Measuring low-dose radiation effects in polymers using DSC for forensic applications

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Abstract:

The enrichment of uranium via gas centrifuges has the potential to be diverted towards the proliferation of nuclear weapons. This challenge cannot be addressed by existing forensic techniques, as they cannot adequately reconstruct the historical enrichments from centrifuge plants. Since radiation is emitted by uranium isotopes, this radiation will interact with the surroundings and may leave behind signatures based on the characteristics of the radiation. However, a simple enrichment model shows that the expected radiation doses are very low. Thus, our work focuses on demonstrating the radiation sensitivity of materials that might be used in centrifuge technology. We use differential scanning calorimetry (DSC) to measure thermal properties of irradiated materials such as polytetrafluoroethylene (PTFE), a common gasket material. For samples exposed to more radiation, microscopic changes to the material change the crystallization behavior of the PTFE and increase the melting enthalpy. Based on our measurements, PTFE is sufficiently sensitive to radiation such that, if it were exposed to radiation emitted by enriched uranium, its forensic signature could be used to deduce characteristics of that uranium. To link these laboratory measurements to their envisioned application, we also propose a method for field sampling and measurements using Flash DSC. Through demonstration of sensitivity and implementation of these techniques, this work has the potential to address the enrichment technology dual-use challenge.