Effect of Tritium Gas Exposure on the Dynamic Mechanical Properties of Polymers

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Background

- Polymers commonly used for O-rings, valves, gaskets and other seals in commercially available fluid handling system components: pumps, instrumentation, …
- Radiation damage of polymers makes them undesirable in tritium processing systems. But: inevitably polymers are used. Limited lifetime makes materials selection and testing during use important.
- Goal of this study: improve understanding of polymeric materials property changes when exposed to tritium gas.

Materials Studied

- Thermoplastics
  - Ultrahigh molecular weight polyethylene (UHMW-PE)
  - Polytetrafluoroethylene (PTFE) (eg. Teflon®)
  - Vespel® polyimide (SP-1 unfilled grade)
- Elastomer- Ethylene Propylene Diene Monomer (EPDM)
  - Nordel™ 1440 (filled & unfilled)
  - Royalene® 580 (filled & unfilled)

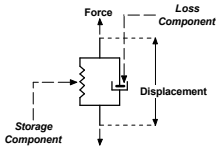
Tritium Exposure

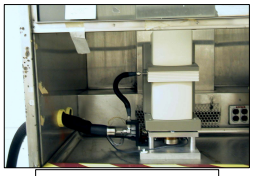
- 1 atmosphere 100% Tritium gas
- Ambient temperature
- Various times

Stainless Steel Exposure Container

Characterization Method: Dynamic Mechanical Analysis

- Modulus = Force/Displacement (small displacement)
- Storage Modulus K'- Measure of Stored Elastic Energy in Polymer, Equivalent to Spring Constant
- Loss Modulus K''- Measure of Energy Dissipation/Loss in Polymer, Equivalent to Viscous Flow/Dashpot
- Tan δ = K''/K'
- DMA Measures Force, Displacement and Phase Angle δ (Between applied force, resulting displacement), Calculates K', K''

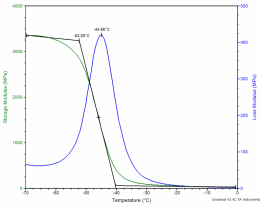




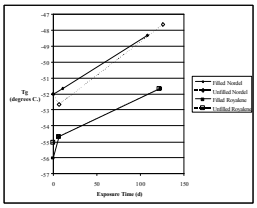
DMA in Tritium Hood

Measuring Tg using DMA

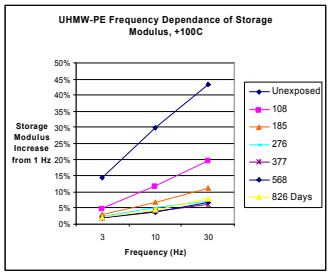
- ASTM E 1640: Storage modulus tangent intersection versus temperature curve; 1 Hz, heating rate of 1 ° C/minute
- Loss modulus peak



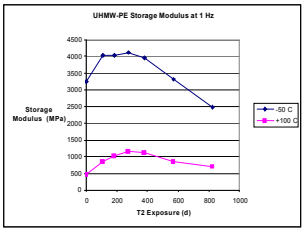
Filled Nordel® 1440: Tg by ASTM E-1640 (-52° C.) and by Loss Modulus (-52° C.)



EPDM Tg increases with tritium exposure- Royalene Tg lower than Nordel



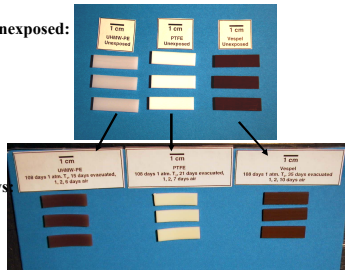
UHMW-PE storage modulus frequency dependence decreases with tritium exposure



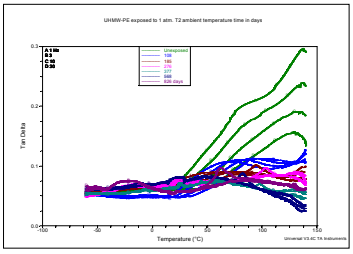
UHMW-PE storage modulus increases then decreases with tritium exposure

Unexposed:

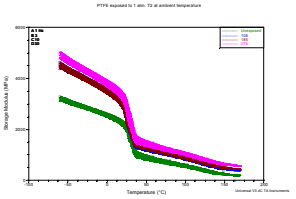
108 Days:



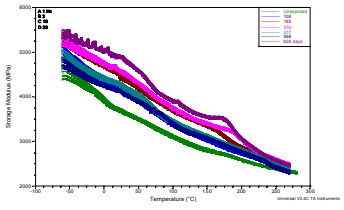
Sample Color Changes with Tritum Exposure



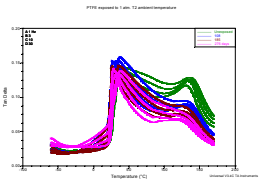
UHMW-PE tan delta at elevated temperature decrease with tritium exposure



PTFE storage modulus: decreases with tritium exposure, crystallographic transition unaffected



Vespel®- no effect of tritium exposure



PTFE tan delta- initial decrease with tritium exposure

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