Effects of space environment

Physico-chemical degradation of plastic films is similar to that of bulk plastics, but the overall effects can be different owing to the particular aspects of films: thinness, need for flexibility, frequent need for stable optical properties.

Vacuum tends to extract additives from plastics, the consequence of which is a degradation of the properties thatwere stabilized by the additives (increase in rigidity and fragility when a plasticiser is lost, for example). Plastic films tend to stiffen as a result. There is also a great risk of contamination by evolved products, which are generally quite high-boiling-point chemicals. The exposed surface areas of plastics films are often large, consequently contamination dangers are high. Polyimides, TFE, FEP and polyterephthalates are generally safe in this respect. Multi-layer systems shall be properly vented to eliminate internal overpressure; these tend to accumulate large amounts of contaminants during handling and shall be baked under vacuum before integration into a spacecraft. In general, “pure” plastics, with the exception of PVC, polyamides, polyvinyl acetates and butyrates, are fairly safe to use, but it is difficult to assess this “purity”, since manufacturers tend to “improve” their products by adding chemicals. In addition it frequently happens that that processing aids or miscellaneous impurities stay absorbed in commercial plastics.The electrical insulation properties of these plastics, which tend to absorb water, are improved by the drying action of a vacuum.

Radiation: Both UV and particle, can modify plastic materials. The result is frequently discoloration accompanied by evolution of gas and hardening. Some fluorinated plastics are rather sensitive to particle radiation (PTFE is limited to 1Mrad) and shall not be used in such a way that it is fully exposed to space. However, a minimal amount of shielding reduces doses to acceptable levels.Other plastics are far more resistant and are not significantlymodified by particle fluxes encountered in space, particularly the filled or reinforced grades. UV damage is generally limited to a very thin surface layer and can be disregarded when optical properties are not a concern. Radiation is quite damaging for thin polymer films exposed to the total space environment. The primary effects are generally deformation, embrittlement and discoloration, which in turn affect the mechanical integrity and the thermal equilibrium of the devices concerned.TFEis very sensitive to particle radiation; polyterephthalates are damaged by solar UV. The best choice is FEP or polyimides (the latter being normally yellow). Radiation effects are frequently increased by impurities and oxidation consecutive to processing.

Temperature: High temperatures soften thermoplastics and degrade polymer films.The low thermal conductivity of “bulk” thermoplastics makes it difficult to eliminate heat except when a suitable filler is present (metal powder for example). Most plastics harden significantly and become brittle at temperatures lower than their “glass-transition temperature”. Fluorinated polymers and polyimides can be used over awide range of temperatures from cryogenic to more than 200 ºC. Thermal cycling can be damaging to some metallized films where tiny metal flakes can loosen and contaminate the vicinity.

Atomic oxygen attacks thermoplastics and affects polymer films with a carbon/ hydrogen skeleton. Protection layers such as SiOx or ITO can be applied in most cases. FEP is sensitive to the combination of ATOX and UV light.