SAND2017-7692D

Evaluating the Integrity of Teflon Wire Insulation

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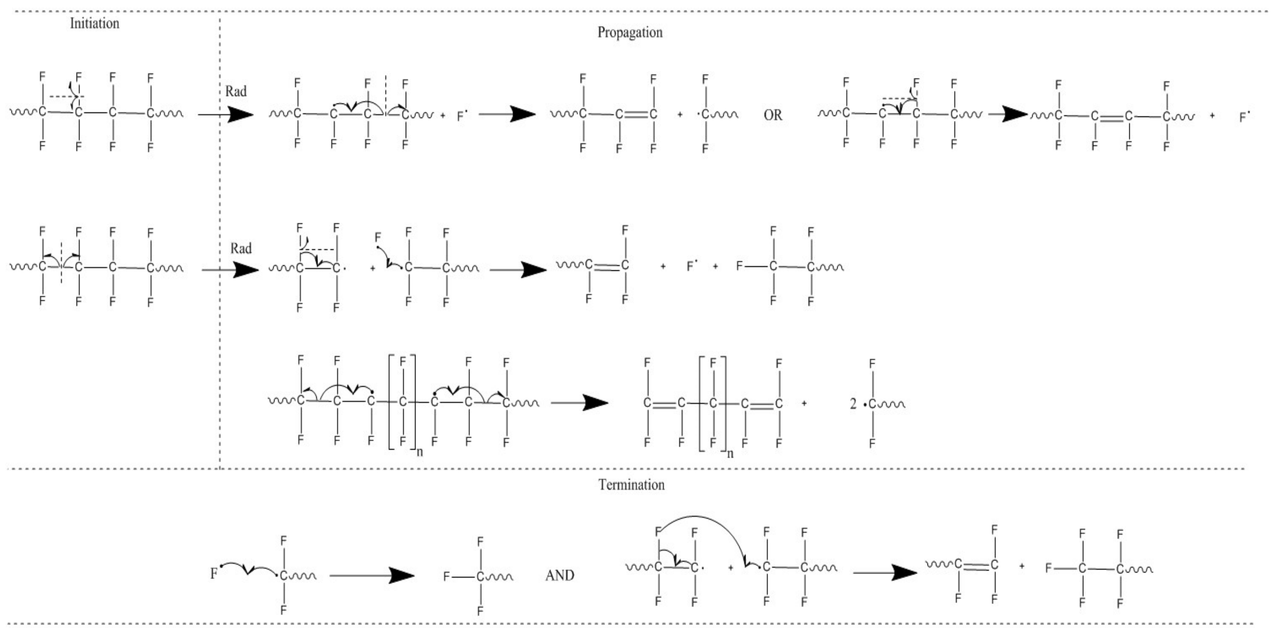
Objective

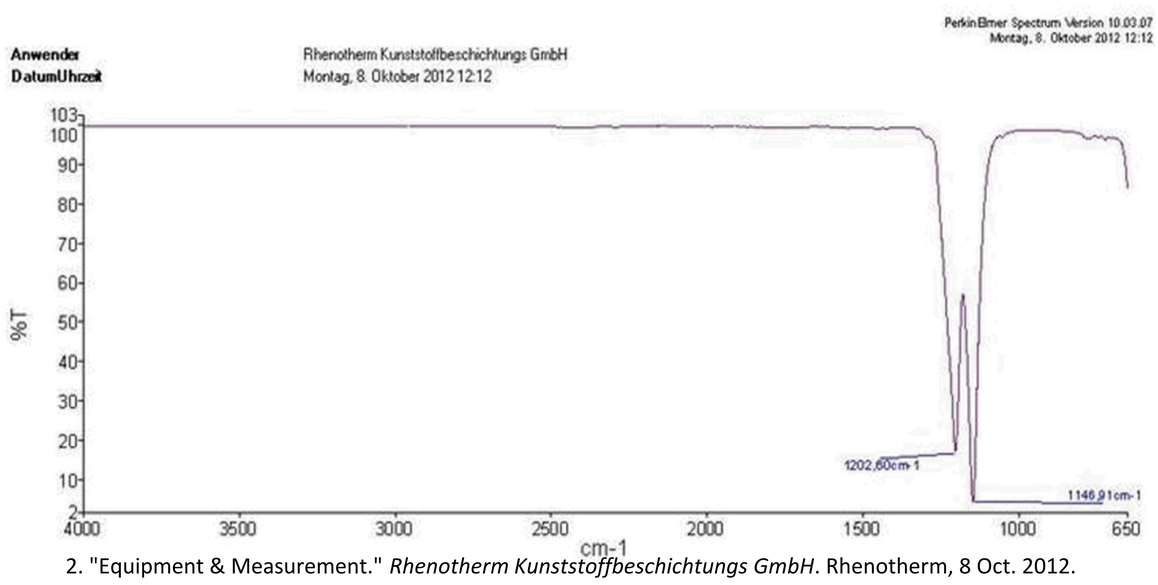
When exposed to radiation, many materials experience structural or chemical changes which lead to a reduction in strength, ductility or other desired parameters. The material in focus is poly tetra-flouroethylene(PTFE) or Teflon. Teflon is especially vulnerable to radioactive damage due to its Fluorine atoms. When Fluorine is separated from the Teflon structure, its high electronegativity causes it to react with other radicals and break the carbon backbone as illustrated below.[1]This can also cause crosslinking between separate Teflon chains, decreasing ductility. The goal of this experiment is to observe the level of deterioration experienced by Teflon insulated wiring that has been exposed to radiation.



1. Kunkwitz, K., D. Handte, and A. Ferse. "The Radiation Degradation of Polytetrafluoroethylene Resulting in Low-molecular and Functionalized Perfluorinated Compounds.". Akademie Der Wissenschaften Der DDR, Institut F/Jr Technologie Der Polymere, 10 Sept. 1998.

Methods

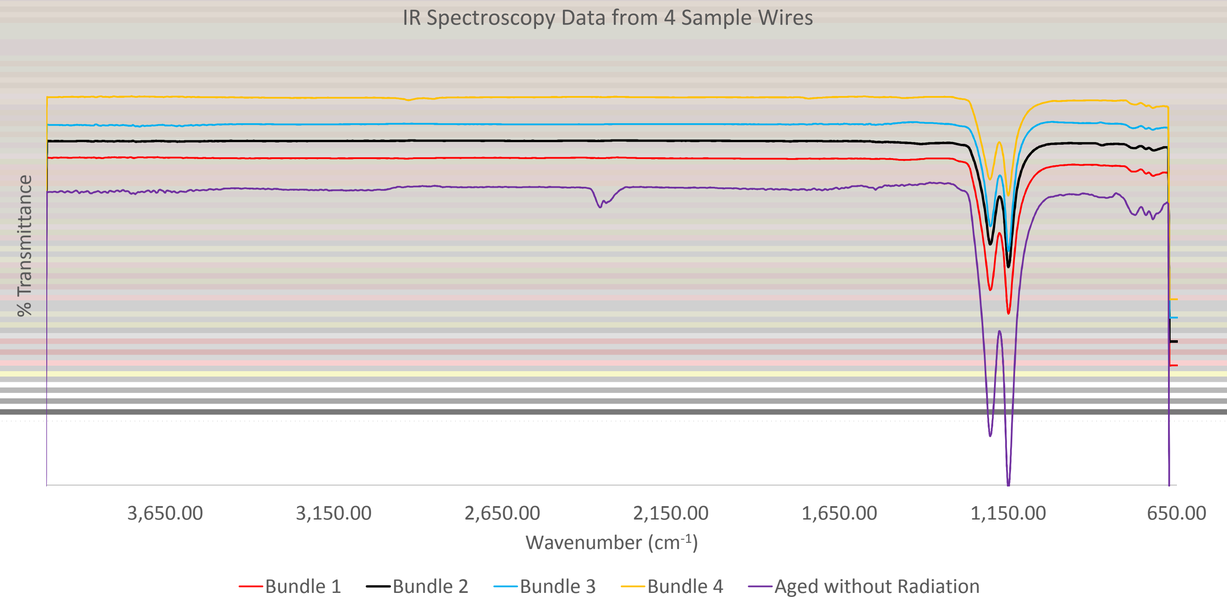
For this experiment, Teflon samples exposed to varying levels of radiation were tested and observed using IR Spectroscopy and a Keyence digital microscope. With the digital microscope, small signs of degradation, such as cracks or peeling, can be detected. With IR spectroscopy, degradation can be determined by comparing the collected results with documented data for unaffected PTFE.[2] Significant discrepancies are signs of physical and chemical change.



Left: IR spectroscopy data for pristine PTFE samples

2. "Equipment & Measurement." *Rhenotherm Kunststoffbeschichtungs GmbH*. Rhenotherm, 8 Oct. 2012.

Results



Above: Average IR data for a sample of four wires tested
Bottom Left: A section of Bundle 1 at 30X magnification
Bottom Right: The same section of Bundle 1 at 100X

The IR data shows some signs of degradation in the PTFE compared to the pristine and unirradiated data , especially from Bundle 4. The lower absorption at 1146-1202 cm^{-1} shows a reduction in C-F bond concentration; which would signify crosslinking or scission reactions are occurring. Since there are no other peaks observed, C=C bond formation is not happening at a significant rate. From the Keyence images, some peeling can be seen on the surface of the Teflon. This shows that there is slight degradation occurring which would affect the tensile strength and structural integrity of the Teflon.

Impact and Future Work

Observing these changes demonstrates the long-term effect that occurs when materials are exposed radiation. Although the degradation is mild; over time, this damage will make the Teflon unsuitable or even fail at loads that new samples would easily survive.[3] Tensile tests are currently being performed to determine the Teflon's change in strength. Future tests would involve exposing the Teflon to varying levels of radiation to determine the upper limits of its resistance.

3 Dever, Joyce A., Kim K De Groh, Bruce A. Banks, and Jacqueline A. Townsend. "Effects of Radiation and Thermal Cycling on Teflon ® FEP." *High Performance Polymers*. Sage Journals, 1 Mar. 1999..

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