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Rapid, two-step chromatographic purification of Mg, K, Ca, Fe, Cu, Zn, and Pt from a single sample aliquot prior to isotopic analysis via MC-ICP-MS

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In the last 20 years, the application of high-precision isotopic analysis of essential mineral elements in biomedicine has demonstrated that their stable isotopic compositions are altered by the metal dysregulation that is fundamental to the pathogenesis of cancers and other diseases [1,2]. This has revealed a number of promising prospective stable isotope-based biomarkers, including a commercially-available early detection method for osteoporosis using Ca isotopic analysis of urine or blood [3]. Recently, the combination of 10^{13} Ω amplifiers to improve signal-to-noise ratio and an aerosol desolvation system hyphenated to the multi-collector ICP-MS unit to improve sensitivity have enabled the accurate and precise determination of metal isotope ratios in microsamples, such as cerebrospinal fluid [4–7]. However, such investigations have predominantly been limited to the analysis of a single element from a sample aliquot, with information from other biologically relevant elements lost during chromatographic purification. With the goal of maximizing the amount of isotopic information extracted from precious, low-volume patient samples, we have developed (and validated with a range of matrix reference materials) a two-step chromatographic purification of six essential mineral elements (Mg, K, Ca, Fe, Cu and Zn) and Pt, a key component of several widely used chemotherapeutic compounds. First, Cu-Fe-Zn-Pt are sequentially purified with anion exchange chromatography using HCl and HNO_3, and the matrix fraction, containing Na, Mg, K, and Ca, is collected. From the matrix fraction, K-Mg-Ca are sequentially purified with cation exchange chromatography using HCl in a vacuum box to significantly speed up the separation. Beyond biomedicine, the procedure we developed may also be relevant to researchers in other fields with limited sample availability (archaeology, anthropology, cosmochemistry) or logistical challenges associated with returning large samples from remote areas (hydrogeochemical mineral exploration, environmental geochemistry).

References

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