Effect of electron irradiation on wear resistance of filled PTFE composites

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ABSTRACT

Polytetrafluoroethylene (PTFE) has received much attention for the last several decades as a self-lubricating material due to its exceptionally low friction coefficient. However, the poor wear resistance of pure PTFE limits its applicability to the systems such as bearings and gears. This poor wear resistance of pure PTFE has been greatly improved by adding various, micrometer-scale, and currently nanometer-scale hard fillers. Instead of adding hard fillers, many researchers have reported that an irradiation process can also drastically reduce the poor wear rate of pure PTFE by up to four orders of magnitude.

This study investigated the combined effect of irradiation on the wear rate of PTFE composites also containing hard fillers. Alpha-phase alumina of average particle sizes of $1\mu m$ (0.8 wt %), $20\mu m$ (0.8 wt %), and $40nm$ (0.8 wt % and 4 wt %) as well as micro-graphite (0.8 wt % and 4 wt %), nano-carbon (0.8 wt % and 2 wt %), diamond (< 10nm, 4 wt %), carbon nano-tube (2 wt % and 10 wt %), and graphene (2 wt % and 10 wt %) were used as fillers for the irradiated PTFE based composites. For comparison, unirradiated filled PTFE based composites were also tested in unirradiated form. The irradiation helped most of the lower filler content (0.8%, 2%, and 4%) PTFE composites further reduce wear rates, except 0.8% 20μm and 40nm alpha-phase alumina filled PTFE composites which already exhibit very low wear rates. It was not helpful for the more heavily filled 10% by weight PTFE composites containing graphene or carbon nanotubes, which also already exhibit very low wear rates in unirradiated form. The total wear volumes were also decreased for radiation induced lower filler content PTFE composites, except for 4% 40 nm alpha-phase alumina, 2% nano-carbon, 4% diamond, and 10% graphene filled composites.

Detailed results of the wear rates, transfer films, wear debris, and worn surfaces for all twenty-seven samples are presented with optical microscope images.