Materials

Polyimides From a-BPDA and Aromatic Diamines

These polyimides have low color and high mechanical properties.

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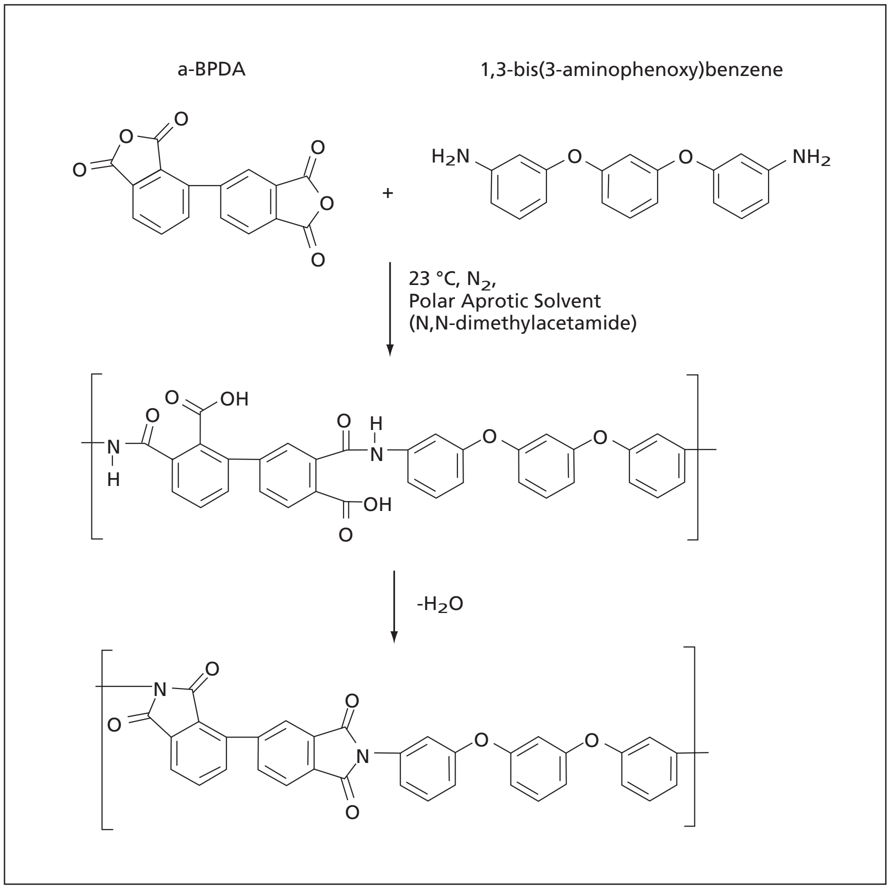
Polymers having low color and a favorable combination of other properties, including high glass-transition temperature (T_g) and high mechanical properties (strength, tensile modulus, and toughness) will find use in a variety of terrestrial and space applications. Some of the space applications will be in thin films used as membranes on antennas, solar concentrators, coatings on second-surface mirrors, solar sails, sunshades, thermal and optical coatings, and multi-layer thermal insulation blankets. Depending upon the application, the film will be required to exhibit a unique combination of such properties as resistance to degradation by ultraviolet light, visible light, and electrons; low color and/or low solar absorptivity; resistance to tearing and/or wrinkling during packaging and deployment; and high mechanical properties (e.g. high strength, stiffness, and toughness). Recently developed polyimides having several of these desired properties are described below.

These polyimides were prepared by reacting a unique aromatic dianhydride — 2,3,3′,4′-biphenyltetracarboxylic dianhydride (a-BPDA) — in polar aprotic solvents with aromatic diamines. The selection of the aromatic diamines enabled the tailoring of the polyimides to obtain low color plus combinations of other properties desired for specific applications.



A **Low-Color Polyimide Was Synthesized** from a-BPDA and 1,3-bis(3-aminophenoxy)benzene.

In the example of the figure, a-BPDA was reacted with 1,3-bis(3-aminophenoxy)benzene in N,N-dimethylacetamide, at a solids content of 20 weight percent, to obtain a polyamide acid having an inherent viscosity of 0.73 dL/g. A thin film cast from the polyamide acid on plate glass was stage-dried for 1 hour at a temperature of 250 °C in air. The 0.066-mm thick film was nearly colorless and exhibited a transparency of 86 percent at a wavelength of 500 nm. The T_g of the film was found to be 207 °C. At a temperature of 23 °C, the film exhibited the following tensile properties: strength of 16 kpsi (≈110 MPa), modulus of 476 kpsi (≈3.28 GPa), and elongation of 6 percent. The film acquired a pale yellow color when it was further cured for 1 hour at 350 °C in air. The T_g increased to 209 °C and the tensile properties at 23 °C changed slightly to strength of 18 kpsi (≈124 MPa), modulus of 476 kpsi (≈3.28 GPa), and elongation of 5.7 percent.

Polyimides derived from a-BPDA exhibited less color, and, accordingly, lower solar absorptivity and thermal emissivity, than did polyimides in general and particularly the corresponding polyimides made from the symmetric dianhydride, 3,3′,4,4′-biphenyltetracarboxylic dianhydride. The latter two properties are particularly important for use in outer space. Solar absorptivity pertains to the fraction of incoming solar energy that is absorbed by the film or, more precisely, a measure of light reflected by a second-surface mirror at wavelengths between 250 and 2,800 nm. The thermal emissivity is a measure of the ability of a film to radiate energy from its surface or, more precisely, a measure of the infrared transmission of the film. The ratio between solar absorptivity and thermal emissivity is more important than are the individual values of solar absorptivity and thermal emissivity because this ratio is more directly indicative of the temperature that a film or surface will attain in a particular orbit. Polyimides derived from a-BPDA have highly irregular structures that contribute to lower melt viscosities, and higher T_gs, than those of polyimides derived from the symmetric dianhydride.

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