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Towards Improved Sample Utilization: Development of filament loading techniques for trace isotopic analyses by TIMS

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Thermal ionization mass spectrometry (TIMS) has long been considered the 'gold standard' for isotopic analysis. In contrast to plasma-based methods, where transmission hinders sample utilization efficiency (SUE), the ability of atoms to volatilize and ionize is the primary process inhibiting sample utilization efficiency (SUE) in TIMS, often limiting its widespread use. Many TIMS methods which boast >1% SUE are time and labor intensive, requiring customized equipment, and challenging to transfer between different laboratories (e.g., resin beads, porous ion emitters). Our group focuses on developing new filament loading techniques to overcome these limitations with both physical modifications and the use of activators. One approach has been to use laser ablation to precisely define an emission region with a method called solution-loaded laser ablation modified source (SLLAMS). Here we have demonstrated up to 2% SUE on femtogram quantities of plutonium. Current research focuses on the development of engineered, nano-porous ion emitters (which we are calling nano-PIES). Metal organic frameworks (MOFs) are used as precursors to generate high surface area structures with controlled synthetic chemistries. By capitalizing on the inherent tunability of MOFs (*i.e.,* adjustable surface area, metal incorporation, and targeted sorption behaviors), they have potential to act as an all-in-one platform to construct nano-PIEs. Preliminary results show promise for these materials to be customized for this application with a SUE of ~1% on picograms of neodymium with MOF-253 and 10x improvement in uranium emission with MOF-74. Sample utilization efficiency experiments have been designed to vary surface area, porosity, and metal composition of the MOF to better understand their role in improving ionization. Recent results demonstrate the importance of the mass of nano-PIE on the filament itself where less material produces higher SUEs which we attribute to be a function of ion permeability.