POLYIMIDES: COMPOSITIONS, METHODS OF MAKING, AND PARTS MADE THEREFROM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] None

FIELD OF THE INVENTION

[0002] The present invention relates, generally, to polyimide compositions, parts made from polyimide compositions, and methods of making polyimide compositions and parts.

BACKGROUND OF THE INVENTION

[0003] Parts made from polyimide compositions are known. For example, parts have been made from polyimide compositions derived from 4, 4'oxydianaline (ODA) and pyromellitic dianhydride (PMDA) and, separately, derived from p-phenylene diamine (PPD), m-phenylenediamine (MPD), and biphenyl tetracarboxylic acid dianhydride (BPDA). However, with increasing demands for higher performance and more demanding applications, limitations of polyimides derived from these polyimides have become apparent. For example, improved toughness is desired from parts derived from these polyimide compositions in some applications. Increased toughness can equate to improved product life in use. Higher toughness of the polymer also provides the design engineers a greater flexibility in designing parts that can withstand more challenging operating conditions than may be feasible with a brittle polymer.

[0004] One such application where improved toughness is desired of polyimide parts is in clutches for primary and secondary transmissions. Polyimides may be formed into rollers that may be used in clutches (clutch rollers). As engines continue to get more powerful, more stress is being applied to clutch rollers made from existing polyimide materials, and these more demanding conditions have caused some polyimide parts to fail earlier than desired resulting in costly repairs.

[0005] Therefore, there exists a need for new polyimide compositions and methods of making polyimide compositions that provide improved toughness when formed into parts such as clutch rollers.

SUMMARY

[0006] In one aspect, the present disclosure is directed to a polyimide composition, comprising particles of a polyimide polymer derived from (i) ODA, (ii) PMDA, (iii) PPD, and (iv) BPDA monomers,

wherein, when the polyimide composition consists of the particles of the polyimide polymer, the polyimide composition has an apparent density of ≤ 0.25 grams per cubic centimeter.

[0007] The present disclosure is further directed to a method of making a polyimide composition comprising combining (i) ODA, (ii) PMDA, (iii) PPD, (iv) BPDA and (v) a solvent for a time and at conditions sufficient to form a reaction product mixture comprising a polyamide and solvent; heating the reaction product mixture at a temperature ≥ 110 degrees C and for a time sufficient to form a solid polyimide particles and to remove water; filtering and washing the formed solid polyimide particles to form washed solid polyimide particles; and drying the washed solid polyimide particles to form the polyimide composition comprising dried polyimide particles having an apparent density of less than 0.25 g/cm^3.

[0007a] In another aspect, the present disclosure is directed to a method of making a polyimide composition, comprising: combining (i) ODA, (ii) PMDA, (iii) PPD, (iv) BPDA and (v) a solvent for a time and at conditions sufficient to form a reaction product comprising a polyamide and solvent; heating the reaction product at a temperature and time sufficient to remove water and to form particles of a polyimide; filtering and washing the formed particles of polyimide; drying the washed polyimide particles to form the polyimide composition, wherein the polyimide composition comprises the particles of polyimide; wherein when the polyimide composition consists of the particles of the polyimide polymer, the polyimide composition has an apparent density of ≤ 0.25 grams per cubic centimeter.

[0008] The present disclosure is still further directed to a part formed from a polyimide composition comprising particles of a polyimide polymer derived from (i) ODA, (ii) PMDA, (iii) PPD, and (iv) BPDA monomers, wherein, when the polyimide composition consists of the particles of the polyimide polymer, the polyimide composition has an apparent density of ≤ 0.25 grams per cubic centimeter.

[0008a] In another aspect, the present disclosure is directed to a part, comprising: the polyimide composition as defined herein.

[0009] The present disclosure provides polyimide compositions that may be formed into parts with increased toughness and density and providing improved life span in applications with the ability to withstand greater stresses during typical use. The present disclosure further provides polyimide compositions with improved anti-friction or lubrication properties.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **Figure 1** represents friction and wear test material machined to a specific shape and size for testing on a Falex instrument.

[0011] **Figure 2** represents tensile strength of sintered parts plotted against % BPDA and % PPD in the polymer tested. The open symbols represent polymer compositions formed by blending BPDA-PPD homopolymer and PMDA-ODA homopolymer in different proportions. Filled symbols represent different copolyimide compositions of this invention. The tensile strength for copolymers is significantly higher than for blended polymers having the same composition of monomers.

[0012] **Figure 3** represents % Elongation at break of sintered parts plotted against % BPDA and % PPD in the polymer being tested. The open symbols represent polymer compositions formed by blending BPDA-PPD homopolymer and PMDA-ODA homopolymer in different proportions. Filled symbols represent different copolyimide compositions of this