Effects of Tritium Gas Exposure on Polymers

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In spite of the deleterious effects of irradiation on polymers, various thermoplastics and elastomers are employed in tritium handling systems. These materials are almost always used in sealing applications, for example valve stem tips, valve packing, and in pumps and compressors. The susceptibility of polymers to radiation damage means that any facility using polymeric components must regularly maintain and replace them according to their known service lifetime. The unique properties of polymers are so compelling that they are used in tritium systems in spite of their limited life and maintenance cost. Also, polymers have been developed that have the potential for use as the sensing material in a tritium detector as well as a semi-permeable medium to process tritiated water. This study contains an overview of the polymers studied for various tritium-related applications at the Savannah River Site.

A program to study the properties and degradation of various polymers when exposed to significant quantities of initially pure tritium gas has been underway at the Savannah River Site for a number of years. The goals of this program include studying the rate of material property changes with time for various polymers of interest, and characterizing the amount and species of gas produced by radiolysis. Applications of this understanding include improved materials selection, and also a better understanding of radiolytic gas generation and other degradation products, and improved radioactive waste characterization. Two materials were studied to evaluate their use in a tritium sensing system and one material for a permeable membrane for hydrolysing tritiated water. Materials that have been studied include ultra-high molecular weight polyethylene (UHMW-PE), polytetrafluoroethylene (PTFE), Vespel® polyimide, ethylene propylene-diene monomer (EPDM) elastomer, two types of conductive polymer, polyaniline (PANi) and poly (3,4-ethylenedioxythiophene) (PEDOT) (potential tritium sensor materials), and Nafion® (potential hydrolysis membrane). Polymer samples have been characterized by dynamic mechanical analysis (DMA) (including changes in Tg); mass, volume, and density changes; colorimetry and visual appearance; electrical conductivity; infrared spectroscopy; and bend testing. The exposure gas was characterized after exposure by measuring total pressure at the end of exposure (exposures were performed in closed containers), and the composition was determined by mass spectroscopy.