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5-stage multielement separation procedure: A unique and essential tool for the multi-isotopic analyses of precious (< 30 mg) meteorites and asteroidal materials

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Existing understanding of the chemical composition and the formative processes of our early Solar System has mainly come from studies of the elemental abundance and multi-element isotopic investigations of the available meteorite collections[1] [2]. There are several target elements for these isotopic studies, that vary from trace elements (e.g. Sr, REEs) to major elements (e.g. Ca, Cr). Such studies are limited to the meteorites for which sufficient sample amounts are available. Therefore, it is of utmost importance (and a challenge) to develop a chemical separation procedure in which, from a limited amount of such precious samples (<30 mg), trace and major elements can be extracted and purified to carry out the respective isotopic analyses. We have developed such a 5-stage multi-element separation procedure over the last three years. This method has important applications, which could be beneficial to the ongoing and future sample return missions such as Hayabusa2, OSIRIS-REx and MMX.

Our procedure is designed for the separation of the trace elements first, followed by purification of the major elements at the final stage (Fig 1). Therefore, anion-exchange resin is used in the initial stages (1–3), and cation exchange resin is used only in the final stage 5. Pb is separated first to keep the blank levels to a minimum. In the same stage, Zn, Highly Siderophile Elements (HSEs) and Pd are also extracted from the sample matrix. In stage 2, High Field Strength Elements (HFSEs) are separated followed by removal of Fe and U in stage 3. Stage 4 makes use of extraction chromatographic resins – Sr-Resin and RE-Resin, in tandem assembly to respectively extract Ba, Sr and REEs-Th as group. In final stage 5, Ca, Cr, Al and Mg-Ni-K as group are extracted using tandem column assemblies of DGA Resin and a cation exchange resin. This is a robust method through which we can separate a minimum of 15 elements from ~ 25 mg sample with high recovery yields (> 90 %).

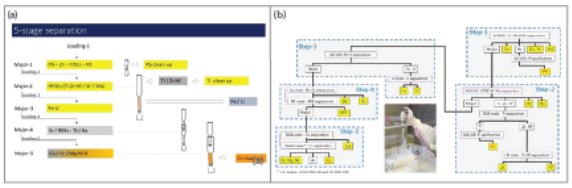

Figure 1. Schematic of the five-stage chemical separation procedure. (a) Color code for the boxes: yellow – AG 1-X8 resin; grey – Eichrom's extraction chromatographic resins like SR, RE, DGA, UTEVA; orange – 1:1 mixture of AG 50W-X8 and AG 50WX-12. (b) Details of the five stages of separation.

References:

[1] Krot et al. (2014) Treatise on Geochem. 2nd ed Chap. 1.1.

[2] Wadhwa (2014) Treatise on Geochem. 2nd ed Chap. 1.12.