Draw characteristics of all aromatic copolyester melts in Electrospinning

Takashi Eguchi, Yoshiaki Taguchi*, Hiroshi Ito, Yuji Jinbo,
Sathish K. Sukumaran, Masataka Sugimoto, Kiyohito Koyama
Graduate School of Science and Engineering, Yamagata University, Yonezawa, Yamagata, Japan
*Research and Development Center, Polyplastics Co., Ltd., Miyajima, Fuji, Shizuoka, Japan
eguchi@ckpss.yz.yamagata-u.ac.jp

1. Introduction

Electrospinning uses an applied potential difference to draw fine fibers from a liquid. Usually, the liquid from which the fiber is drawn is stored in a syringe fitted with a needle. When the fiber draw direction is horizontal a potential difference is necessary to draw the liquid from the needle tip and deposit the resulting fiber onto the collector plate. In some cases, this can be accomplished by gravity alone by changing the geometry of the set-up. Even in this case, a sufficiently high potential difference is necessary to establish a *continuous* liquid jet. Increasing the potential difference just increases the volume rate of flow out of the needle tip. However, for certain all aromatic copolyester melts novel behavior is observed. For one of the melts, at a certain voltage difference, a continuous jet is established as expected. Surprisingly, upon increasing the potential difference beyond a certain value, the melt is not drawn but remains around the tip of the syringe for several seconds after the voltage is switched on. More interestingly, the melt is then drawn out of the tip for a centimeter or two but then the liquid jet suddenly stops in mid-flight and recoils back into the syringe. To the best of our knowledge, such behavior has hitherto not been reported.

2. Experiment

We used two different all aromatic copolyesters D950 and A950. A950 is similar to commercially available all aromatic copolyesters but at roughly half the molecular weight. D950 is a specially formulated resin. During electrospinning, the tip to collector distance is fixed at 5cm. D950 was spun at 360^{o}C and A950 at 320^{o}C. Under these spinning conditions, both the polymers have almost identical viscosities. The structure of the produced fiber was characterized using Small Angle X-ray Scattering (SAXS).

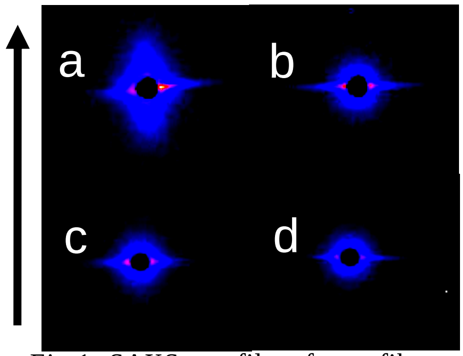

Fig.1 SAXS profiles from fibers fabricated at 0kV/cm – D950 (a), A950 (b); at 2kV/cm - D950 (c), A950 (d). Arrow: fiber direction.

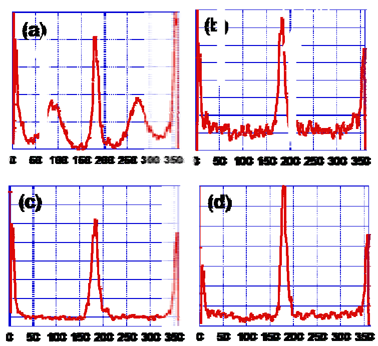

Fig2. Azimuthal intensities extracted from the data shown in Fig. 1.

3. Results and Discussion

Electrospinning:

At electric field strength of 4kV/cm, a continuous liquid jet was observed from both D950 and A950. When the applied voltage is higher than 6kV/cm, a continuous jet is still observed from A950. However, for D950 after switching on this potential difference, the melt remains around the tip of the syringe for several seconds. It is then drawn out of the tip in a continuous filament for about two centimeters but then swiftly recoils back into the syringe.

Domain Structure: SAXS profile:

Figure 1 shows the SAXS profiles obtained from D950 and A950 fibers for two different applied voltages. At 0kV/cm, both A950 and D950 fibers have strong streaks along the horizontal direction, see Figure 1(a), (b). The strong horizontal streaks suggest that nanoscale structures oriented along the fiber axis exist. If we remove this strong streak, then the remaining intensity is essentially isotropic in the case of A950, but there is strong anisotropy due to the scattered intensity being almost diamond shaped for D950. At 2kV/cm, the scattering profile for A950 shows very little change from the 0kV/cm case but the D950 profile appears less anisotropic and the scattered intensity is significantly weaker at the higher-q values, see Figure 1(c), (d). Further work will involve understanding the origin of these scattering patterns in terms of the fiber structure and determining the quantitative characteristics of the fibers from their scattering curves.