

Investigating the use of MOF-derived nano-PIEs to improve thermal ionization efficiencies of actinides

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In the field of nuclear non-proliferation, the precise isotopic characterization of low-level samples by thermal ionization mass spectrometry (TIMS) relies on maximizing the generation of charged particles. Without specialized sample preparation and loading methods, >99.95% of the sample is never detected. We present recent results in the development of nano-porous ion emitters (nano-PIEs) which utilize metal organic frameworks (MOFs) as scaffolds. The modular MOF framework enables us to customize the structure and composition of the nano-PIE to deconvolute the roles of each in promoting ionization. For example, within the MOF-74 family, changing the metal node can impact the sample utilization efficiency (SUE). We observe that features typically thought to predict enhanced ionization, such as ionization energies and work function of metallic components, do not correlate to SUE; however, thermal properties such as boiling point and heat of vaporization do correspond to observable trends. The observed trend in MOF-74 metal nodes show that average SUEs of uranium loaded with lower boiling point metal nodes (i.e., Mg, Zn, Cd) are about two times higher than those with higher boiling points (i.e., Ni, Co). We hypothesize there may be an optimum range in these properties that balances metal loss as neutral volatiles and efficient ion formation. Additionally, recent SEM imaging of nano-PIEs exposed to and quenched at different run conditions show that material with crystalline and porous features remains on the filament to temperatures in excess of 1700 °C, well beyond expected stability of MOFs, albeit in minute quantities. These results suggest that further preservation and adherence of nano-PIEs on the filament through alternate loading approaches may improve overall performance.