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NASA TECH BRIEF

Ames Research Center

Polyimide Foams Provide Thermal Insulation and Fire Protection

Polymer foams may be used as flame-resistant insulative materials. When exposed to intense heat or flame, properly formulated foams maintain dimensional stability and provide an efficient thermal barrier because they form stable, integral chars which insulate and protect the substrates. New types of semi-rigid polyimide foams have been developed which have markedly improved thermal and physical properties in comparison to other polyimide foams. Under standard test conditions in a smoke chamber, an index of zero is registered, implying that negligible smoke is evolved by the new types of semi-rigid polyimide foams; the results of other standard tests indicate a low flame-spread index. Moreover, the foams retain resiliency and good dimensional stability at cryogenic temperatures.

The new polyimide foams can be prepared by mixing 100 parts by weight of an aromatic anhydride, such as pyromellitic anhydride, with 100 to 500 parts by weight of an aryl polyisocyanate, such as poly(methylenephenylene) polyisocyanate. From 2 to 40 parts by weight of a siloxane-oxyalkylene copolymer are added to this mixture as a foam stabilizer and initiator. Alkanolamines may be added in small amounts (0.1 to 10 percent by weight) to catalyze reaction. The materials are mixed at room temperature and then transferred to low or vertical-rise molds of any desired shape. The density of the resulting semi-rigid foams [about 0.2–0.08 g/cm^3(1–5 lb/ft^3)] can be varied by keeping the mixture at different temperatures during the rise; however, more precise control can be exercised by adjusting the concentration of surfactant in the mixture. Mixtures will cure slowly at 93°C or more rapidly at temperatures up to 316°C.

Preferred materials and ratios are briefly outlined below:

Ratio of diisocyanate to dianhydride: 150–300 parts by weight.

Water: a small amount should be present.

Ratio of foam stabilizer to polymer-forming species: 5–20 parts by weight silicone–glycol copolymer (2% or more hydroxyl termination) to 100 parts anhydride-isocyanate mixture.

Surfactant: DC193.

Alkanolamine: 1-Hydroxyethyl-3-heptadecenyl glyoxalidine, which can be added from 0.1 to 10 parts by weight of total reactants. The alkanolamine is also an effective emulsifier, and it contributes significantly to cell quality and texture; it also terminates the polymer chain, thereby increasing char yield. Other alkanolamines are effective as initiators, for example, triethanolamine and dimethylethanolamine. Conventional emulsifiers such as sulfonates, epoxidized soy bean oil, and blends of polyol carboxylic acids and their esters are less effective in the new foam mixture than in other foam compositions.

The basic formulation can be improved by adding silica or carbon fibers (0.8 to 6.35 mm long) at a concentration of from 5 to 8% of the total formulation. The fibers improve mechanical and physical properties such as strength, density, and char integrity during combustion of the cured polyimide foam.

Notes:

1. The developed formulations are especially attractive because they utilize commercially available materials and because there is no need to use complicated mixing procedures during polymerization.

(continued overleaf)

2. Requests for additional information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP72-10300

Patent status:

No patent action is contemplated by NASA.

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