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Short Communication

Fabrication and Properties of Elastomeric Yarn from Poly (Ether Ester) Staple Fiber by Ring Spinning

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Abstract

In order to produce elastomeric yarns, elastomeric staple fibers must be fabricated first. For this reason, it was to try utilizing several kind of poly (ether ester) with different structures to obtain staple fibers with different elasticity by using the melt spinning. It was found experimentally that the elasticity of poly (ether ester) staple fibers was too high to be processed by ring spinning machine. Only in the case where poly (ether ester) and poly (butylene terephthalate) were blended and then processed by melt spinning, the obtained fibers with low elasticity could be processed normally to make elastomeric yarns with ring spinning machine. It was shown that the elastomeric yarn could be fabricated successfully by the ring spinning technology.

Keywords: Poly (ether ester); Elastomeric staple fiber; Elastomeric yarn; Ring spinning

Introduction

So-called poly (ether ester) or poly (ester ether), shortly PEE, is one of block copolymers composed of soft and hard segments, which are polyether and polyester, respectively. The most important poly (ether ester) is 4GT/PTMEG (1000)T copolymers. This kind of segmented copolymer has been known for almost 70 years from Coleman [1]. In the 1970s the developments led to commercial production of copolymer ether-ester by du Pont, Toyobo and Akzo. However, 4GT/PTMEG (1000)T copolymers are usually used as thermoplastic elastomers. Generally speaking, the production of fiber is much more complicated than that of plastics and rubbers, so the report of industrial production of fiber from them is very rare. Many papers, for examples [2,3] have been published on the manufacture of filaments on a laboratory scale, but few have been published on the manufacture of staple fibers from them. The only exception was the author's own recent article [4].

Our research plan is to make elastomeric yarn from elastomeric staple fibers, so we must use spinning machine. At present, ring spinning machine is the most widely used spinning machine in the textile industry. According to statistics, the global textile industry still has 250 million ring spinning spindles, and the production capacity accounts for about 80% of the entire spinning market. This most traditional spinning is still the most common technology [5].

Based on the reports in the literature [6], the mechanical properties of various textile fibers vary widely, whether natural fibers or chemical fibers.

However, the variation has a certain range: the tensile stress at break is 1-6cN/dtex, and the tensile elongation at break is 2-50%. These indicators are very important for the textile

processing process and the end application. For example, ring spinning is basically suitable for the spinning process of most textile fibers, and requires only minor adjustments for different materials. On the other hand, it is well known that the basic mechanical properties of rubber filaments, spandex and other elastomeric fibers are completely different compared to the common fibers mentioned above. In principle, elastomeric fibers have low strength (<1cN/dtex), large elongation (>300 %), high elastomeric recovery, and very coarse single fiber fineness (>10 dtex), even if they can be cut into staple. As you can imagine, it is a difficult task to make elastomeric yarn from elastomeric by the traditional ring spinning machine. This work intends to explore the above assumption experimentally.

Experimental Result

Manufacture of PEE-PBT elastomeric staple fiber

PEE-PBT blend elastomeric staple fibers were fabricated in the fiber material platform including equipments of drying, melt spinning, stretching, drying and cutting processes. The supplier of several PEE chips was the First Fiber Co. Limited. The main mechanical properties of PEE elastomeric fibers produced by their PEE chips are listed in Table 1.

Table 1: Main mechanical properties of elastomeric fibers.

Type	Tenacity (g/d)	Elongation at Break (%)	Elastic Recovery (%)			
			Elongation at 10%	Elongation at 20%	Elongation at 40%	Elongation at 100%
High Elasticity	0.80-1.5	200	100	100	99	98
Middle Elasticity	2.5	100	100	100	99	——
Low Elasticity	2.8-3.0	40	100	99	——	——

It was shown experimentally that the elasticity of the above fibers is too large to pass the carding process, so they cannot be processed by ring spinning machine. In this way, we must make staple fibers with lower elasticity suited to the ring spinning. According to our previous experimental experience, one simple way was to blend PEE and poly (butylene terephthalate), shortly PBT, and then process the blend with melt spinning. The obtained fibers with low elasticity could be suited to the ring spinning machine.

The raw materials of this PEE and PBT were chips of low elasticity and PBT chips. For PEE chips, the characteristic viscosity [η] = 1.3dl / g, melting point 214.7 ℃, provided by First Fiber Co. Limited. For PBT chips of Jiangsu Yizheng Company, the characteristic viscosity [η]=0.98 dl/g, melting point 223.4 ℃. The adopted mass ratio of PEE to PBT was 1:3. The technical parameters of the melting spinning were as follows: 100L vacuum drum dryer at 160 ℃ dried for 9 hours, the water content less than about 40ppm, and then through a single screw (Φ50mm) melt spinning machine (1250 hole round hole type spinning plate), the melt temperature during the spinning 245 ℃. After spinning seven roll drawing test line, crimping machine, relaxation dryer, and fiber cutting machine were used for the further processing.

The main mechanical properties of the elastomeric fiber were as follows: the fineness 2.03dtex, the tenacity 3.20cN/dtex, and the elongation at break 64.3%, and the elastic recovery at 10% elongation100%.

Manufacture of PEE-PBT elastomeric yarn

In order to fabricate the elastomeric yarn from PEE-PBT elastomeric staple fiber, the technology of basic spinning process of cotton yarns was utilized, including Blowing, Carding, Drawing, Frame Roving, and Ring spinning. The above processes were realized by the following machines: A076H Cotton Cleaning Machine, FB218 Cotton Carding Machine, FA304 Carding Machine (3-Way Mixing), A450C Roving Machine, FA506 Spinning Machine, and ESPERO-M Winder.

The appearance of obtained elastomeric yarn is shown in Figure 1. The main mechanical properties of the elastomeric yarn were as follows: the fineness 229.2dtex, the tenacity 1.64cN/dtex, and the elongation at break 23.3%, and the elastic recovery at 10% elongation 99%. Its stress-strain curve and elastic recovery curves for the initial elongation at 20% are shown in Figure 2&3, respectively.

Figure 1: The appearance of obtained elastomeric yarn.

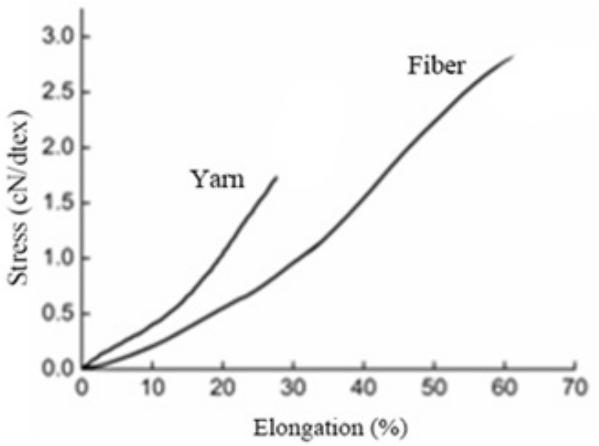

Figure 2: Typical Stress-strain curves of elastomeric fiber and yarns.

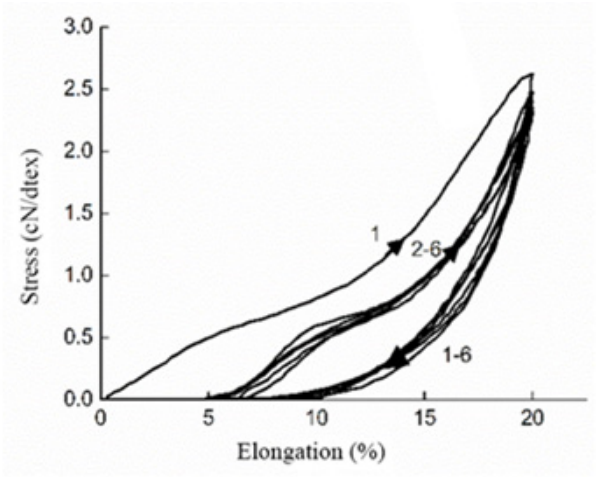

Figure 3: Elastic recovery of elastomeric yarn for the initial elongation at 20%.

Conclusion

The experiment of this work shows that elastomeric yarns can be produced by ring spinning machine with appropriate elastomeric staple fibers as the raw material. The main mechanical properties of the elastomeric fiber are as follows: the fineness 2.03dtex, the tenacity 3.20cN/dtex, and the elongation at break 64.3%, and the elastic recovery at 10% elongation100%. The main mechanical properties of the obtained elastomeric yarn obtained are as follows: the fineness 229.2dtex, the tenacity 1.64cN/dtex, and the elongation at break 23.3%, and the elastic recovery at 10% elongation 99%. However, the elastomeric staple fibers with a higher elastic recovery than that of the above staple fibers cannot be operated by this traditional ring spinning process.

Acknowledgement

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