INFLUENCE OF MIXED FIELD RADIATION AND GAMMA RADIATION ON NANO ADHESIVE BONDING OF HIGH PERFORMANCE POLYMER

S. Bhowmik[a, *], R. Benedictus[a], J. A. Poulis[a], H. W. Bonin[b] and V. T. Bui[b]

[a]*Faculty of Aerospace Engineering, Delft University of Technology Kluyverweg 1, 2629 HS Delft, The Netherlands*
[b]*Department of Chemistry and Chemical Engineering, Royal Military College of Canada, Kingston, Ontario, K7K 7B4 Canada*

ABSTRACT

In this investigation, attempts are made to fabricate high performance polymer such as polybenzimidazole (PBI) (service temperature ranges from –260°C to +500°C) by nano silicate epoxy adhesive and to see its performance under space radiation. The polybenzimidazole sheets are fabricated by high performance nano adhesive i.e., by dispersing silicate nano powder into the ultra high temperature resistant epoxy adhesive (DURALCO 4703, the service temperature of the adhesive is –260°C to +350°C) with 2 to 20% weight ratios with the matrix adhesive. Prior to fabrication of polybenzimidazole sheet, the surface of the polybenzimidazole is ultrasonically cleaned by acetone followed by its modification through low-pressure plasma by using 13.56 MHz RF Glow Discharge with 30, 60, 120, 240 and 480 seconds at 100 W of power using nitrogen as process gas. It is observed that polar component of surface energy leading to total surface energy of the polymer increases with exposure time of low pressure plasma up to 120 seconds and then it saturates. Nano adhesive bonding of high performance polymer is exposed to two types of radiations (i) mixed field radiation for 24 hours at a

* Correspondence author
Tel: +31-15-27-84186; Fax: +31-15-27-81151;
Email: S.Bhowmik@TUDelft.Nl

dose rate of 37kGy/hr in the pool of a SLOWPOKE-2 (safe low power critical experiment) nuclear reactor and (ii) Co-60 irradiation with 100 % gamma radiation at a dose rate of 4 kGy/hr for 60 hours. Tensile lap shear strength reveals that when the polymer surface is modified by low pressure plasma, joint strength increases from 1 MPa to 13 MPa and increases further up to 23 MPa when the polymer is fabricated by nano silicate epoxy adhesive with increasing weight ratios of silicate nano powder up to 10% and then it deteriorates with the increasing weight ratio of silicate nano powder. When this nano silicate epoxy adhesive joint is exposed to high-energy radiation of mixed field, there is a further considerable increase in joint strength up to 30 MPa. However, when the nano silicate epoxy adhesive joint is exposed to 100 % gamma rays condition, joint strength deteriorates. Therefore, this is possible that mixed field radiation; basically increase the crosslink density of the adhesive resulting in increase in adhesive joint strength and in the second case: gamma radiation is detrimental and which could essentially makes chain scission to the basic adhesive and resulting in significant deterioration of joint strength. Finally, to understand the behaviour of nano silicate epoxy adhesive bonding of Polybenzimidazole, the fractured surfaces of the joints are examined by scanning electron microscope.

Keywords: adhesion; space durable polymer; space environments