RESONANCE IONIZATION MASS SPECTROMETRY FOR ISOTOPIC ABUNDANCE MEASUREMENTS; C. M. Miller, Los Alamos National Laboratory

Resonance ionization mass spectrometry (RIMS) is a relatively new laser-based technique for the determination of isotopic abundances. The resonance ionization process depends upon the stepwise absorption of photons from the laser, promoting atoms of the element of interest through progressively higher electronic states until an ion is formed. Sensitivity arises from the efficiency of the resonant absorption process when coupled with the power available from commercial laser sources. Selectivity derives naturally from the distinct electronic structure of different elements. This isobaric discrimination has provided the major impetus for development of the technique.

Resonance ionization mass spectrometry in our laboratory has been explored for analysis of the isotopic abundances of the rare earth lutetium. Isobaric interferences from ytterbium severely affect the ability to measure small amounts of the neutron-deficient Lu isotopes (mass 170-174) by conventional mass spectrometric techniques. Separation chemistry is of limited utility to date in eliminating the ytterbium interferences.

Resonance ionization for lutetium is performed using a continuous-wave laser operating at 452 nm, through a sequential two-photon process, with one photon exciting the intermediate resonance and the second photon causing ionization. Ion yields for microgram-sized quantities of lutetium lie between 10^6 and 10^7 ions per second, at overall ionization efficiencies approachiung 10^{-4}. Discrimination factors against ytterbium greater than 10^6 have been measured. Table 1 shows the results of a recent analysis of a 60 nanogram Lu sample, where the RIMS ratios are compared to thermal ionization ratios. The effect of isobaric Yb in the latter is readily apparent. Also, it should be noted that the ^{173}Lu content of the sample was only 10^8 atoms.

Resonance ionization for technetium is also being explored, again in response to an isobaric interference, molybdenum. Because of the relatively high ionization potential for Tc, three-photon, two-color RIMS processes are being developed. A variety of these schemes have been cataloged, virtually assuring a selective excitation process can be found. To date, however, sensitivity has been limited, with ionization efficiencies of only 10^{-8} demonstrated. Evidence exists for a molecular Tc species that is not responsive to resonant excitation. Development work for Tc RIMS is continuing.

Table 1 - Isotope Ratio Measurements

Ratio	RIMS (Lu alone)	Thermal (Lu and Yb)
173/175	4.4×10^{-7}	3.36×10^{-3}
174/175	3.62×10^{-6}	9.29×10^{-4}
176/175	2.64×10^{-2}	2.63×10^{-2}