Microstructural Characterization of Crazed Polypropylene Film by Scanning Electron Microscopy

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Application of crazed polymer films are expected in many fields, e.g. viewing angle-selective films, and nanobubble generators. Fig.1 shows a schematic diagram of a crazing device consisting of a film feed system, a tension control part, and a local bend processing part. A craze is induced in a polymer film owing to stress concentration at the tip of the edge (Fig. 1(a)), and then the Young's modulus of the section of the film, where the craze is induced decreases (Fig. 1(b)). Further crazing does not occur until the section, where a craze has been induced, moves away from the tip of the edge (Fig. 1(c)). Microstructures of the crazed films, especially pore size formed on the surface and inside of the films, has been unclear. In this study, the microstructural characterization of the crazed polypropylene films were carried out by a Hitachi SU8000 scanning electron microscope (SEM) at an accelerating voltage of 0.8 kV. SEM observation was performed without electro-conductive coating, so as to observe the original structures of the crazed polypropylene films. We have developed an original specimen stage in order to observe the film during the application of tensile stress, which simulates the crazing process.

Figure 2(a) shows a SEM image of a surface morphology of the crazed polypropylene film. Crazes are introduced at intervals of about 10-20 μm. Fig. 2(b) shows a higher magnification image of a ditch with approximately 300-500 nm width formed by the introduction of a craze. A lot of pores of the size of 10-20 nm are found on the ditch.

Figure 3(a) shows a SEM image of the cross-section of the crazed polypropylene film and (b) a higher magnification image. Many pores with a few 100 nm are visible in the cross-section, and they are connected from one side of the surface to the other. The size of the pores inside the film is bigger than that formed on the surface of the ditch. Therefore formation of nanobubbles in water should be concerned the size of pores formed on the ditch shown in Fig. 2(b), because the size of the nanobubbles occurring from the pores is proportional to the cube root of their diameter.

A SEM image of a polypropylene film surface applying tensile stress using the original stage is shown in Fig. 4. A crack is formed in the film and extensions of polypropylene fibers are confirmed inside the crack. After the film was released from the tensile stress, these fibers would be shrunken, so that the ditches with 10-20 nm pores were considered to be induced on the film.

Acknowledgement:

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References

[1] K. Naito et al., J. Appl. Polym. Sci. (2013)2307.
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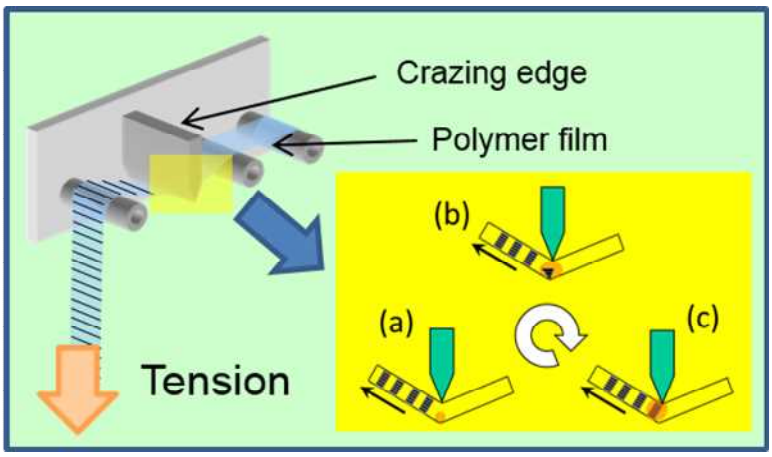

Fig. 1 Schematic diagram of crazing process. The crazing device consists of film feed system, tension control part, and local bend processing part. (a) A craze is induced owing to stress concentration at the tip of the edge. (b) Young's modulus of the section of the film, where craze is induced, decreases. (c) Crazing does not occur until section, where craze has been induced, moves away from the tip of the edge.

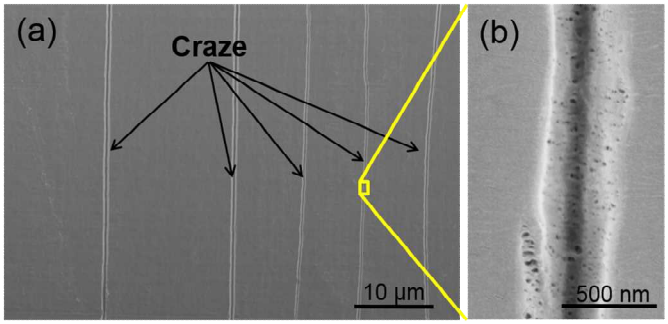

Fig. 2 SEM images of crazed polypropylene film surface. (a) Low magnification image and (b) high magnification image.

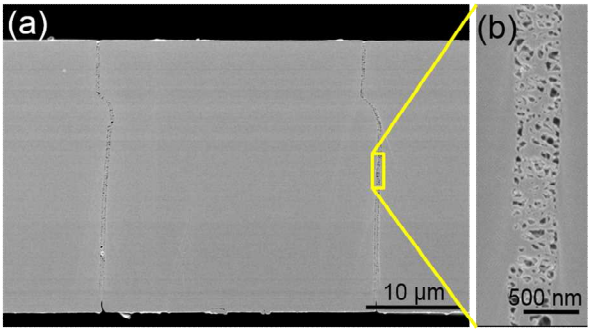

Fig. 3 SEM images of cross-section of crazed polypropylene film. (a) Low magnification image and (b) high magnification image.

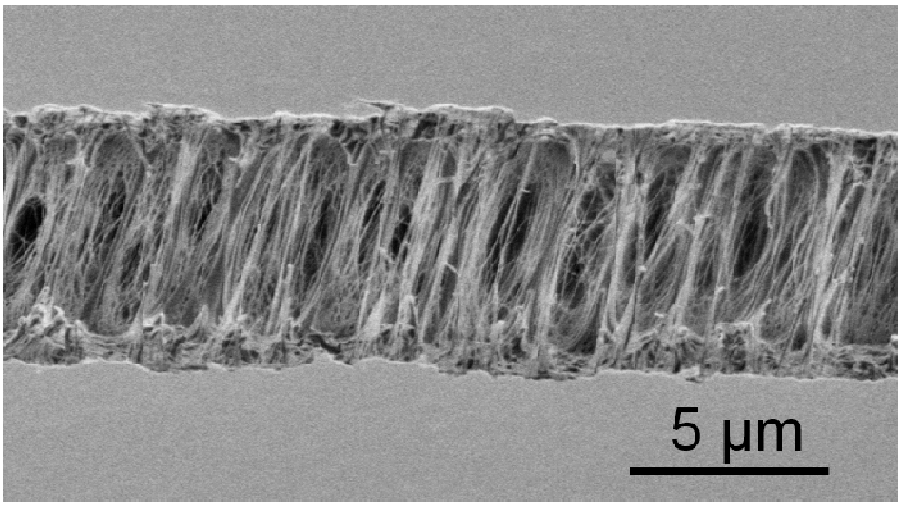

Fig.4 SEM image of polypropylene film surface during applying tensile stress using original stage.