Synthesis and Space-Survivability of Polyimides Produced from Novel Polyhedral Oligomeric Silsesquioxane Dianilines

Vandana Vij, [2] Sandra J. Tomczak, [1] Gregory R. Yandek, [1] Timothy Haddad, [2]
Joseph M. Mabry, [1] Timothy K. Minton, [3] Amy L. Brunsvold, [3]
[1]AFRL/RZSM, Materials Applications Branch, Air Force Research Laboratory,
10 E. Saturn Blvd, Bldg. 8451, Edwards AFB, CA 93524, USA,
E-mail: Vandana.vij.ctr@edwards.af.mil

[2]ERC Incorporated, Materials Applications Branch, Air Force Research Laboratory,
10 East Saturn Blvd, Bldg 8451, Edwards AFB, CA 93524, USA
[3]Department of Chemistry and Biochemistry, Montana State University, 108 Gaines Hall,
Bozeman, MT 59717, USA

Polyimides (PIs) are used extensively in many spacecraft materials, including solar arrays, thermal insulation blankets, and space inflatable structures. Upon exposure to atomic oxygen (AO) in low Earth orbit (LEO), these materials are severely degraded. An effective approach to prevent this erosion is the chemical bonding of polyhedral oligomeric silsesquioxanes (POSS) into the polyimide matrix by copolymerization of a POSS-diamine with the typical polyimide monomers. POSS is a silicon and oxygen cage-like structure surrounded by organic groups, which may be reactive. The copolymerization of POSS incorporates Si and O into the polymer matrix on the nano-scale. During POSS polyimide exposure to atomic oxygen, organic material is degraded and a silica layer is formed. This silica layer protects the underlying polymer from further degradation. Ground based studies have shown that POSS polyimides are resistant to LEO conditions.

We have synthesized several POSS monomers with variations in the diamine moiety, as well as their corresponding POSS polyimides. The atomic oxygen exposure has shown that copolymerization of POSS imparts similar AO resistance to polyimide materials, regardless of POSS monomer structure. It has also been demonstarted that POSS diamines can be polymerized into several polyimide backbones. Transmission electron and scanning electron micrographs, physical properties, and synthesis of POSS monomers and polyimides will be discussed. Findings on POSS dispersion and the silica layer on AO-exposed materials will also be discussed.