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B72-10551

NASA TECH BRIEF

NASA Pasadena Office

PTFE Films with Improved Flexibility

The problem:

To produce highly flexible polytetrafluoroethylene (PTFE) films for the expulsion bladders used in spacecraft propellant tanks.

The solution:

Reduce the crystallinity of PTFE by annealing and then quenching in ice water.

How it's done:

An aqueous dispersion of PTFE is sprayed onto a shaped aluminum form to build up layers of about 0.13-mm (0.5-mil) thickness; each layer is sintered for 20—30 minutes at about 365°C and then allowed to cool. When the required film thickness has been obtained, the form is dissolved by caustic soda, leaving the film as a bladder with a small opening. A bladder produced in this way is somewhat brittle, especially at low temperatures, and can scarcely withstand the repeated flexures and creasings which occur when its liquid content is expelled by application of gas pressure to its outside. Flexing tests on bladders produced this way show that if a 3-corner crease is formed 5 to 10 times at the same place, the film will break.

The flexibility of PTFE bladders has been increased significantly by heat treating after the required film thickness has been obtained. Thus, after the final spray application, the film on the form is sintered for more than 24 hours at about 365°C and then immediately plunged into an ice-water bath so as to effect a cooling rate in excess of 20°C per second.

During the extended period of heating at about 365°C, crystallites in PTFE slowly break down, and the long molecules intermingle; rapid quenching prevents reforming of crystallites and, as a result, the quenched film is less crystalline and therefore less brittle.

Experimental results indicate that sintering times of at least 24 hours are required to reduce the crystallinity of PTFE films from more than 95 percent to less than 60 percent. Moreover, properly quenched films can resist 500 cycles of 3-corner flexure before rupture.

The permeability of PTFE films is a function of crystallinity, and the more crystalline films show the least permeability. For most rocket propellants, however, the permeability of quenched films is not sufficiently different from unquenched films to be of concern. However, the solubility of dinitrogen tetroxide in highly crystalline PTFE is about 3 times less than in essentially amorphous material. As a result, the permeation of dinitrogen tetroxide will be somewhat higher for heat-treated PTFE bladders than for those made in the usual way.

Notes:

1. The sintering temperature of 365°C is higher than the "melting" point of PTFE (327°C) and above the phase-transition temperature of 356°C. By mass spectrometry, it has been shown that PTFE does not pyrolyze at 365°C; decomposition is evident at 400°C.
2. A micro-scale crease-and-fold test apparatus is described in Tech Brief B72-10552.

(continued overleaf)

3. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP72-10551

Patent status:

NASA has decided not to apply for a patent.

Source: Raffaele F. Muraca and
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