of experimental methods were already reported.[1,2,3]

RESULTS and DISCUSSION

Figure 1 indicates the in situ measurement of electrical conductivity of polythiophene under the irradiation of γ-ray. At first, conductivity slightly increases and then decreases again at higher dose of irradi-

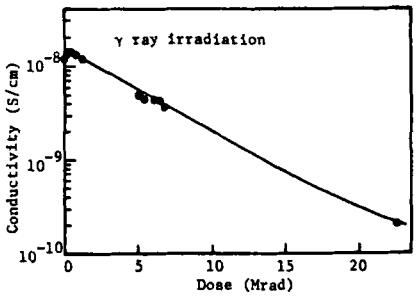

Fig.1 Irradiation of γ-ray on polythiophene in vacuum

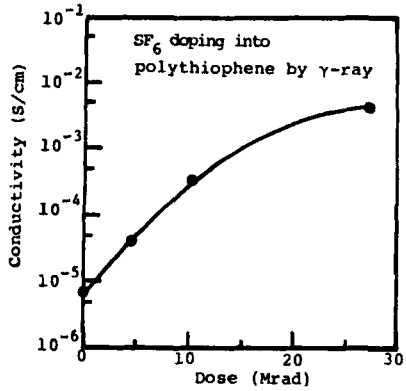

Fig.2 Irradiation of γ-ray on polythiophene under SF_6

ation. Similar effects are also observed in $(CH)_x$ and other conducting polymers by electron beam and γ-ray irradiations.

Irradiation effect of γ-ray and electron beam under the existence of SF_6 is much more remarkable as shown in Fig.2. Though SF_6 is not effective to enhance the electrical conductivity of conducting polymers by itself. Similar enhancement of conductivity was also observed by the irradiation under the coexistence of other substances, for example, freon gas.

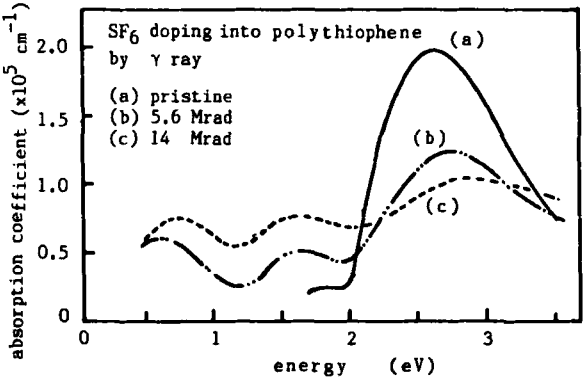

Fig.3 Absorption spectra of polythiophene irradiated with various dosages of γ-ray under SF_6 gas

Figure 3 indicates the change of absorption spectra of polythiophene by the irradiation of γ -ray (c). The curve (d) in this spectrum corresponds to the electrochemical doping of 15% (for example of BF_4). The weight up-take was also confirmed after the irradiation under coexistence of SF_6.

ESR spectrum of non-doped polythiophene does not change even by higher dose of irradiation (~150 Mrad), indicating that the conducting polymer is quite resistive to irradiation. On the other hand, by irradiation under SF_6 gas, it changes remarkably as indicated in Fig.4 and also summarized in Fig.5. By the irradiation, narrowing of ESR line width and the peak shift occure. The ESR spectral change by γ -ray irradiation of 90 Mrad nearly conincides with the electrochemical doping of around 2% of BF_4. These results can be explained

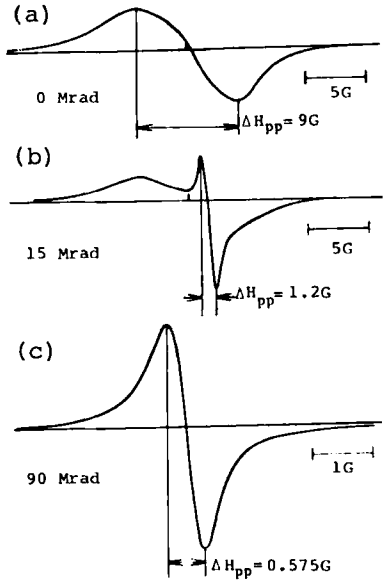

Fig.4 Change of ESR spectrum by γ-ray irradiation under SF_6 gas

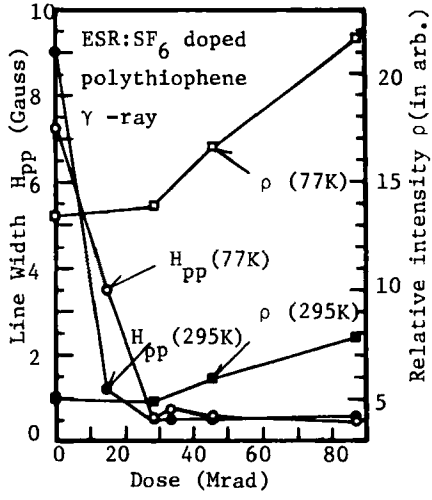

Fig.5 Dependence of ESR line width and intensity on dose (γ-ray irradiation in SF_6)

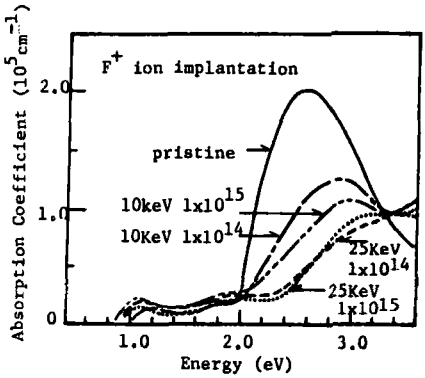

Fig.6 Spectral change of polythiophene by ion implantation

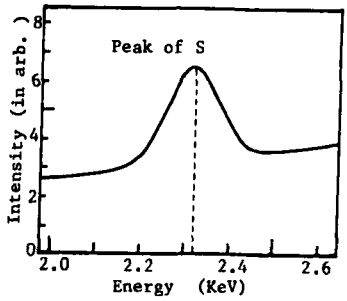

Fig.7 X-ray fluorescence analysis of (CH)x irradiated in SF_6 by Y-ray

in terms of the radiation induced doping. However, it is still not clear, whether SF_6 itself or some decomposed fragments are doped.

As indicated in Fig.6, the absorption spectrum of the sample implantated by F ion with the acceleration voltage of 10–40 kV shows some evidence of degradation, though slight doping also seems to proceed. Therefore, the doped spiece by radiation doping seems not to be only F ion from decomposition of SF_6.

Figure 7 indicates the X-ray fluorescence spectra obtained from $(CH)_x$ irradiated under SF_6. It is clear that S atom is also included in the polymer. Therefore, the dopant spieces should have structure of SF_n (n=1–6).

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