



# Stable Element Doping of Sol-gel Toward Simulating Environmental Matrix in Surrogate Explosive Nuclear Debris

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*Changing the World's Energy Future*

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Training nuclear forensic analysis personnel in post-detonation scenarios is of critical importance to nuclear threat response capabilities. Thus, realistic nuclear debris simulants which resemble the size, color, elemental composition, and radionuclide content of actual nuclear fallout from a recent detonation would be valuable for training nuclear first responders in realistic scenarios. As nuclear fallout types vary significantly in each of these parameters based on detonation environment (rural, urban, maritime etc.) and collection location, the ability to tailor each of these parameters accurately in simulated debris would be of immense benefit to the post-detonation analysis community for training both in-field collections and triage and the validation of laboratory level nuclear forensic techniques.

Sol-gel synthesis techniques can provide the tunability of size, shape and composition required for producing surrogate nuclear debris of a wide variety. The sol-gel process consists of forming a metal oxide material, often silica, through polymerization of a metal-alkoxy precursor. In this work, we characterize the ability to load the sol-gel particles with secondary elemental components such as iron, aluminum, and calcium toward approximating the elemental composition of debris from various detonation environments and demonstrate the ability to produce particles with controllable size, shape, and color. We also demonstrate quantitative radionuclide encapsulation toward reproducing the radionuclide content of actual fallout from a recent detonation. Finally, we then employ these techniques in producing simulated aerodynamic debris samples with realistic elemental matrix composition and radionuclide content simulating a recent uranium-fueled detonation taking place in a rural desert environment and compare it to historic fallout from the Nevada Nuclear Security Site.