

TITLE**MELT-SPUN THERMOPLASTIC POLYURETHANE FIBER AND FABRIC MADE THEREFROM****BACKGROUND OF THE INVENTION**

5 [0001] Crystalline thermoplastic polyurethane (TPU) materials can provide beneficial properties to extruded shapes, such as hose, tube, sheets, films, and filaments. For example, crystalline TPU materials generally have stronger wear and solvent resistance than their relatively low crystalline counterparts. Further, the crystalline TPU materials are generally easier to handle after the polymer melt exists the shaping die. This can provide increased productivity and better final product quality.

10 [0002] However, generally crystalline, thermoplastic polyurethane (TPU) materials have typically not been utilized in extrusion applications as the compositions are generally difficult to process or are even unprocessable as they crystallize and form conglomerates or chunks of solid matter in the extrusion process equipment. Furthermore, attempts to prevent crystallization by increasing the processing temperature have been unsuccessful, resulting in
15 heat-decomposed products. It would be desirable to have a crystalline TPU material that can be processed and made into articles by extrusion processes, such as extrusion spinning at high speeds without these drawbacks.

[0003] Prior art attempts to provide crystalline TPU that can be processed by extrusion methods have included adding a crystallization retarding components to the TPU to delay
20 the crystallization, thereby avoiding appreciable solid or crystallization in the extruder. This process was described in US Patent 6,995,231. It would also be desirable to have a crystalline TPU composition that can be extrusion processed without the need for adding additional chemicals to delay the crystallization.

25 [0004] TPU materials have been developed that are useful in hot-melt adhesive (HMA) compositions which are solid at room temperature, become tacky or sticky upon heating, and typically solidify rapidly at ambient temperatures to develop internal strength and cohesion. PCT Patent Application Publication WO2016/144676 describes such a TPU composition. TPU materials useful as adhesives are generally believed to not be suitable for extrusion

processes because of these properties. However, as these TPU may have useful properties for articles, it would be desirable to make articles from these TPU materials by extrusion.

[0005] The present invention provides a crystalline TPU material that can be extrusion processed to create extruded articles with improved properties.

5

SUMMARY OF THE INVENTION

[0006] The present invention relates to a melt-spun fiber and a fabric made therefrom, where the fiber comprises a thermoplastic polyurethane comprising the reaction product of poly(butanediol) succinate, a diisocyanate, and a chain extender diol. In one embodiment, the fiber is formed from a thermoplastic polyurethane composition comprising a soft segment
10 provided by a crystalline polyol component and a hard segment provided by a diisocyanate and a hydroxyl terminated chain extender. In another embodiment, the fiber is made from a thermoplastic polyurethane comprising at least 77.5 wt% poly(butanediol) succinate polyol and 15 wt% to 22.5 wt% of a hard segment, wherein the hard segment comprises the total wt% of the diisocyanate and the chain extender.

15 [0007] In another embodiment, the invention provides a fabric, wherein the fabric comprises a thermoplastic polyurethane fiber, wherein the thermoplastic polyurethane fiber is formed from the reaction product of at least 77.5 wt% poly(butanediol) succinate polyol and 15 wt% to 22.5 wt% of a hard segment, wherein the hard segment comprises the total wt% of the diisocyanate and the chain extender diol.

20 [0008] These various embodiments are described in more detail below.

DETAILED DESCRIPTION OF THE INVENTION

[0009] The features and embodiments of the present invention will be described below by way of the following non-limiting illustration.

25 [0010] The disclosed technology includes a melt-spun fiber comprising a thermoplastic polyurethane ("TPU") composition. The TPU composition useful in making the melt-spun fiber of the present invention comprises a "soft segment" and a "hard segment" where the soft segment is derived from a polyol component and the hard segment is derived from is the reaction product of a diisocyanate component and a hydroxyl terminated chain extender. The
30 invention also includes a fabric made including the fiber described herein. Each of these components will be described in more detail below.

[0011] As used herein, weight average molecular weight (Mw) is measured by gel permeation chromatography using polystyrene standards and number average molecular weight (Mn) is measured by NMR end group analysis.

Thermoplastic Polyurethane

5 [0012] The TPU compositions useful in making the melt-spun fiber of the present invention includes a polyester polyol component, which may also be described as a hydroxyl terminated intermediate. In the present invention, the polyol component comprises or consists of a poly(butanediol) succinate polyol.

[0013] Polyester polyol intermediates may be produced by (1) an esterification reaction
10 of one or more glycols with one or more dicarboxylic acids or anhydrides or (2) by transesterification reaction, i.e., the reaction of one or more glycols with esters of dicarboxylic acids. Mole ratios generally in excess of more than one mole of glycol to acid are preferred so as to obtain linear chains having a preponderance of terminal hydroxyl groups. For the present invention, the poly(butanediol) succinate is a polyester polyol prepared by the reac-
15 tion of succinic acid with butandiol (e.g. 1,3-butanediol or 1,4-butanediol). The succinic acid used to form the polyester may be derived from biomass resources, petroleum resources, or mixtures thereof.

[0014] In one useful embodiment, the poly(butanediol) succinate may have a number average molecular weight of about 1000 g/mol to about 3000 g/mol, or about 1500 g/mol to
20 about 2500 g/mol, or about 1800 g/mol to about 2200 g/mol, or even about 2000 g/mol.

[0015] In the thermoplastic polyurethane composition used for preparation of the fiber of the present invention, the thermoplastic polyurethane comprises at least 77.5 wt% poly(butanediol) succinate. In another embodiment, the thermoplastic polyurethane comprises 82.5 wt% to 85 wt% poly(butanediol) succinate. In one embodiment, the soft segment of the thermoplastic polyurethane consists essentially of or consists of poly(butanediol) succinate. In
25 some embodiments, only trivial amounts (e.g. less than 5 wt%, or less than 3 wt%, or even less than 1 wt%) of polyols other than poly(butanediol) succinate may be included in the thermoplastic polyurethane of the present invention.

[0016] In addition to the poly(butanediol) succinate containing soft segment, the thermoplastic polyurethane used in the present invention also includes a hard segment which is
30 defined as the combination of a diisocyanate component and a chain extender component.

[0017] The diisocyanate component may comprise one or more diisocyanates. Suitable diisocyanates include aromatic diisocyanates, aliphatic diisocyanates, or combinations thereof. In some embodiments, the polyisocyanate component includes one or more aromatic diisocyanates. In some embodiments, the polyisocyanate component is essentially free of, or even completely free of, aliphatic diisocyanates. In other embodiments, the polyisocyanate component includes one or more aliphatic diisocyanates. In some embodiments, the polyisocyanate component is essentially free of, or even completely free of, aromatic diisocyanates. In some embodiments, mixtures of aliphatic and aromatic diisocyanates may be useful.

[0018] Examples of useful polyisocyanates include aromatic diisocyanates such as 4,4'-methylenebis(phenyl isocyanate) (MDI), 3,3'-dimethyl-4,4'-biphenylene diisocyanate (TODI), 1,5-naphthalene diisocyanate (NDI), m-xylene diisocyanate (XDI), phenylene-1,4-diisocyanate, naphthalene-1,5-diisocyanate, and toluene diisocyanate (TDI); as well as aliphatic diisocyanates such as 1,6-hexamethylene diisocyanate (HDI), isophorone diisocyanate (IPDI), 1,4-cyclohexyl diisocyanate (CHDI), decane-1,10-diisocyanate, lysine diisocyanate (LDI), 1,4-butane diisocyanate (BDI), isophorone diisocyanate (PDI), and dicyclohexylmethane-4,4'-diisocyanate (H12MDI). Isomers of these diisocyanates may also be useful. Mixtures of two or more polyisocyanates may be used. In some embodiments, the isocyanate component comprises or consists of an aromatic diisocyanate. In some embodiments, the isocyanate component comprises or consists of MDI.

[0019] The TPU compositions described herein are made using a chain extender component. Suitable chain extenders include diols, diamines, and combination thereof.

[0020] Suitable chain extenders include relatively small polyhydroxy compounds, for example lower aliphatic or short chain glycols having from 2 to 20, or 2 to 12, or 2 to 10 carbon atoms. Suitable examples include ethylene glycol, diethylene glycol, propylene glycol, dipropylene glycol, 1,4-butanediol (BDO), 1,6-hexanediol (HDO), 1,3-butanediol, 1,5-pentanediol, neopentylglycol, 1,4-cyclohexanedimethanol (CHDM), 2,2-bis[4-(2-hydroxyethoxy) phenyl]propane (HEPP), 1,4-bis(β -hydroxyethoxy)benzene (HQEE), hexamethylenediol, heptanediol, nonanediol, dodecanediol, 3-methyl-1,5-pentanediol, ethylenediamine, butanediamine, hexamethylenediamine, and hydroxyethyl resorcinol (HER), and the like, as well as mixtures thereof. In one embodiment, the chain extender comprises or consists of 1,4-butanediol.

[0021] In one embodiment of the invention, the TPU used to prepare the fiber of the present invention contains 15 wt% to 22.5 wt% hard segment. In another embodiment, the TPU used to prepare the fiber of the present invention contains 15 wt% to 17.5 wt% hard segment.

5 [0022] Optionally, one or more polymerization catalysts may be present during the polymerization reaction of the TPU. Generally, any conventional catalyst can be utilized to react the diisocyanate with the polyol intermediates or the chain extender. Examples of suitable catalysts which in particular accelerate the reaction between the NCO groups of the diisocyanates and the hydroxy groups of the polyols and chain extenders are the conventional
10 tertiary amines known from the prior art, e.g. triethylamine, dimethylcyclohexylamine, N-methylmorpholine, N,N'-dimethylpiperazine, 2-(dimethylaminoethoxy)ethanol, diazabicyclo[2.2.2]octane and the like, and also in particular organometallic compounds, such as titanate esters, iron compounds, e.g. ferric acetylacetonate, tin compounds, e.g. stannous diacetate, stannous octoate, stannous dilaurate, bismuth compounds, e.g. bismuth trineodecanoate, or the dialkyltin salts of aliphatic carboxylic acids, e.g. dibutyltin diacetate, dibutyltin
15 dilaurate, or the like. The amounts usually used of the catalysts are from 0.001 to 0.1 part by weight per 100 parts by weight of polyol component. In some embodiments, the reaction to form the TPU of the present invention is substantially free of or completely free of catalyst.

[0023] TPU compositions used in the present invention may be made via a "one shot"
20 process wherein all the components are added together simultaneously or substantially simultaneously to a heated extruder and reacted to form the TPU. The equivalent or molar ratio of the diisocyanate to the total equivalents of hydroxyl terminated intermediate and the chain extender is generally from about 0.9 to about 1.05, for example about 0.95 to about 1, or even about 0.98 to about 1.0. In one embodiment, the molar ratio of isocyanate groups from
25 the diisocyanate to hydroxyl groups from the poly(butanediol) succinate and chain extender diol is 0.9:1 to 1:1. In one embodiment, the equivalent ratio may be less than 1.0 such that the TPU has terminal hydroxyl groups to enhance the reaction with the crosslinking agent during the fiber spinning process. The weight average molecular weight (MW) of the TPU is generally from about 25,000 g/mol to about 300,000 g/mol, for example from about 50,000
30 g/mol to about 200,000 g/mol, even further for example about 75,000 g/mol to about 175,000

g/mol, where the weight average molecular weight is measured by GPC using a polystyrene standard.

[0024] In another embodiment, the TPU may be prepared using a pre-polymer process. In the pre-polymer process, the hydroxyl terminated intermediate is reacted with generally an equivalent excess of one or more diisocyanates to form a pre-polymer solution having free or unreacted isocyanate therein. Subsequently, a chain extender, as described herein, is added in an equivalent amount generally equal to the isocyanate end groups as well as to any free or unreacted diisocyanate compounds. The overall equivalent ratio of the total diisocyanate to the total equivalent of hydroxyl terminated intermediate and chain extender is thus from about 0.95 to about 1.10, for example about 0.97 to about 1.03, or even about 0.98 to about 1.0. In one embodiment, the equivalent ratio may be less than 1.0 such that the TPU has terminal hydroxyl groups to enhance the reaction with the crosslinking agent during the fiber spinning process. Typically, the prepolymer process can be carried out in any conventional device, such as an extruder.

[0025] Optional additive components may be present during the polymerization reaction, and/or incorporated into the TPU elastomer described above to improve processing and other properties. These additives include but are not limited to antioxidants, organic phosphites, phosphines and phosphonites, hindered amines, organic amines, organo sulfur compounds, lactones and hydroxylamine compounds, biocides, fungicides, antimicrobial agents, compatibilizers, electro-dissipative or anti-static additives, fillers and reinforcing agents, such as titanium dioxide, alumina, clay and carbon black, flame retardants, such as phosphates, halogenated materials, and metal salts of alkyl benzenesulfonates, impact modifiers, such as methacrylate-butadiene-styrene ("MBS") and methylmethacrylate butylacrylate ("MBA"), mold release agents such as waxes, fats and oils, pigments and colorants, plasticizers, polymers, rheology modifiers such as monoamines, polyamide waxes, silicones, and polysiloxanes, slip additives, such as paraffinic waxes, hydrocarbon polyolefins and/or fluorinated polyolefins, and UV stabilizers, which may be of the hindered amine light stabilizers (HALS) and/or UV light absorber (UVA) types. Other additives may be used to enhance the performance of the TPU composition or blended product. All of the additives described above may be used in an effective amount customary for these substances.

[0026] These additional additives can be incorporated into the components of, or into the reaction mixture for, the preparation of the TPU resin, or after making the TPU resin. In another process, all the materials can be mixed with the TPU resin and then melted or they can be incorporated directly into the melt of the TPU resin.

5 [0027] In one embodiment, the TPU composition of the present invention will be clear and/or transparent. For instance, the TPU composition of the present invention may have a clarity of greater than 80% measured according to the procedure in ASTM D1003. In another embodiment, the thermoplastic polyurethane has a melt onset temperature of 100°C to 120°C determined by thermomechanical analysis on a 10 mil sample using a TAQ400 TMA instru-
10 ment. In another embodiment, the thermoplastic polyurethane composition has a melt index of greater than 25 g/10min at 190°C measured according to the procedure in ASTM D1238.

Thermoplastic Polyurethane Fibers

[0028] Melt-spun TPU fibers are made by melting the TPU composition in an extruder. The TPU melt is fed to a spinneret. The melt exits the spinneret to form the fibers and the
15 fibers are cooled and wound onto bobbins.

[0029] The melt-spinning process begins with feeding a preformed TPU polymer, into an extruder. The TPU is melted in the extruder. After exiting the extruder and mixer, the melted TPU polymer flows into a manifold. The manifold divides the melt stream into different streams, where each stream is fed to a plurality of spinnerets. Usually, there is a melt pump
20 for each different stream flowing from the manifold, with each melt pump feeding several spinnerets. The spinneret will have a small hole through which the melt is forced and exits the spinneret in the form of a fiber. The size of the hole in the spinneret will depend on the desired size (denier) of the fiber. The fiber is drawn or stretched as it leaves the spinneret and is cooled before winding onto bobbins. The fibers are stretched by winding the bobbins
25 at a higher speed than that of the fiber exiting the spinneret. For the melt-spun TPU fibers, the bobbins are usually wound at a rate that is greater than the speed of the fiber exiting the spinneret, for example, in some embodiments, of 4 to 8 times the speed of the fiber exiting the spinneret, but can be wound slower or faster depending on the particular equipment. Typical bobbin winding speeds can vary from 100 to 3000 meters per minute, but more typ-
30 ical speeds are 15000 to 2500 meters per minute for TPU melt-spun fibers. Finish oils, such

as silicone oils, are usually added to the surface of the fibers after cooling and just prior to being wound into bobbins.

[0030] The spinning temperature (the temperature of the polymer melt in the spinneret) should be higher than the melting point of the polymer. In the present invention, due to the crystalline nature of the TPU, the spinning temperature may be 80°C to 100°C above the melting point of the polymer. The spinning temperature for the fibers produced by this invention is greater than 190°C and preferably from about 190°C to about 220°C, or even about 190°C to about 210°C.

[0031] Melt-spun TPU fibers of the present invention may be made as mono-filaments or multi-filament yarns. In addition, the melt-spun TPU fibers can be made in a variety of denier. The term “denier” is defined as the mass in grams of 9000 meters of fiber, fiber, or yarn. It is describing linear density, mass per unit length of fibers, fibers, or yarns and is measured according to ASTM D1577, Option B. Typical melt-spun TPU fibers are made in a denier size less than 240, more typical from 10 to less than 240 denier size, with 100 and 160 denier being a popular size.

[0032] Melt-spun TPU fibers made in accordance with the present invention also have an ultimate elongation of at least 50%, for example 50% to 200% as measured by ASTM D2256.

[0033] In addition, the melt-spun TPU fibers made in accordance with the present invention may also have melt on-set of 100° - 120°C, measured according to ASTM D3418. Fibers made according to the present invention will shrink less than 20%.

Fabrics

[0034] The TPU fibers of the present invention may be used alone or combined with natural or synthetic other fibers by knitting or weaving fibers to make fabrics which can be used in a variety of articles.

[0035] In one embodiment, the melt-spun TPU fiber of the present invention may be woven to make a fabric. In another embodiment, the melt-spun TPU fiber of the present invention may be combined with one or more different TPU fibers to make a fabric. In still another embodiment, the melt-spun TPU fibers of this invention may be combined with other fibers, such as cotton, nylon or polyester to make various end use articles.

[0036] For example, a fabric in accordance with the present invention may combine the melt-spun TPU fiber of the present invention with a yarn that is less elastic than the TPU

fibers of the present invention, also referred to herein as a “hard yarn.” Hard yarns may include, for example, polyester, nylon, cotton, wool, acrylic, polypropylene, or viscose-rayon. Hard yarns may also include, for example, other TPU fibers (not of the present invention) that are less elastic than the TPU fibers of the present invention. In one embodiment, the hard yarn has ultimate elongation 10% - 200%, for example, 10% to 75%, or even 10% to 60%, or even 10% to 50%, or even 10% to 30% and the melt-spun TPU fiber of the present invention has at least 50% ultimate elongation, for example 50% to 200% ultimate elongation. Each of the fiber components may be included in amounts of 1-99% by weight in the composition. The weight % of the melt-spun TPU fibers in the end use application can vary depending on the desired functionality. For example, woven fabrics have from 1-8wt.%, underwear from 2-5 wt.% bathing suits and sportswear from 8-30 wt.% foundation garments from 10-45 wt.%, and medical hose from 35-60 wt.% of the melt-spun TPU fibers with the remaining amount being a hard, non-elastic fiber. The fabrics made with these two fiber materials can be constructed by various processes including but not limited to circular knitting, warp knitting, weaving, braiding, nonwovens or combination thereof. In one embodiment, fabrics made of the fibers of the present invention can be heat treated to fuse TPU fibers and form a monolithic film. This construction will withstand cracking up to 300,000 cycles at – 5°C when measured as per ASTM D1052.

[0037] Various properties of the fibers and fabrics made in accordance with the present invention may be measured in accordance with the measurement methods listed below:

- Denier is the measure of linear density and is measured as per ASTM D1577, Option B;
- The tenacity of TPU fibers which is tensile strength normalized by denier is also measured per ASTM D2256;
- The ultimate elongation of TPU fibers which is elongation at break is measured per ASTM D2256;
- Shrinkage of the fibers is measured by comparing the length of a filament before and after exposure to elevated temperature using a one meter long filament (free standing) and exposing the filament of temperatures of 70°C for 90 seconds in an oven;

- TMA melt onset is measured by heating a sample to its melting point so that it deforms from the force applied by the probe. The TMA instrument detects and records the changes in sample height as a function of temperature, the deflection in sample height is indicative of softening (or melting on-set point of polymer). Melt onset point is measured on Thermal Analysis (TA) Q400 unit with penetration type probe in a temperature range of 50°C to 210°C, ramp rate of 5°C per minute, with a preload and applied force 0.05 N and 0.02 N respectively;
- Hardness is measured as per ASTM D2240;
- Melting point T_m of the Soft Segment (TM-SS) is measured as per ASTM D3418;
- Melt index is measured as per ASTM D1238;
- Haze, Clarity, and Transparency are measured as per ASTM D1003.

[0038] The invention will be better understood by reference to the following examples.

15 **EXAMPLES**

[0039] Table 1 lists TPU compositions prepared used to make fibers in the present invention. Unless otherwise noted, the hard segment for all examples is made from 4,4'-methylenebis(phenyl isocyanate) and 1,4-butanediol. The amount of polyol in the TPU is 100% - Hard Segment%.

20 **Table 1**

Ex.	Polyol (Mn)	Hard Segment	NCO:OH ratio	TMA Melt Onset (°C)	Melt Index	Clarity %	Haze %
1	Butanediol adipate (1300)	25.0%	1.00	122		12	60
2 ¹	Butanediol adipate (950)	36.0%	1.00	124		8	77
3	Poly(butanediol) Succinate (4000)	5.3%	1.00	110		100	4
4	Poly(butanediol) succinate (2000)	15.0%	1.00	105			
5	Poly(butanediol) Succinate (2000)	17.5%	1.00	105		41	94
6	Poly(butanediol) succinate	20.0%	1.00	103			

	(2000)						
7	Poly(butanediol) succinate (2000)	22.5%	1.00	178			
8	Poly(butanediol) succinate (2000)	25.0%	1.00	188			
9	Poly(butanediol) succinate (2000)	30.0%	1.00	165			
10	Poly(butanediol) succinate (2000)	17.5%	1.07	100/181	7.0		
11	Poly(butanediol) succinate (2000)	17.5%	1.06	100/176	6.0		
12	Poly(butanediol) succinate (2000)	17.5%	1.04	100/175	5.3		
13	Poly(butanediol) succinate (2000)	17.5%	1.02	93/172	5.0		
14	Poly(butanediol) succinate (2000)	17.5%	1.01	100/181	7.0		
15	Poly(butanediol) succinate (2000)	17.5%	1.00	97/97	52.0		
16	Poly(butanediol) succinate (2000)	17.5%	0.96	100/100	167.0		

¹ Chain extender for example 2 is a mixture of 1,4 butanediol and neopentyl glycol.

[0040] Fibers were prepared using selected TPU materials from Table 1.

Table 2

TPU Ex.	Spinning speed (m/min)	Denier	Tenacity (gram-force/Denier)	Elongation (%)	Shrinkage (%)	TMA Melt Onset (°C)
1	1500	370	1.9	69	70	122
2	1500	240	1.4	254	40	124
3	1500	180	2.2	188	4	110
5	500	160	1.4	234	< 2	120
5	1500	145	2.4	80	5.4	120
5	2200	106	3	76	10	120
6	1500	130	2.2	100	8	
6	2000	115	2.5	70	18	

[0041] Each of the documents referred to above is incorporated herein by reference, including any prior applications, whether or not specifically listed above, from which priority is claimed. The mention of any document is not an admission that such document qualifies as prior art or constitutes general knowledge of the skilled person in any jurisdiction. Except
5 in the Examples, or whether otherwise explicitly indicated, all numerical quantities in this description specifying amounts of materials, reaction conditions, molecular weights, number of carbon atoms, and the like are to be understood as modified by the word “about.” It is to be understood that the upper and lower amount, range, and ratio limits set forth herein may be independently combined. Similarly, the ranges and amounts for each element of the in-
10 vention can be used together with ranges or amounts for any of the other elements.

[0042] As used herein, the transitional term “comprising,” which is synonymous with “including,” “containing,” or “characterized by,” is inclusive or open-ended and does not exclude additional, un-recited elements or method steps. However, in each recitation of “comprising” herein, it is intended that the term also encompass, as alternative embodiments,
15 the phrases “consisting essentially of” and “consisting of,” where “consisting of” excludes any element or step not specified and “consisting essentially of” permits the inclusion of additional un-recited elements or steps that do not materially affect the basic and novel characteristics of the composition or method under consideration.

[0043] While certain representative embodiments and details have been shown for the
20 purpose of illustrating the subject invention, it will be apparent to those skilled in this art that various changes and modifications can be made therein without departing from the scope of the subject invention. In this regard, the scope of the invention is to be limited only by the following claims.

CLAIMS

What is claimed is:

1. A melt-spun fiber, wherein the fiber comprises:
a thermoplastic polyurethane comprising the reaction product of at least 77.5 wt% poly(butanediol) succinate and up to 22.5 wt% of a hard segment component, wherein the hard segment component comprises a diisocyanate and a chain extender diol, wherein the molar ratio of isocyanate groups from the diisocyanate to hydroxyl groups from the poly(butanediol) succinate and chain extender diol is 09:1 to 1:1.
2. The fiber of claim 1, wherein the poly(butanediol) succinate has a number average molecular weight of 1000 g/mol to 3000 g/mol or 1500 g/mol to 2500 g/mol or 1800 g/mol to 2200 g/mol or 2000 g/mol as measured by NMR end group analysis.
3. The fiber of any preceding claim, wherein the thermoplastic polyurethane has a clarity of greater than 80% as measured by ASTM D1003.
4. The fiber of any preceding claim, wherein the thermoplastic polyurethane has a melt onset of 100°C to 120°C as determined by thermomechanical analysis.
5. The fiber of any preceding claim, wherein the thermoplastic polyurethane has a melt index of greater than 25 g/10min at 190°C/10kg as measured by ASTM D1238.
6. The fiber of any preceding claim, wherein the thermoplastic polyurethane comprises 15 wt% to 17.5 wt% hard segment.
7. The fiber of claim 6, wherein the thermoplastic polyurethane comprises 82.5 wt% to 85 wt% poly(butanediol) succinate.
8. The fiber of any preceding claim, wherein the fiber is free of nano-silica.
9. The fiber of any preceding claim, wherein the diisocyanate comprises or consists of 4,4'-diphenylmethane diisocyanate.

10. The fiber of any preceding claim, wherein the chain extender diol is selected from the group consisting of ethylene glycol, diethylene glycol, propylene glycol, dipropylene glycol, 1,4-butanediol, 1,6-hexanediol, 1,3-butanediol, 1,5-pentanediol, neopentylglycol, 1,4-cyclohexanedimethanol, 2,2-bis[4-(2-hydroxyethoxy) phenyl]propane, 1,4-bis(β -hydroxyethoxy)benzene, hexamethylenediol, heptanediol, nonanediol, dodecanediol, 3-methyl-1,5-pentanediol, ethylenediamine, butanediamine, hexamethylenediamine, and hydroxyethyl resorcinol or mixtures thereof.
11. The fiber of any preceding claim, wherein the chain extender diol comprises or consists of 1,4-butanediol.
12. A fabric comprising:
a thermoplastic polyurethane fiber wherein the thermoplastic polyurethane comprises the reaction product of at least 77.5 wt% poly(butanediol) succinate and up to 22.5 wt% of a hard segment component, wherein the hard segment component comprises a diisocyanate and a chain extender diol, wherein the molar ratio of isocyanate groups from the diisocyanate to hydroxyl groups from the poly(butanediol) succinate and chain extender diol is 09:1 to 1:1.
13. The fabric of claim 12, wherein the poly(butanediol) succinate has a number average molecular weight of 1000 g/mol to 3000 g/mol or 1500 g/mol to 2500 g/mol or 1800 g/mol to 2200 g/mol or 2000 g/mol as measured by NMR end group analysis.
14. The fabric of claim 12 or 13, wherein the fiber shrinks less than 20%.
15. The fabric of any of claims 12 to 14, wherein the thermoplastic polyurethane has a clarity of greater than 80% as measured by ASTM D1003.
16. The fabric of any of claims 12 to 15, wherein the thermoplastic polyurethane comprises 15 wt% to 17.5 wt% hard segment.

17. The fabric of any of claims 12 to 16, wherein the thermoplastic polyurethane comprises 82.5 wt% to 85 wt% poly(butanediol) succinate.
18. The fabric of any of claims 12 to 17, wherein the thermoplastic polyurethane has a melt onset of 100°C to 120°C as determined by thermomechanical analysis.
19. The fiber of any of claims 12 to 18, wherein the thermoplastic polyurethane has a melt index of greater than 25 g/10min at 190°C/10kg as measured by ASTM D1238.
20. The fabric of any of claims 12 to 19, wherein the fiber is free of nano-silica.
21. The fabric of any of claims 12 to 20, wherein the diisocyanate comprises or consists of 4,4'-diphenylmethane diisocyanate.
22. The fabric of any of claims 12 to 21, wherein the chain extender diol comprises or consists of 1,4-butanediol.
23. The fabric of any of claims 12 to 22, wherein the fiber has a denier measured by ASTM D1577, Option B of 100 to 2500, or 100 to 2000.
24. The fabric of any of claims 12 to 23, wherein the fabric further comprises a second fiber, wherein the second fiber is selected from nylon fibers, polyester fibers, polypropylene fibers or mixtures thereof.
25. The fabric of any of claims 12 to 24, wherein the fabric further comprises a second thermoplastic polyurethane fiber.
26. The fabric of any of claims 12 to 25, wherein a film formed from the fabric withstands cracking for 300,000 cycles at -5°C measured by ASTM D1052.
27. A melt-spun fiber, wherein the fiber comprises:
 - a thermoplastic polyurethane comprising the reaction product of 82.5 wt% to 85 wt% poly(butanediol) succinate and 15 wt% to 17.5 wt% of a hard segment component, wherein the hard segment component comprises 4,4'-diphenylmethane diisocyanate

and 1,4-butanediol, wherein the molar ratio of isocyanate groups from the diisocyanate to hydroxyl groups from the poly(butanediol) succinate and chain extender diol is 09:1 to 1:1 and wherein the thermoplastic polyurethane has a clarity of greater than 80% as measured by ASTM D1003, a melt onset of 100°C to 120°C as measured by thermomechanical analysis, and a melt index of greater than 25 g/10min at 190°C/10kg as measured by ASTM D1238.

28. The fiber of claim 27, wherein the poly(butanediol) succinate has a number average molecular weight of 1000 g/mol to 3000 g/mol or 1500 g/mol to 2500 g/mol or 1800 g/mol to 2200 g/mol or 2000 g/mol as measured by NMR end group analysis.

29. A fabric comprising:

a thermoplastic polyurethane fiber wherein the thermoplastic polyurethane comprises the reaction product of 82.5 wt% to 85 wt% poly(butanediol) succinate and 15 wt% to 17.5 wt% of a hard segment component, wherein the hard segment component comprises 4,4'-diphenylmethane diisocyanate and 1,4-butanediol, wherein the molar ratio of isocyanate groups from the diisocyanate to hydroxyl groups from the poly(butanediol) succinate and chain extender diol is 1:09 to 1:1 and wherein the thermoplastic polyurethane has a clarity of greater than 80% as measured by ASTM D1003, a melt onset of 100°C to 120°C as measured by thermomechanical analysis, and a melt index of greater than 25 g/10min at 190°C/10kg as measured by ASTM D1238 and wherein the fiber shrinks less than 20%.

30. The fabric of claim 29, wherein the fabric further comprises a second fiber, wherein the second fiber is selected from nylon fibers, polyester fibers, polypropylene fibers or mixtures thereof.

31. The fabric of claim 29 or 30, wherein a film formed from the fabric withstands cracking for 300,000 cycles at -5°C measured by ASTM D1052