

RADIATION EFFECTS OF HIGH ENERGY ION BEAMS ON POLYSTYRENE —EMISSION SPECTRA—

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1. Introduction

Recently the interaction of ion beams with solid polymers has attracted attention in the aspect of their applications such as ion beam lithography, resist and surface modification. While we have been studying radiation effects of high energy ion beams on fundamental polymers in the aspect of the high density electronic excitation and linear energy transfer (LET) effects [1,2]. The chemical reactions in the polymers induced by ion beams are observed as chain scission, cross-linking, carbonization, ablation and sputtering. In these reaction processes, short-lived reactive intermediates such as electrons, ions, radicals and excited states play important roles. The mechanisms of these reactions, however, have not been cleared yet. In this paper we report on time dependent emission spectra from ion-beam irradiated polystyrene thin films in order to understand reaction mechanisms under the irradiation of various kinds of ion beams.

2. Experimental

A monodispersed polystyrene sample of molecular weights of 9000 was prepared and spin-coated on Si wafer with 0.5 μm thickness. 1.0 MeV H^+ and He^+ ions from a single-ended Van de Graaff accelerator of Research Center for Nuclear Science and Technology, University of Tokyo [2] were used for the irradiation on polystyrene thin films in a vacuum chamber ($<10^{-5}$ Pa) at room temperature. Emission spectra from polystyrene were measured by a time resolving optical multichannel analyzer (OMA) with the wavelength between 260 ~ 600 nm.

3. Results and discussion

Fig.1 shows typical emission spectra from polystyrene thin film obtained (a) after 300 seconds irradiation which corresponds to the ion fluence of $0.12 \mu\text{C}/\text{cm}^2$ and (b) after 5000 seconds ($2 \mu\text{C}/\text{cm}^2$) with 1.0 MeV H^+ ions. Two main peaks are seen in the measured range. One peak seen

around 328 nm is assigned to excimer fluorescence [4] and the other one can be observed around 500 nm which was found by our group for the first time [2]. The peak height of the latter emission grows up drastically as the irradiation time increases.

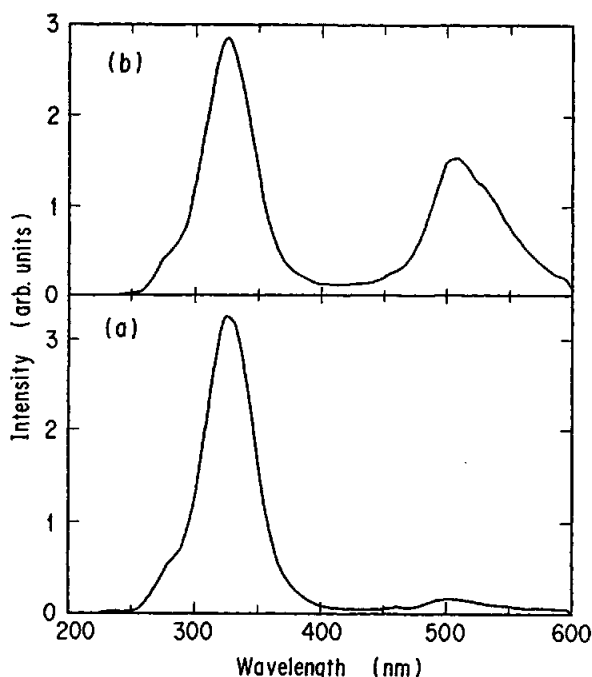


Fig.1 Emission spectra from polystyrene obtained after (a) 300 and (b) 5000 sec irradiation with 1.0 MeV H⁺ ions.

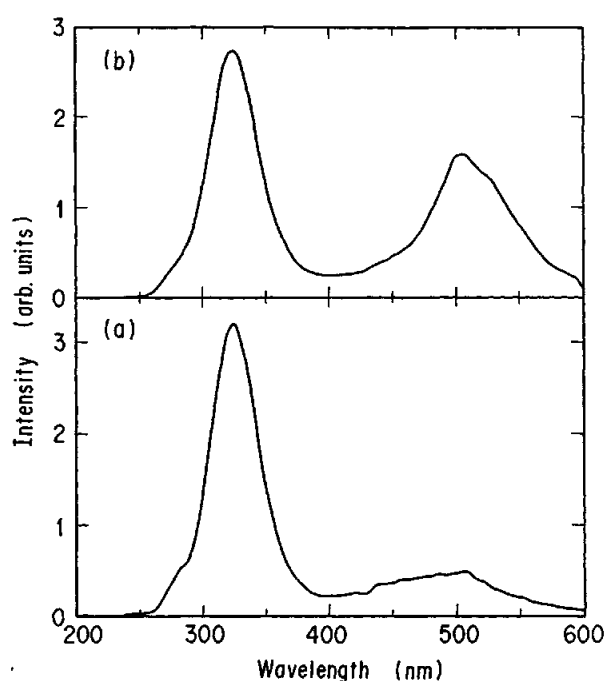


Fig.2 Emission spectra from the same sample of polystyrene exposed in the air for 12 hours. After 300 (a) and 5000 sec (b) irradiation with 1.0 MeV H⁺ ions.

Fig.2 shows emission spectra from the same sample used in the above experiment after 12 hours air exposure which were obtained after (a) 300 and (b) 5000 seconds irradiation. The peak height of 500 nm emission almost diminishes after the air exposure and increases to almost the same height as Fig.1 (b). As seen in Fig.2 (a), new emission bands around 450 nm can be observed after the air exposure. These phenomena may support that the emission around 500 nm is due to radicals produced by the ion irradiation.

References

1. Y.Aoki, N.Kouchi, H.Shibata, S.Tagawa, Y.Tabata and S.Imamura, *Nucl. Instr. and Meth.*, B33 (1988) 799.
2. N.Kouchi, S.Tagawa, H.Kobayashi and Y.Tabata, *Radiat. Phys. Chem.*, 34 (1989) 453.
3. N.Kouchi, Y.Aoki, H.Shibata, S.Tagawa, H.Kobayashi and Y.Tabata, *Radiat. Phys. Chem.*, 34 (1989) 759.
4. For example, W.W.Parkinson and R.M.Keyser, *Polystyrene and Related Polymers in The Radiation Chemistry of Macromolecules* Vol.II, M.Dole, Ed., Academic Press (1973).