

# **Experimental determination of equilibrium isotope fractionation factor between V(V) sorbed to goethite and liquid at 21°C**

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Vanadium is a critical commodity, intrinsic to the development of renewable technologies, such as energy efficient batteries, in addition to its established role in the steel industry as a strengthening agent. Although V enables beneficial socio-economic technologies, its release to soils, sediments and waters is increasingly recognised as a serious environmental hazard. Thus, pinpointing the sources and delineating the pathways of V release is important. There are, however, obstacles to this undertaking. First, natural surface substrates span orders of magnitude in V concentration. Second, V is a multi-valent element and its toxicity of V is dependent on both its concentration and speciation. Simply put, it is challenging to use V concentrations to vector towards contaminants, and, paradoxically, soils and waters with lower V concentration can be more hazardous than those with higher concentration, depending on V speciation. The most toxic species of V involves V(V), due to its ability to mimic phosphates and interfere with enzyme activity. Unfortunately, anthropogenic activities generally release V in the form V(V) vanadate oxyanions (e.g.,  $\text{H}_2\text{VO}_4^-$ ). There is currently no single method able to determine V speciation of both solid and dissolved phases to enable V hazard assessment in surface environments. We are developing a novel, unifying approach to circumvent these challenges via the calibration of V equilibrium stable isotope fractionation factors in response to speciation at controlled experimental conditions. Here we present preliminary data for the sorption of V(V) on goethite, a process which has been investigated in detail<sup>1</sup>. Our preliminary isotope data has several striking features: 1) the experiments achieved V isotopic equilibrium between solid and liquid, 2) they provide the first confirmation of theoretical predictions<sup>2</sup> that goethite preferentially sorbs light V, and 3) there is a constant liquid-solid V isotope fractionation factor of 0.5 to 0.6 per mil. The consistency and magnitude of the fractionation factor indicates that it will be feasible to apply experimentally determined fractionation factors to well-characterised surface environments to deduce V speciation and thus assess potential risks.