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Review Article

Reviewing the Production Process, Physical and Chemical Properties of Spandex Fibers

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Abstract

The aim of this paper is to review the production process, physical and chemical properties of spandex fibers. Elastic fibers have the capability to introduce the stretching behavior on cloths. Stretching characteristic enhance the welcoming properties on cloths such as comfort properties, flexibility and fittings. Sports industries are directly dependent on the elastomeric fibers. The excellence of spandex fibers has recurrently enhanced since they were first produced. Different sphere of research aided to continue their development. Experts found that by exchanging the starting pre-polymers they could progress fibers those have enhanced elastic behavior. Other physiognomies can be developed by using diverse pre-polymer ratios, better substances, and several plasters. In adding to spandex fiber developments, it is probable that progressive fabrics will be manufactured which include spandex fibers with conservative fibers. New methodology can be developed to focus on the production process to manufacture elastic fibers of enhanced characteristic. Further research can develop the quality and production process of spandex production.

Keywords: Spandex fibers; Elasticity; Comfort properties; Stretching behavior; Melt technique; Pre-polymer; Monomer

Introduction

There is a great importance of this paper in the spandex clothing industries. Spandex has a destructive influence on the environment. This influence is not as distinct as the negative impression of other types of artificial fabrics, but it is surely present, and at this point, no possible solutions have been recommended to curb the environmental deprivation caused by spandex fabric [1]. If only the manufacturing approaches used to make spandex are measured, then this fabric does not seem to have a meaningfully harmful effect on the environment [2].

Definite synthetic resources, such as nylon, are openly resulting from non-renewable properties like coal and petroleum oil, but spandex is made completely from substances that are manufactured in lab backgrounds [3]. The manufacture of spandex is, therefore, highly energy exhaustive, but if renewable dynamism sources are applied to make the pre-polymers that this fabric contains of, this delinquent can be resolved [4]. There's an opportunity that the same health matters that workers meeting in the manufacture of polyurethane are met in the manufacture of spandex, but no investigation has been done into this topic [5]. Figure 1 shows the raw materials of spandex fibers.

Moreover, it's likely that isocyanates, which are poisonous substances usually found in polyurethane, may also be existing in spandex, but there is no strong suggestion that this is the circumstance [6]. The distinguished environmental influence of spandex comes into play only after it is wholesaled to customers. It has been unwavering that 60 out of a hundred the garbage in US. watercourses is collected of non-biodegradable textile strands, and spandex clothes and fibers structure a large share of this excess [7].

Straight if spandex is likely of correctly in landfills or other chosen trash removal areas, tiny fibers of this material are presented into the watercourses whenever spandex cloths are washed, which troubles marine life, decreases drinking water excellence, and eventually donates to the huge garbage isles that are progressively accruing in the world's mountains [8]. Spandex and other non-biodegradable materials will be about long after humanoid development has decease the earth, and at this time, there are no recognized approaches for changing spandex fabrics and like resources into recyclable materials [9].

Harmless removal and incomplete washings are the only ways to alleviate the environmental influence of this fabric. Even when dissimilar manufacture approaches are applied to make spandex, the end consequence is chemically the similar [10]. Though, misperception can follow owing to the dissimilar footings that are applied to define this fabric. Spandex is not a symbol, and it is, actually, an anagram of "grows." Spandex was not ever planned to be the main term applied to mention to spandex fabric, but the tenure wedged in the customer mind, and maximum people now mention to this textile materials with this term [11].

Most Europeans people apply the term of Elastane for referring this type of stretched fabric. Elastane is the best chemically precise way of mentioning to this fabric [12]. Lycra is a recorded trademark of the DuPont Company [13]. Merely, spandex made by DuPont can be named Lycra, but this fabric is chemically indistinguishable to cloths that are named spandex or Elastane, and it has the similar qualities. Spandex is a artificial fabric that is valued for its elasticity [14].

Conflicting to popular trust, the term "spandex" is not a product name, and this word is used to usually refer to polyether-polyuria copolymer cloths that have been made with a diversity of manufacturing techniques [15]. The words spandex, Lycra, and

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Figure 1: Raw materials of spandex fibers.

elastane are identical or nearly equal. This fabric can spring to 5-8 times its usual size, and it is normally used in form appropriate to customer attire [16]. In most stages, unalloyed spandex isn't applied in garments, and in its place, small amounts of this fabric are woven into other artificial, semi-synthetic, or biological fibers [17].

The base substances used to produce spandex is polyurethane, which was invented in 1937 by IG Farben in Germany [18]. At the finish of World War II, hundreds of top German experts instigated new vocations in the United States, and numerous of the textile experts at IG Farben moved to the DuPont Company, which was the era's undisputed leader in artificial textile expansion [19].

Production Process of Spandex Fibers

Spandex fibers are created in several ways such as melt extrusion, solution dry spinning, reaction spinning and solution wet spinning technique [20]. These techniques include the first step of reacting monomers to make a pre-polymer [21]. After that, the pre-polymer is responded to subsequent, in numerous behaviors, and haggard out to yield a long fiber. As, solution dry spinning is applied to make over 90% of the earth's spandex fibers, it is labeled [22].

The production process of elastomeric fibers comprises several steps. The first stage creates the pre-polymer by mingling di-phenyl-methane di-iso-cyanide monomer with micro polyester in a reaction container [23]. After that, the pre-polymer is responded to a di-amine of equivalent quantity [24]. The substance is then combined with a solvent to thinned it and provide it a spiraling motion [25]. Afterward weakening into a stripper solution, it's then impelled into the fiber manufacture chamber. Figure 2 shows the spandex chemical structures.

The revolving elucidation goes to a tubular revolving cubicle. It's then enforced to a metallic salver named a spinneret. It's preserved and twisted into fibers [26]. The elements are intended in the attendance of nitrogen and solvent blast. By this technique, the fluid polymer is responded to chemically and solidary elements [27]. These solidary elements are shoved to custom fibers of the preferred width as they departure the booth. A solitary fiber is prepared up of several lighter discrete fibers [28].

The subsequent fibers are pickled with a polymer like as magnesium stearate to avoid the fibers from jabbing [29]. When the coils are occupied with fiber, they are placed into concluding wrapping and transported to textile producers and other clients [30]. Now, the fibers may be interlaced with other fibers like as cotton or nylon to make the cloths that is used in apparel production [31]. This

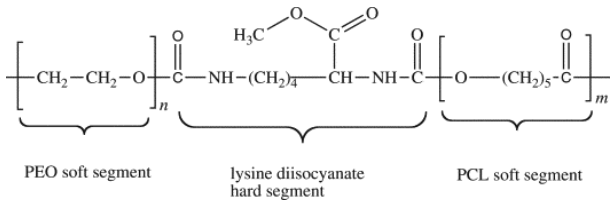

Figure 2: Spandex chemical structure.

cloth can also be colored to fashion different shades. High elasticity is possible to get using these fibers into cloths [32]. Figure 3 shows the clothing made up of spandex fibers.

Properties of Spandex Fibers

Spandex fibers are known for its excellent elasticity [33]. It is created with a long chain polymer named polyurethane that is formed by reacting polyester with a di-iso-cyanide. Spandex fibers have better resistance to temperature and oil in compare to rubber like plastics [34]. Spandex fibers and yarns both have the physical and chemical properties those are discussed below [35].

Physical properties of spandex fibers

Physical properties comprise the most common properties like strength, elasticity, durability, shrinkage, heat conductivity etc.

Strength: Strength is an important parameter of these spandex fibers. If the materials of the spandex are well organized then the property of strength can be easily attained [36]. Fiber does not touch the breaking point till after the fiber has been stressed to its extreme stretch [37]. This point is not typically extended in overall use and attire [38]. The great elasticity of elastane fibers further enhances to their resilience [39]. The scrape resistance of the numerous spandex fibers is decent, thereby subsidizing to their good clothing features [40].

Elasticity: Elasticity is an important parameter of the spandex fibers. It is the major physiognomies of fiber along with its stock power [41]. These fibers can be overextended up to 800 percent which is nearly 8 multiple times then tranquil state before flouting [42]. If the spandex internal materials are well organized then this property is attained.

Shrinkage: Spandex fibers are not affected in water but they are sensitive in temperature [43]. If these fibers are submerged in hot water, shrinkage may occur due to thermal shrinkage. But in normal water or in cool water, these fibers are not affected while washing [44].

Growth: Spandex fibers have the property of growth that most elastic fabric poses [45]. Due to stretching, these fabrics are often seen to be extended which is related to growth. Actually, the average area or length of the fabrics is seen to be extended than its original length due to stretching which is related to growth [46].

Effect of temperature: Temperature has direct consequences on the spandex cloths [47]. Over temperature may cause damage to the cloths [48]. Heat often creates thermal shrinkage which is injurious to the elastic cloths. Spandex cloths sticks at 350°F and melts at 350°F.

Consequence of sunlight: Sunlight does not directly hamper spandex cloths but if heat creates then the fabrics may be discolored

Figure 3: Clothing made up of spandex fibers.

[49]. Sometimes sunlight causes slight thermal shrinkage but it is negligible. Spandex cloths should be given to the normal condition for drying but not in the direct contact of sunlight to dry [50].

Resistance to mildew: Spandex fibers have very good resistance to mildew and microorganism [51]. Fungus cannot do any harm to spandex cloths. Spandex cloths are naturally resistant to such molds [52].

Resistance to insects: Spandex cloths have good resistance to insects. Insects, pests and other creatures cannot do any harm to the elastic cloths [53].

Spandex cross-section: Spandex fibers have the linear density of filaments sorts from 0.05 Tex to 3.00 Tex in the unit of g/km [54].

Spandex density: Spandex fibers density may vary from 1.10 to 1.35 g/cc [55].

Moisture Regain: The moisture regain of spandex fibers may varies from 0.7% to 1.3% [56].

Length: Spandex fibers are filaments and can bear any length it wants like 1km to 10km [57].

Color: Spandex fibers are while or nearly white colors. Some spandex fibers have bright look but some are dull look [58].

Luster: Spandex fibers are lustrous but some are dull look [59].

Flammability: Spandex fibers are elastic so it burns quickly. Spandex cloths should be kept away from flame [60].

Electrical conductivity: Spandex fibers expose lower electrical conductivity. Spandex fibers are not damaged in any conductive radiation [61].

Breaking tenacity: Spandex fibers have the breaking tenacity of 0.5g/denier to 1.0 g/denier [62].

Elongation: Spandex fibers can be elongated up to 800 times than its original length [63].

Elastic Recovery: Spandex fibers have excellent elastic recovery [64].

Tenacity: Spandex fibers have the tenacity of 0.5 Tex to 1.0 Tex [65].

Surface: Spandex fibers have very smooth surface [66].

Chemical properties of spandex fibers

Spandex fibers have the common chemical properties like behavior in acidic and alkaline solution, resistance to oxidizing and bleaching agents etc those are discussed below [67].

Resistance to oil: Spandex cloths have very good resistance towards any types of organic or chemical oils. Normal body oil cannot hamper spandex cloths [68].

Resistance to perspiration: Spandex fibers have good resistance to perspiration. Normal body sweat or secretion cannot hamper spandex cloths [69].

Response to alkali solution: Spandex fibers are slightly hampered in alkaline solution. Spandex fabrics should be kept away from such types of alkaline condition. Spandex fibers are damaged heavily in alkaline solution with high temperature [70].

Response to acid solution: Elastic cloths have petty resistance to acid solutions. Spandex cloths submerged in acidic solution may cause discolor. But, it is wise to keep away the spandex cloths both from acid and alkaline solution [71].

Attraction to dyes: Spandex fabrics have good attraction to some dyes like disperse, acid, chrome, etc but spandex dyes are inactive in reactive dyes. Spandex cloths may respond in reactive dyes if it is cored with cotton yarns [72].

Hygiene and wash ability: Spandex fibers are not influenced by dry cleaning strippers. These products are washable with machine by the normal domestic cleansers like soaps and detergents [73]. Heat of the water should be no more than 60°C, regarding to the specific spandex fibers use. Over heat might diminish the elasticity of the fibers and the materials it contains [74].

Consequence of bleaches: Spandex fibers have good response to bleaching reactions. Bleaching action can hamper the spandex fibers or elastic fibers or the content it has [75]. Most of the components are white with bright color; however the extent of whiteness differs. In some specific conditions, yellowing shade may be created. Fibers used in combination with elastane in the fabric can be changed upon the extent of bleaching [76]. Though, some spandex fibers vary in their reaction to bleaches. Fabrics contains spandex should avoid bleaching or conduct with mild bleaching [77].

Consequence of seawater: Spandex fabrics or the elastic fabrics are used to make swim wear. Swimmers often use their cloths to drive or swim in sea and of course spandex fabrics are not influenced by sea water [78].

Organic solvents: Spandex cloths have good resistance to organic solvents. They also have good resistance to dry cleaning agents [79].

After burning: After burning spandex fibers produce a gummy deposit. It sticks to the surface where it lays [80].

Iron temperature: Spandex fibers can be ironed in the heat of maximum 150°C. Over heat can spoil these fibers [81].

Dry cleaning: Spandex cloths are not damaged in dry cleaning or laundering. But laundering in machine may damage the spandex fibers [82].

Conclusion

It is seen from the paper that, the production process of spandex goes through several manufacturing systems. The performances of the elastic fibers depend on the manufacturing processes it showed. The physical and chemical properties of spandex fibers are dependent on the substances it covers. To guarantee the excellence of the spandex fibers, producers observe the product during each stage of manufacture. Examinations begin with the assessment of the inward raw materials. Numerous chemical and physical physiognomies are confirmed. For instance, the common properties like pH, viscosity, elasticity of the products may be tested. Moreover, look, shade, and scent can also be assessed. By having stern quality control checking on the substances can the producer is assured that they will create a reliable product. At last, the spandex fibers are examined of its all the physiognomies. These examinations may comprise those that assess fiber elasticity, flexibility and porosity. This paper opens possible ways for the scholars to further study in this filed.

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