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(54) **Title**: POLY(TRIMETHYLENE ARYLATE)/POLYSTYRENE COMPOSITION AND PROCESS FOR PREPARING

(57) **Abstract**: A composition of poly(trimethylene arylate), especially poly(trimethylene terephthalate), and polystyrene that is useful in the production of shaped articles such as fibers, films, and molded structures. The invention is useful as a masterbatch, also known as a concentrate, composition for combining with a PTT diluent in the economical production of fiber spinning compositions.

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TITLE

POLY(TRIMETHYLENE ARYLATE)/POLYSTYRENE COMPOSITION AND PROCESS FOR PREPARING

The present application claims the benefit of US provisional patent application number 61/235399, filed August 20, 2009 which is herein incorporated by reference. Further, the present application is related to United States Patent provisional application number 61/235405, filed August 20, 2009, which is designated by Applicant as CL4791, entitled “Films of Poly(trimethylene arylate)/Polystyrene Blends”, and to United States Patent provisional application number 61/235403, filed August 20, 2009, which is designated by Applicant as CL4697, entitled “Masterbatch Process for Producing Shaped Articles of Poly(trimethylene arylate)”.

FIELD OF THE INVENTION

The present invention is directed to a polymer blend comprising poly(trimethylene arylate), especially poly(trimethylene terephthalate), and polystyrene, that is useful in the production of shaped articles such as fibers, films, and molded structures. The invention is also directed to the use of the masterbatch in the production of fibers, films and molded structures.

BACKGROUND OF THE INVENTION

Poly(trimethylene terephthalate), also known as poly(propylene terephthalate), or, less formally, as “3GT” polymer, is well known in the art. The properties and manufacturing thereof are described by Chuah in The Encyclopedia of Polymer Science, on-line, DOI 10.1002/0471440264.pst292.

J.C. Chang et al., US 6,923,925, describes a composition comprising poly(trimethylene dicarboxylate), especially poly(trimethylene arylate), most especially poly(trimethylene terephthalate) (PTT), with 0.01-10 % by weight of preferably high molecular weight polystyrene (PS) dispersed within the poly(trimethylene dicarboxylate), and having a PS particle size of less than 2 micrometers (μm). that the examples show PTT compositions comprising 1-2% by weight of PS, on the basis of total polymer weight, were capable of melt spinning into fiber at spinning speeds significantly higher than that achievable with PTT without PS. The manner by which the compositions were prepared was by co-feeding pellets of the two polymers into a twin screw extruder or by making a salt and pepper blend of pellets of the two polymers in the desired proportions and then feeding the resulting pellet mixture into a twin screw extruder. The extrudate was extruded as a strand and chopped into pellets. These blend pellets were then fed to a spinning machine to melt spin fiber.

U.S. Pat. No. 4,475,330 discloses a polyester multifilament yarn made from polyester filaments consisting essentially of (a) a copolymer of two or more monomers selected from the group consisting of ethylene terephthalate, trimethylene terephthalate and tetramethylene terephthalate, and/or (b) a blend of two or more polymers of ethylene terephthalate, trimethylene terephthalate and tetramethylene terephthalate. This patent describes blends of polyesters with 3 to 15% of non-crystalline polymer, preferably styrene polymers or methacrylate polymers.

The process of Chang et al., *op.cit.*, was developed to produce poly(trimethylene dicarboxylate) yarns, particularly partially oriented yarns, at high spin speeds. The advantages of the invention were obtained using a blend comprising poly(trimethylene dicarboxylate) and (PS). Achievement of commercial scale operation of the process of Chang et al., may present several problems. It could be very expensive to transition a commercial scale continuous melt polymerizer from a PTT product containing PS to a PTT product not containing PS. Employing a side-stream extruder and feeding in the required amount of PS to arrive at a 1% PS composition could require specially designed equipment to feed in the small proportion of PS needed.

The masterbatch, or concentrate, technology of the present invention represents a significant cost savings over the present practice of fiber spinning. Additionally, the composition hereof has utility in the preparation of fibers, toughened molded parts and films of poly(trimethylene arylate) polymers.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides a composition comprising a poly (trimethylene arylate) and polystyrene dispersed therewithin, the polystyrene at a concentration 15% to 40% by weight on the basis of total polymer weight.

In another aspect, the present invention provides a process comprising combining poly (trimethylene arylate) and 15 % to 40% by weight on the basis of total polymer weight, of polystyrene, melting the poly (trimethylene arylate) and polystyrene, and melt blending the thus melted poly (trimethylene arylate) and polystyrene in a high shear melt mixer to provide a melt composition comprising a poly (trimethylene arylate) and a polystyrene dispersed therewithin.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic representation of one embodiment of melt feeding a spinneret.

Figure 2 is a schematic representation of one embodiment of the fiber spinning process.

DETAILED DESCRIPTION

Poly(trimethylene arylate) polymers suitable for the practice of the invention include but are not limited to poly(trimethylene terephthalate), poly(trimethylene isophthalate), poly(trimethylene naphthalate), and mixtures and copolymers thereof. In one embodiment, the poly(trimethylene arylate) is a poly(trimethylene terephthalate) (PTT).

In one aspect, the invention provides a composition comprising a poly (trimethylene arylate) and polystyrene wherein the polystyrene is dispersed therewithin the composition and wherein the polystyrene is found at a concentration of 15% to 40% by weight, on the basis of total polymer weight. The term “PS” is an abbreviation for polystyrene.

In the following, the term “PTT,” is an abbreviation for poly(trimethylene terephthalate) and will be employed in lieu of the more generic poly(trimethylene arylate). However, the technology described herein can readily be adapted to other poly(trimethylene arylate) polymers, and the invention is considered to encompass poly(trimethylene arylate) polymers. The term “PTT” is meant to encompass homopolymers and copolymers containing at least 70 mole % trimethylene terephthalate repeat units.

Unless otherwise noted, the polymer compositions are described in terms of weight per cent of ingredients based upon the total weight of polymers. Thus, the percentage of PS in the composition is expressed as a percentage of the total weight of the polymers, including, e.g., PTT, and any other additional polymers that may be incorporated into the composition hereof.

When a range of numerical values is provided, it shall be understood to encompass the end-points of the range unless specifically stated otherwise. Numerical values are to be understood to have the precision of the number of significant figures provided. For example, the number 40 shall be understood to encompass a range from 35.0 to 44.9, whereas the number 40.0 shall be understood to encompass a range from 39.50 to 40.49.

For the purpose of the present invention, the term “copolymer” shall be understood to encompass terpolymers, tetrapolymers and so forth, as well as dipolymers.

In one aspect, the present invention provides a composition comprising PTT and 15% to 40 % by weight of PS dispersed therewithin. In the composition of the invention, the PTT is a continuous phase or “matrix” and the PS is a discontinuous phase dispersed within the PTT matrix. The composition contemplated according to the invention includes a molten composition and a solid composition, and any transition states there-between. As described “therewithin”, in one embodiment, the PTT is molten and the PS is dispersed within the PTT matrix as molten droplets.

In an alternative embodiment, the PTT is solid and the PS is dispersed within the PTT matrix as solid particles.

In one embodiment, the composition comprises 50 to 85 weight % of the PTT, and 15 to 40 weight % of PS, by weight of the total polymer in the composition, and may comprise up to 30 weight % of other polyesters. Other polyesters include but are not limited to poly (ethylene terephthalate), poly(butylene terephthalate), and poly (ethylene naphthalate). In a further embodiment, the composition comprises 50 to 80 % of the PTT, and 20 to 30 % of PS, and up to 30 % of other polyesters.

Suitable PTT polymer is formed by the condensation polymerization of 1,3-propanediol and terephthalic acid or dimethylterephthalate. One or more suitable comonomers for copolymerization therewith is selected from the group consisting of linear, cyclic, and branched aliphatic dicarboxylic acids or esters having 4-12 carbon atoms (for example butanedioic acid, pentanedioic acid, hexanedioic acid, dodecanedioic acid, and 1,4-cyclohexanedicarboxylic acid, and their corresponding esters); aromatic dicarboxylic acids or esters other than terephthalic acid or ester and having 8-12 carbon atoms (for example isophthalic acid and 2,6-naphthalenedicarboxylic acid); linear, cyclic, and branched aliphatic diols having 2-8 carbon atoms (other than 1,3-propanediol) for example, ethanediol, 1,2-propanediol, 1,4-butanediol, 3-methyl-1,5-pentanediol, 2,2-dimethyl-1,3-propanediol, 2-methyl-1,3-propanediol, and 1,4-cyclohexanediol; and aliphatic and aromatic ether glycols having 4-10 carbon atoms, for example, hydroquinone bis(2-hydroxyethyl) ether, or a poly (ethylene ether) glycol having a molecular weight below about 460, including diethyleneether glycol. The comonomer typically is present in the PTT copolymer at a level in the range of about 0.5-about 15 mole %, and can be present in amounts up to 30 mole %.

The PTT can contain minor amounts of other comonomers, such comonomers are usually selected so that they do not have a significant adverse affect on properties. Such other comonomers include 5-sodium-sulfoisophthalate, for example, at a level in the range of about 0.2 to 5 mole %. Very small amounts of trifunctional comonomers, for example trimellitic acid, can be incorporated for viscosity control. The PTT can be blended with up to 30 mole percent of other polymers. Examples are polyesters prepared from other diols, such as those recited *supra*.

In one embodiment, the PTT contains at least 85 mol% of trimethylene terephthalate repeat units. In a further embodiment, the PTT contains at least 90 mol% of trimethylene terephthalate repeat units, In a still further embodiment the PTT contains at least 98 mol- % of of trimethylene terephthalate repeat units. In a still further embodiment the PTT contains 100 mol% of trimethylene terephthalate repeat units.

In one embodiment, suitable PTT is characterized by an intrinsic viscosity (IV) in the range of 0.70 to 2.0 dl/g. In a further embodiment, suitable PTT is characterized by an IV in the range of 0.80 to 1.5 dl/g. In a still further embodiment, suitable PTT is characterized by an IV in the range of 0.90 to 1.2 dl/g.

In one embodiment, suitable PTT is characterized by a number average molecular weight (M_n) in the range of 10,000 to 40,000 Da. In a further embodiment suitable PTT is characterized by M_n in the range of 20,000 to 25,000 Da.

In one embodiment, a polystyrene is selected from the group consisting of polystyrene homopolymer, α-methyl-polystyrene, and styrene-butadiene copolymers, and blends thereof. In one embodiment, the polystyrene is a polystyrene homopolymer. In a further embodiment, the polystyrene homopolymer is characterized by M_n in the range of 5,000 to 300,000 Da. In a still further embodiment, M_n of the polystyrene homopolymer is in the range of 50,000 to 200,000 Da. In a still further embodiment M_n of the polystyrene homopolymer is in the range of 75,000 to 200,000 Da. In a still further embodiment, M_n of the polystyrene homopolymer is in the range of 120,000 to 150,000 Da. Useful polystyrenes can be isotactic, atactic, or syndiotactic. High molecular weight atactic polystyrene is preferred.

Polystyrenes useful in this invention are commercially available from many suppliers including Dow Chemical Co. (Midland, Mich.), BASF (Mount Olive, N.J.) and Sigma-Aldrich (Saint Louis, Mo.).

In another aspect of the invention, PTT and PS are melt blended and, then, extruded in the form of a strand that is subsequently cut into pellets. Other forms of melt blending and subsequent comminution, such as into flake, chips, or powder, can also be performed. In one embodiment, the pellets are then remelted, diluted with additional PTT, and extruded into filaments. In another embodiment, the pellets are remelted and extruded into films, with our without dilution.

The polymer blend comprises poly(trimethylene terephthalate) and polystyrene. In some embodiments, these will be the only two materials in the blend and they will total 100 weight %. However, in many instances the blend will have other ingredients such as are commonly included in polyester polymer compositions in commercial use. Such additives include but are not limited to other polymers, plasticizers, UV absorbers, flame retardants, dyestuffs, and so on. Thus the total of the poly(trimethylene terephthalate) and polystyrene will not be 100 weight %.

In one embodiment, the composition is in the form of a solid wherein the polystyrene is in the form of particles having an average size of less than 500 nanometers, the polystyrene is polystyrene homopolymer at a concentration of 20 to 30%; and, the poly (trimethylene arylate) is poly (trimethylene terephthalate) comprising at least 98 mol% of trimethylene terephthalate monomer units.

In a further aspect, the invention provides a process comprising combining poly (trimethylene arylate) and 15 % to 40% by weight on the basis of total polymer weight, of polystyrene, melting the poly (trimethylene arylate) and polystyrene, and melt blending the melted poly (trimethylene arylate) and polystyrene in a high shear melt mixer to provide a melt composition comprising a poly (trimethylene arylate) and a polystyrene dispersed therewithin. The polystyrene at a concentration 15% to 40 wt% on the basis of total polymer weight.

In one embodiment of the process hereof, the poly(trimethylene arylate) is PTT.

In one embodiment of the process hereof, the PS is at a concentration of 20 % to 30 % by weight.

In one embodiment of the process hereof, the PTT is characterized by an IV in the range of 0.90 to 1.2 dl/g.

In one embodiment of the process hereof, the PS is PS homopolymer.

In a further embodiment of the process hereof, the PS homopolymer is characterized by a number average molecular weight of 75,000 to 200, 000 Da.

In one embodiment of the process hereof, the polystyrene is polystyrene homopolymer at a concentration of 20 to 30% and is characterized by a number average molecular weight of 75,000 to 200,000; the poly (trimethylene arylate) is poly (trimethylene terephthalate) comprising 98 mol-% of trimethylene terephthalate monomer units and whereof the intrinsic viscosity is in the range of 0.90 to 1.2 dl/g.

The PTT and PS can be melt blended by any known technique, including but not limited to an embodiment (a) comprising melting and mixing simultaneously from separate feeds, as, for example, in a co-fed twin screw extruder; an embodiment (b) comprising pre-mixing the unmelted polymers in a separate apparatus before melt blending, as, for example, in tumble blending pellets or flake of the polymers prior to feeding a twin-screw extruder, or an embodiment (c) comprising melting each polymer separately and then mixing the melts, as, for example, in feeding a twin screw extruder with the PTT in molten form from a continuous melt polymerizer, and feeding the twin-extruder with PS in molten form from a satellite single or twin screw extruder.

Aspects of the composition include, but are not limited to, the size of the PS particles formed within the PTT matrix, and the volume homogeneity of the PS particle distribution within the PTT matrix. Average particle size greater than 500 nm is not desirable from the standpoint of good fiber spinning performance. Additionally, spinning of uniform fiber, both along a single end, and end to end, depends expressly upon the homogeneity of the volume distribution of the PS particles. It is expected that in the actual melt processing thereof, the PS particles melt to form molten droplets that are dispersed within a molten PTT matrix.

The temperature in the melt mixer should be above the melting points of both the PTT and the PS but below the lowest decomposition temperature of any of the ingredients. Specific temperatures will depend upon the particular attributes of the polymers employed. In typical practice, melt temperature is in the range of 200 °C to 270 °C.

Both fine particle size of PS and volume homogeneity of the dispersion of PS in the PTT depend upon the application of high shear melt blending. This is especially true for the high concentrations of PS employed in the compositions hereof. The amount of shear force applied to the melt depends upon the rotational speed of the mixing elements, the viscosity of the melt, and the residence time of the melt in the mixing zone. If the shear forces are too low there is a tendency for the PS not to break up to begin with, or to agglomerate rapidly into droplets greater than 500nm in size.

The melt blending process can be performed both batchwise and continuously. High shear mixers such as are commonly employed in the art of polymer compounding are suitable. Examples of suitable commercially available high shear batch mixers include, but are not limited to, Banbury mixers and Brabender mixers. Examples of continuous high shear mixers include co-rotating twin-screw extruders and Farrel Continuous Mixers Counter-rotating twin screw extruders are also suitable. In general, suitable high shear mixers are those that are capable of exerting on a polymer melt a minimum shear rate of 50/s, with 100/s preferred.

In one embodiment, the PTT/PS blend so produced is extruded into one or more strands about 1/8” to 3/16” in diameter that are then cut up into pellets.

The pellets so produced can be employed as they are in injection or compression molding, and melt casting of films. The pellets so produced can also be employed as a concentrate or masterbatch useful in the production of melt spun fibers.

The pellets so produced comprise PTT polymer, described *supra*, and PS polymer, described *supra*, wherein the PS polymer is in the form of particles less than or equal to 500 nm in size dispersed in a continuous phase formed by the PTT polymer. In one embodiment, the concentration of the PS particles is in the range of 15 % to 40 wt%. In a further embodiment, the concentration of PS particles is in the range of 20 % to 30 wt%. These pellets shall be known as “concentrate pellets”.

In a further aspect of the invention, the concentrate pellets are melt blended with a PTT diluent to form a homogenous melt blend that has a lower concentration of PS than is found in the concentrate. The PTT diluent may or may not contain PS, but if it does contain PS, the concentration thereof is lower than that found in the concentrate pellets. The concentrate pellets are combined with diluent PTT to form a homogeneous composition comprising 0.5 to 1.5 wt% of PS. This composition shall be known as the “spinning blend.”

In alternative embodiments, both the concentrate and the diluent may be in the form of chips, flakes, or powder instead of pellets. In the discussion herein, wherever pellets are recited, any or all of the alternative forms may be substituted therefor. However, it is found in the polymer art, that extrusion-processing performance is best when the polymeric components are fed as pellets rather than chips, flakes, or powder.

As in the case of melt blending the PS and the PTT, described *supra*, the PTT diluent and the concentrate pellets may be combined in any of a variety of ways. In one embodiment the diluent is initially in the form of pellets. In a further embodiment, the pellets of diluent and concentrate are first tumble-blended and the pellet blend so formed fed to a high shear melt mixer, either batch or continuous. In an alternative embodiment, the diluent can be in the form of a melt and the concentrate pellets fed thereinto in a high shear mixer.

In one embodiment, the diluent is fed as a melt from a continuous melt polymerizer to a twin screw extruder, and downstream from the point of introduction of the diluent, the concentrate pellets are fed to a satellite extruder that melts and feeds the concentrate in molten form into the diluent melt stream. This embodiment is shown schematically in Figure 1. PTT is produced in a continuous melt polymerizer, **1**, from which it is conveyed in molten form via transfer line, **2**, to a twin-screw extruder, **3**. Simultaneously, the concentrate pellets are fed via a weight-loss feeder, **4**, or other pellet feeder means, to a satellite extruder, **5**, wherein the concentrate pellet is melted and fed in molten form via transfer line, **6**, to twin-screw extruder, **3**, either at or upstream from the mixing zone of the twin-screw extruder, **3**. In the twin-screw extruder a PTT/PS melt blend of the concentrate and diluent is formed. The resulting melt blend is fed via transfer line, **7**, to a spin block comprising a spinneret, **8**, from which continuous filaments, **9**, are extruded.

In an alternative embodiment, the resulting PTT/PS melt blend is extruded as a strand which is subsequently cut into pellets. The pellets so formed shall be referred to as “PTT/PS blend pellets.” The PTT/PS blend pellets can then be fed to an extruder to be melted and fed to a spinneret for melt spinning of fiber.

As indicated in Figure 1, and as is generally true for melt spinning of polymer fibers, the polymer melt is fed to the spinneret via a transfer line. The melt input to the transfer line from the extruder is in general quite turbulent. However, the spinneret feed must be laminar in order to achieve uniform flow through the plurality of holes in the spinneret. It is in the transfer line that the melt flow shifts from turbulent to laminar.

It has been found that there is a threshold concentration of PS above which an unacceptable degree of PS agglomeration occurs, causing the PS particle size to exceed 500 nm, thus interfering with the achievement of the desired high spinning speed. The particular value of the threshold concentration depends upon the length of the transfer line, the viscosities of the PS and PTT, and the residence time of the melt in the transfer line.

While not limited by any theoretical considerations, a theoretical model of laminar flow of the spinning composition hereof shows that a concentration of PS exists below which agglomeration and particle growth do not occur. It is desirable to operate the process hereof in that region. The specific value of the needed concentration depends upon the shear rate and residence time applied to the melt in laminar flow. It is found for example that at a shear rate of 5/s and a residence time of 6 seconds as found in a transfer line, the needed concentration of PS is 1.2%.

Fiber spinning can be accomplished using conventional apparatus and procedures that are in widespread commercial use. As a practical matter, it is found that for spinning fine denier filaments of 3 denier per filament (dpf) or lower, a PS concentration of > 3% leads to a degradation in mechanical properties of the fiber so produced. It is further found that at 5% PS, fine denier filaments cannot be melt spun at all.

The PTT/PS blend produced suitable for fiber spinning is characterized by a concentration in the range of 0.5 to1.5% of PS particles characterized by an average size of less than 500 nm. Prior to melt spinning, the polymer blend pellets are preferably dried to a moisture level of <30 ppm to avoid hydrolytic degradation during melt spinning. Any means for drying known in the art is satisfactory. In one embodiment, a closed loop hot air dryer is employed. Typically, the PTT/PS blend is dried at 130 °C and a dew point of <−40 °C for 6 h. The thus dried PTT/PS polymer blend is melt spun at 250–265 °C into fibers using conventional processing machines as appropriate for bulk continuous filaments (BCF), partially oriented yarn (POY), spin-draw yarn (SDY), and staple fiber.

In a typical melt spinning process, one embodiment of which is described in detail, *infra*, the dried polymer blend pellets are fed to an extruder which melts the pellets and supplies the resulting melt to a metering pump, which delivers a volumetrically controlled flow of polymer into a heated spinning pack via a transfer line. The pump provide a pressure of 10–20 MPa to force the flow through the spinning pack, which contains filtration media (eg, a sand bed and a filter screen) to remove any particles larger than a few micrometers. The mass flow rate through the spinneret is controlled by the metering pump. At the bottom of the pack, the polymer exits into an air quench zone through a plurality of small holes in a thick plate of metal (the spinneret). While the number of holes and the dimensions thereof can vary greatly, typically a single spinneret hole has a diameter in the range of 0.2– 0.4 mm. A typical flow rate through a hole of that size tends to be in the range of about 1–5 g/min. Numerous cross-sectional shapes are employed for spinneret holes, although circular cross-section is most common. Typically a highly controlled rotating roll system through which the spun filaments are wound controls the line speed. The diameter of the filaments is determined by the flow rate and the take-up speed; and not by the spinneret hole size.

The properties of the produced filaments are determined by the threadline dynamics, particularly in the region between the exit from the spinneret and the solidification point of the fibers, which is known as the quench zone. The specific design of the quench zone, air flow rate across the emerging still motile fibers has very large effects on the quenched fiber properties. Both transverse (or lateral) quench and radial quench are in common use. After quenching or solidification, the fibers travel at the take-up speed, which is typically 100–200 times faster than the exit speed from the spinneret hole. Thus, considerable acceleration (and stretching) of the threadline occurs after emergence from the spinneret hole. The amount of orientation that is frozen into the spun fiber is directly related to the stress level in the fiber at the solidification point.

The invention is further described but not limited by the following specific embodiments.

EXAMPLES

Example 1-6

Sorona® Bright PTT resin (1.02 IV available from the DuPont Company, Wilmington, DE) polytrimethylene terephthalate was combined with polystyrene (168 M KG 2 available from BASF) in the amounts shown in Table 1. The PTT was dried in a vacuum oven with a nitrogen purge at 120°C for 14 hours prior to use. The two polymers were individually weight-loss fed to the fourth barrel section of a Werner & Pfleiderer ZSK-30 co-rotating twin screw extruder. The feed rates employed are shown in Table 1 in pounds per hour (pph). The extruder had a 30 mm diameter barrel constructed with 13 barrel sections provided in alternating arrangement with two kneading zones and three conveying sections, the extruder having an L/D ratio of 32. Each barrel section was independently heated. Sections 1-4 were set at 25°C, Sections 5-13 were set at 210°C, the 3/16" strand die was also set at 210°C. A vacuum was applied to barrel segment 8. The screw speed was as indicated in Table 1. Table 1 also shows the composition of the feed, the rate of output, and the melt temperature. The polymer was quenched in water immediately upon exiting the die and was then pelletized using standard pelletizing equipment into 1/8" pellets.

Table 1

Example #	Compostion (PTT/PS)	PTT Set Feed Rate (pph)	Polystyrene Set Feed Rate (pph)	Output Rate (pph)	RPM of screws	Melt Temperature (°C)
1	85/15	25.5	4.5	30.4	200	278
2	80/20	24.0	6.0	30.0	250	277
3	75/25	22.5	7.5	30.2	200	268
4	70/30	14.0	6.0	20.0	200	265
5	65/35	13.0	7.0	20.0	200	263
6	60/40	12.0	8.0	23.0	200	270

Example 7

Sorona® Semi Dull PTT resin (1.02 IV – 0.3 wt-% TiO_2, available from the DuPont Company) was combined with 8 wt% of the polystyrene of Examples 1-6. The PTT was dried prior to use as in Examples 1-6. The two polymers were independently fed by weight loss feeders at 184 pph of PTT and 16 pph of PS (using a K-tron S-200 single screw feeder and a K-tron K2ML-T20 twin screw spiral feeder for the PTT and PS, respectively, K-Tron International, Inc., Pitman, NJ) to the second barrel section of a 40 mm co-rotating twin-screw extruder (Werner & Pfleiderrer Corp., Ramsey, NJ) provided with 10 independently heated barrel sections. The throat temperature was 50°C, barrel sections 1-4 were set at 230°C, barrel section 5 was set at 225 °C, barrel sections 6-9 were set at 200°C, and barrel section 10 was set at 245 °C, and the 6-hole strand die, provided with 3/16” holes, was set at 245°C, melt temperature using this heating profile was 255°C. The six output strands were water-quenched and pelletized into 1/8” pellets.

The process for spinning was as shown in Figures 1 and 2 except that the continuous melt polymerizer shown in Figure 1 was replaced by a weight-loss pellet feeder. Referring to Figure 1, pellets of Sorona® Semi Dull PTT resin were employed as the diluent polymers, as described *supra*. The pellets were fed to a 28 mm co-rotating twin-screw extruder (Werner & Pfleiderrer Corp., Ramsey, NJ) at 41.58 g/min. Simultaneously, the 8 wt% PS/PTT pellets prepared *supra* were fed via a weight-loss feeder, **4**, to a satellite extruder that has 4 independently heated barrel sections (Prism corotating twin screw extruder, Thermo Scientific, Waltham, MA), **5**. Barrel section 1 was set to 250°C and barrel sections 2-4 were set to 260°C. A gear pump set to 260°C delivered the 8 wt% PS/PTT polymer melt to the 28 mm extruder, **3**, in barrel section 2, at a rate of 4.62 g/min. The 28 mm twin-screw extruder was provided with 10 barrel sections set at 265 °C. The resulting melt temperature at the die exit was 265°C. In the 28 mm twin screw extruder the 8 wt% PS/PTT melt blend of the concentrate and diluent PTT melt, were mixed to form a 0.8 wt% PS/PTT polymer melt blend, which was fed via transfer line, **7**, to a spin pack, **8**, containing a sand filter (25/50 layer on top of a 50/325 mesh layer) to the 34 hole spinneret. The holes were of round cross-section and

0.012” in diameter and 0.022” in length from which continuous 2.2 denier per filament yarns were extruded.

Figure 2 is a schematic representation of the fiber spinning process. 34 filaments, **22**, were extruded through spinneret,**21**. The filaments passed through a cooling zone, **23**, formed into a bundle, and passed over a finish applicator, **24**. The cooling zone comprised cross-flow quench air at room temperature and at 60% relative humidity and a velocity of 40 feet/min. Following the finish applicator, **24**, the filament bundle passed to a pair of feed rolls, **25**, set at 75 °C. The filament bundle was wrapped around the feed rolls 6 times. From the feed rolls, the filament bundle was passed to a pair of draw rolls set at 125 °C, wrapped around the draw rolls 8 times. Draw roll speed was 4500 m/min while the feed roll speed was 2000 m/min. From the draw rolls, the filament bundle was passed to a pair of let-down rolls, **27**, operated at room temperature and at a speed 1-2% faster than the draw rolls speed. The filament bundle was wrapped around the let-down rolls 10 times. From the let-down rolls, the filament bundle passed though an interlace jet, and thence to a wind-up operated at 4445 m/min. The fiber so prepared was characterized as 2.32 dpf, with a tenacity of 2.84 g/denier.

Example 8

Sorona® Bright PTT resin was combined with 20 weight% of the polystyrene of Examples 1-6. The PTT was dried prior to use as in Examples 1-6. The two polymers were independently fed by weight loss feeders at 28 pph of PTT and 7 pph PS into the 4th barrel section of a Werner & Pfleiderer ZSK-30 co-rotating twin screw extruder provided with 13 independently heated barrel sections. The throat temperature and first barrel temperature were set at 190°C, with the following 12 sections set at 210°C. The polymer was extruded through a single stand die with a 3/16” hole. The polymer strand was then water-quenched and pelletized into 1/8” pellets.

Approximately 10 g of the pellets so prepared were placed between two sheets of 0.006 inch thick poly(tetrafluoro ethylene)- coated fiber glass release sheets. These sheets were then placed between the platens of a hydraulic press (PHI, City of Industry, CA). The press was heated to 260°C and 4.5 psi gauge pressure until the pellets had melted and the pressure stabilized. Then the pressure was raised to 22.5 psi gauge pressure, and held for 5 minutes. The pressure was then released, and the release sheets were removed from the press and placed into an ice water bath. A film having a thickness of less than 0.010 in was removed from the release sheet and compared to a similar sheet made of PTT pellets that did not contain polystyrene. The film made with 20% polystyrene was more opaque than the film without polystyrene, while feeling the same with relation to brittleness and tensile properties.

Example 9

0.4 lbs of the PTT/PS pellets produced in Example 8 were mixed with 9.6 lbs of Sorona® Bright PTT resin pellets containing no PS. The resulting pellet mixture was fed to a Werner & Pfleiderer extruder with a 28 mm diameter barrel and 6 barrel segments each set to 240 °C. Screw speed was 150 rpm. a melt temperature of 268°C was determined by hand at the exit of the extruder. The extruder output was fed to a 10 inch coat hanger film die set at 239 °C. The die gap was set at 0.010 in and the die pressure was 296 psi. A film was cast onto a water-cooled rotating casting drum, and then to a wind-up operating at 8 feet per minute. The prepared film was found to exhibit at a uniform thickness of 0.002 in and was 10 in wide. A section of the film so produced was examined by transmission electron microscopy (TEM). By visual inspection, the preponderance of PS particles was characterized by 150 nm particle size.

Example 10

Sorona® Semi Dull PTT resin is combined with 20 wt% of the polystyrene of Examples 1-6. The PTT is dried prior to use as in Examples 1-6. The two polymers are independently fed by weight loss feeders at 160 pph of PTT and 40 pph of PS (using a K-tron S-200 single screw feeder and a K-tron K2ML-T20 twin screw spiral feeder for the PTT and PS, respectively, K-Tron International, Inc., Pitman, NJ) to the second barrel section of a 40 mm co-rotating twin-screw extruder (Werner & Pfleiderrer Corp., Ramsey, NJ) provided with 10 independently heated barrel sections. The throat temperature is 50°C, barrel sections 1-4 are set at 230°C, barrel section 5 is set at 225 °C, barrel sections 6-9 are set at 200°C, and barrel section 10 is set at 245 °C. The 6-hole strand die, provided with 3/16” holes, is set at 245°C. The six output strands are water-quenched and pelletized into 1/8” PTT/20%PS pellets.

The process for spinning is as shown in Figures 1 and 2 except that the continuous melt polymerizer shown in Figure 1 is replaced by a weight-loss pellet feeder. Referring to Figure 1, pellets of Sorona® Semi Dull PTT resin are are fed to a 28 mm co-rotating twin-screw extruder (Werner & Pfleiderrer Corp., Ramsey, NJ) at 44.35 g/min. Simultaneously, the PTT/20%PS pellets from the preceding paragraph are fed via a weight-loss feeder, **4**, to a satellite extruder that has 4 independently heated barrel sections (Prism corotating twin screw extruder, Thermo Scientific, Waltham, MA), **5**. Barrel section 1 is set to 250°C and barrel sections 2-4 are set to 260°C. A gear pump set to 260°C delivers the 8 wt% PS/PTT polymer melt to the 28 mm extruder, **3**, in barrel section 2, at a rate of 1.85 g/min. The 28 mm twin-screw extruder is provided with 10 barrel sections set at 265 °C. In the 28 mm twin screw extruder the 20 wt% PS/PTT melt blend of the concentrate and diluent PTT melt, are mixed to form a 0.8 wt% PS/PTT polymer melt blend, which is fed via transfer line, **7**, to a spin pack, **8**, containing a sand filter (25/50 layer on top of a 50/325 mesh layer) to the 34 hole spinneret. The holes are of round cross-section and 0.012” in diameter and 0.022” in length from which continuous 2.2 denier per filament yarns are extruded.

Figure 2 is a schematic representation of the fiber spinning process. 34 filaments, **22**, are extruded through spinneret, **21**. The filaments pass through a cooling zone, **23**, are formed into a bundle, and pass over a finish applicator, **24**. The cooling zone comprises cross-flow quench air at room temperature and at 60% relative humidity and a velocity of 40 feet/min. Following the finish applicator, **24**, the filament bundle passes to a pair of feed rolls, **25**, set at 75 °C. The filament bundle is wrapped around the feed rolls 6 times. From the feed rolls, the filament bundle passes to a pair of draw rolls **26** set at 125 °C, wrapped around the draw rolls 8 times. Draw roll speed is 4500 m/min while the feed roll speed is 2000 m/min. From the draw rolls, the filament bundle passes to a pair of let-down rolls, **27**, operated at room temperature and at a speed 1-2% faster than the draw rolls speed. The filament bundle is wrapped around the let-down rolls 10 times. From the let-down rolls, the filament bundle passes though an interlace jet **28**, and thence to a wind-up **29** operated at 4445 m/min. The fiber so prepared is characterized as 2.32 dpf, with a tenacity of 2.84 g/denier.

CLAIMS

We claim:

1. A composition comprising a poly (trimethylene arylate) and 15% to 40% by weight, on the basis of total polymer weight, polystyrene dispersed therewithin.

2. The composition of Claim 1 in the form of a solid wherein the polystyrene is in the form of particles having an average size of less than 500 nanometers.

3. The composition of Claim 1 wherein the poly (trimethylene arylate) is poly (trimethylene terephthalate).

4. The composition of Claim 1 wherein the polystyrene is at a concentration of 20 % to 30 % by weight.

5. The composition of Claim 1 wherein the polystyrene is a homopolymer.

6. The composition of Claim 2 wherein the polystyrene is polystyrene homopolymer at a concentration of 20 to 30%; and, the poly (trimethylene arylate) is poly (trimethylene terephthalate) comprising at least 98 mol-% of trimethylene terephthalate monomer units.

7. A process comprising combining poly (trimethylene arylate) and 15 % to 40% by weight on the basis of total polymer weight, of polystyrene, melting the poly (trimethylene arylate) and polystyrene, and melt blending the melted poly (trimethylene arylate) and polystyrene in a high shear melt mixer to provide a melt composition comprising a poly (trimethylene arylate) and a polystyrene dispersed therewithin.

8. The process of Claim 7 wherein the poly (trimethylene arylate) is poly (trimethylene terephthalate).

9. The process of Claim 7 wherein the polystyrene is at a concentration of 20 % to 30 % by weight.

10. The process of Claim 8 wherein the poly (trimethylene terephthalate) is characterized by an intrinsic viscosity in the range of 0.90 to 1.2 dl/g.

11. The process of Claim 7 wherein the polystyrene is polystyrene homopolymer.

12. The process of Claim 11 wherein the polystyrene homopolymer is characterized by a number average molecular weight in the range of 75,000 to 200,000 Da.

13. The process of Claim 7 wherein the polystyrene is polystyrene homopolymer at a concentration of 20 to 30% and is characterized by a number average molecular weight of 75,000 to 200,000 Da; the poly (trimethylene arylate) is poly (trimethylene terephthalate) comprising at least 98 mol-% of trimethylene terephthalate monomer units and whereof the intrinsic viscosity is in the range of 0.90 to 1.2 dl/g.

14. The process of Claim 7 wherein the process is a continuous process.

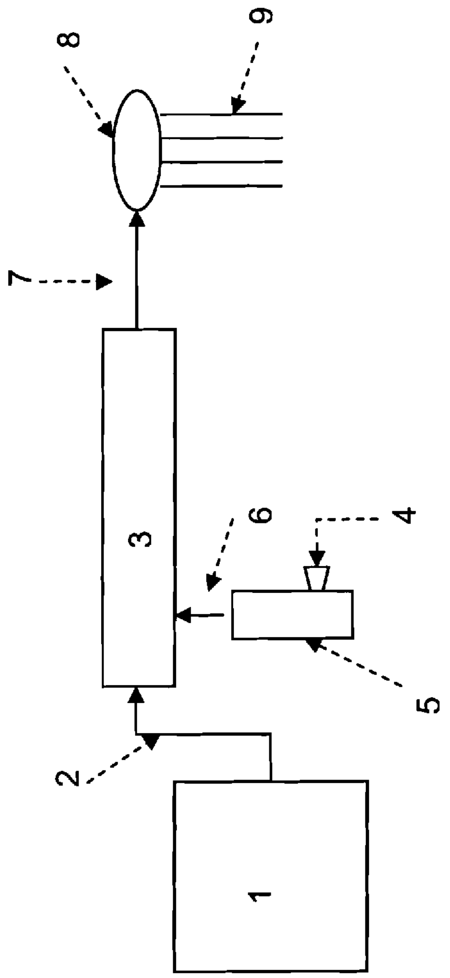

FIG. 1

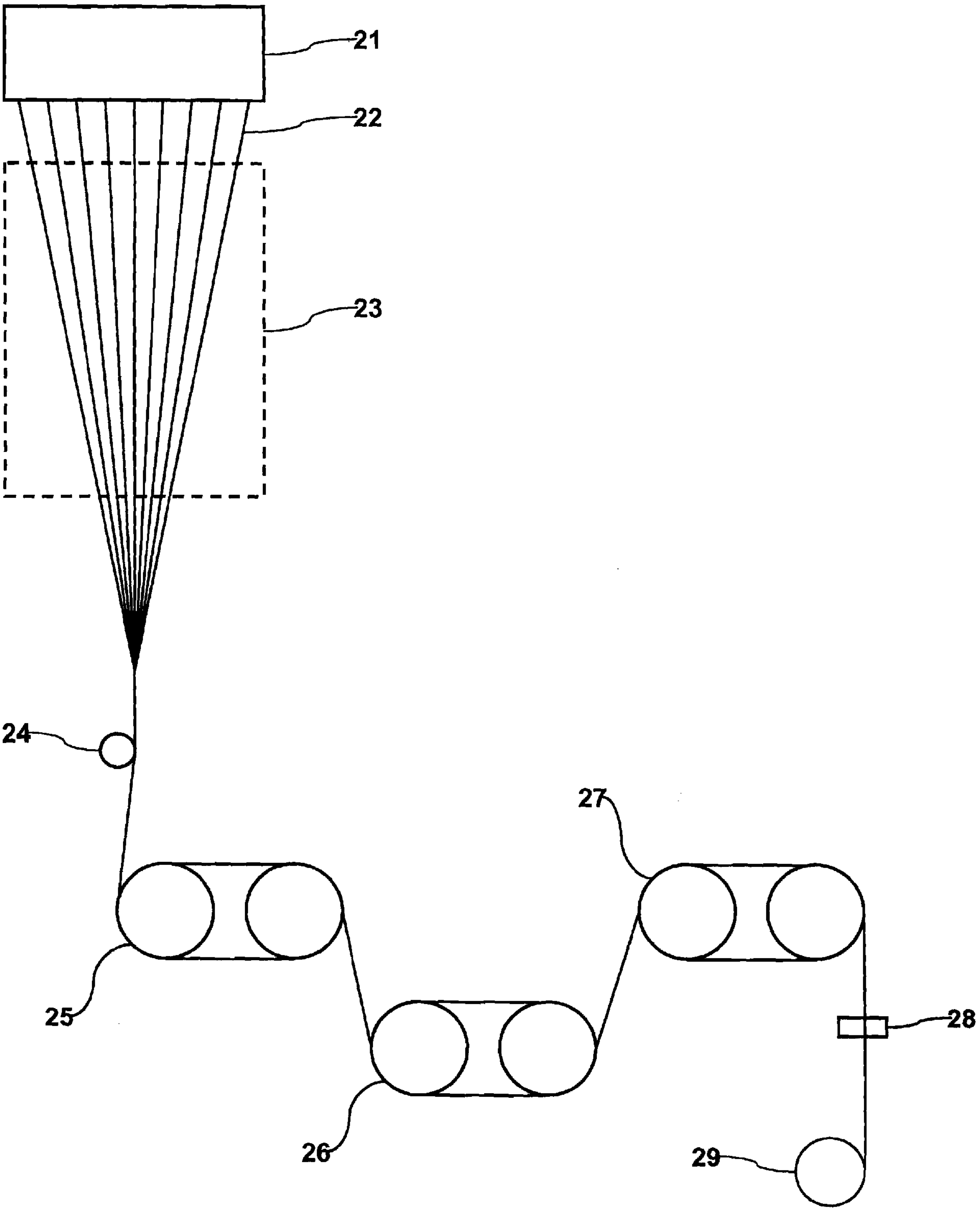

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/046128

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L25/04 C08L67/02 D01F6/92
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08L D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE CA [Online] CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; KANNO, KOJI ET AL: "Manufacture of sheath-core conjugate fibers form poly(propylene terephthalate) sheath with improved modulus and stretch recovery" XP002603696 retrieved from STN Database accession no. 131:74892 * abstract -& JP 11 189925 A (TORAY INDUSTRIES, INC., JAPAN) 13 July 1999 (1999-07-13) -----	1-14
X	US 6 444 754 B1 (CHIN HUI [US] ET AL) 3 September 2002 (2002-09-03) example 6; table 4 ----- -/--	1-14

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 6 October 2010	Date of mailing of the international search report 02/11/2010
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Lohner, Pierre

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 6 923 925 B2 (CHANG JING C [US] ET AL) 2 August 2005 (2005-08-02) Run 5; column 12, line 42 - line 67; table 5 -----	1-14

INTERNATIONAL SEARCH REPORT

Information on patent family members

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