Ion irradiation effects on polymer at solid/liquid interface

Tomohiro Kobayashi, Tokihiro Ikeda, Takao M. Kojima,
Kiyoshi Ogiwara and Yasunori Yamazaki

Atomic Physics Laboratory, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198 Japan

An ion irradiation system in liquid has been developed using a tapered glass capillary with a thin window at the tip. Irradiation at solid-liquid interface is quite interesting because it can be applied to surface modification processes or surface degradation tests. In this study, a polymer surface was irradiated with H^+ ions in water solution.

The capillaries were produced by pulling both ends of heated glass tubes. They have a lid of thin glass or polymer so that the irradiation can be performed in air or liquid (Fig.1). 3MeV H^+ ion beam is focused and guided by small angle scatterings with inner wall of tapered glass capillaries with inlet diameter of 800μm and outlet diameter of 10 – 200μm inserted in a liquid container (Fig.2). At the inlet of a capillary, the beam current density was typically 100 nA/cm^2. At the outlet, it was enhanced to about 10 μA/cm^2 by the focusing effect. The range of the 3 MeV H^+ ions in water after passing through the window was calculated to be 140 μm using the SRIM software. The liquid we chose to use was an aqueous acrylic acid (AAc, CH_2CHCO_2H) solution in concentrations between 0 to 10 wt%. Acrylic acid readily combines with itself or other monomers by reacting at its double bond site to form hydrophilic polymers. In this solution, polyethylene (PE) and polytetrafluoroethylene (PTFE) targets were irradiated with beam scanning by moving a sample stage.

Figure 3 shows an optical micrograph of the surface of irradiated PE in an aqueous acrylic acid solution at a concentration of 10 wt% with a scanning speed of 2 μm/s. The morphology of the irradiated area showed grafted monomers on the surface with the deposition of a flat hydrophilic layer. The irradiated surface showed good adhesion to the base polymers, as checked by rubbing the sample with a finger.

The microscopic FT-IR spectra of an irradiated region showed peaks attributed to poly-acrylic acid which is often used for a water-absorbing resin. Ion-beam-induced monomer grafting seems to be more effective on PE than on PTFE when comparing the peak heights of the deposits and the base polymers.

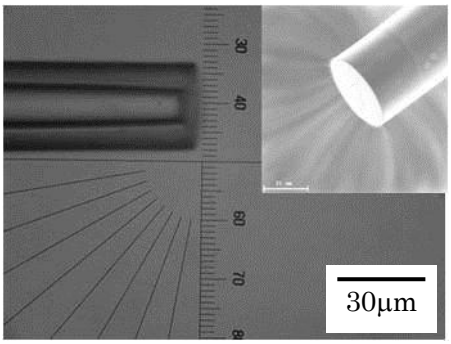

Fig.1 The end of glass capillary with a window

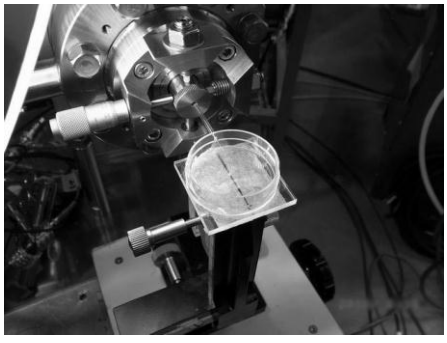

Fig.2 The glass capillary at the end of beamline inserted in a liquid container.

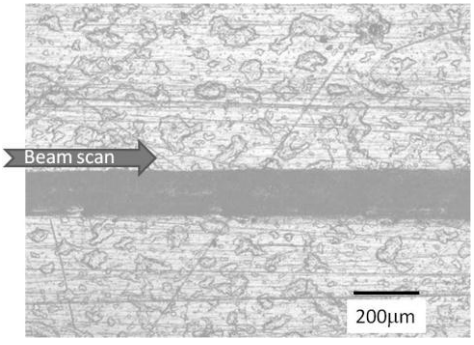

Fig. 3. A polyethylene surface irradiated in an aqueous acrylic acid solution with a scanning speed of 2 μm/s