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Lower the Detection Limits of Accelerator Mass Spectrometry

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Over the past 15 years, several groups have incorporated radio-frequency quadrupole (RFQ) based instruments before the accelerator in accelerator mass spectrometry (AMS) systems for ion-gas interactions at low kinetic energy (＜40 eV). Most AMS systems arebased on a tandem accelerator, which requires negative ions at injection. Typically, AMS sensitivity abundance ratios for radioactive-to-stable isotope are limited to Xr/Xs ＞10^-15, and the range of isotopes that can be analyzed is limited because of theneed to produce rather large negative ion beams and the presence of atomic isobaric interferences after stripping. The potential of using low-kinetic energy ion-gas interactions for isobar suppression before the accelerator has been demonstrated for several negative ion isobar systems with a prototype RFQ system incorporated into the AMS system at IsoTrace Laboratory, Canada (Ontario, Toronto).

Requisite for any such RFQ system applied to very rare isotope analysis is large transmission of the analyte ion. This requires proper phase-space matching between the RFQ acceptance and the ion beam phase space (e.g. 35 keV, φ 3 mm, +-35 mrad), and the ability to control the average ion energy during interactions with the gas. A segmented RFQ instrument is currently being designed at Korea Institute for Science and Technology (한국과학기술연구원, KIST). It will consist of: a) an initial static voltage electrode deceleration region, to lower the ion energy from 35 keV down to ＜40 eV at injection into the first RFQ segment; b) the segmented quadrupole ion-gas interaction region; c) a static voltage electrode re-acceleration region for ion injection into a tandem accelerator. Design considerations and modeling will be discussed.

This system should greatly lower the detection limits of the 6 MV AMS system currently being commissioned at KIST. As an example, current detection sensitivity of 41Ca/Ca is limited to the order of 10^-15 while the 41Ca/Ca abundance in modern samples is typically 41Ca/Ca～10^-14 - 10^-15. The major atomic isobaric interference in AMS is 41K. Proof-of-principal work at IsoTrace Lab. has demonstrated that a properly designed system can achieve a relative suppression of KF3-/ 41CaF3- ＞4 orders of magnitude while maintaining very high transmission of the 41CaF3- ion. This would lower the 41Ca detection limits of the KIST AMS system to at least 41Ca/Ca～

10^-19. As Ca is found in bones and shells, this would potentially allow direct dating of valuable anthropological archives and archives relevant to our understanding of the most pronounced climate change events over the past million years that cannot be directly dated with the presently accessible isotopes.

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