Triple oxygen isotopic composition of hydrogen peroxide produced in water radiolysis and implications for early Earth and Mars

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Radical chemistry induced by high-energy radiation from cosmic rays and long-lived radionuclides plays a vital role in planetary processes in the early Solar System and may contribute to the origin of life on Earth. Hydrogen peroxide produced in water radiolysis might have been a primordial source of molecular oxygen and a crucial component in mineral weathering and early metabolism, but its actual role in ancient terrestrial and Martian environments is yet to be well defined, in part due to the lack of observational evidence. Mass independent O-17 isotopic anomalies ($\Delta^{17}O$) recorded in geological and meteoritic samples have been utilized to understand the early Earth, Mars, and Solar System [1]. A study showing that $\Delta^{17}O$ in hydrogen peroxide heterogeneously formed in the modern atmosphere might be transfered to carbonates through surface reactions provided additional insights into the origin of carbonate $\Delta^{17}O$ in ALH84001 and its geochemical implications [2]. Potential mass-independent reactions in hydrogen peroxide production (photolysis and gas-phase discharge of water vapor) were recently experimentally investigated but remain elusive [3-4].

In this study, we use the Tokyo Tech Co-60 Gamma Radiation Facility as a radiation source (~1.3 MeV) to investigate triple oxygen isotopic fractionation in hydrogen peroxide during water radiolysis and its possible interaction with minerals (e.g., carbonate). This study may shed fresh light into basic chemical physics of mass independent reactions and also potentially provide new interpretation of geological and meteoritic records. Experiments are currently underway and results will be presented and discussed.

References: [1] Thiemens (2016), Annu. Rev. Earth Planet. Sci. 34, 217-262; [2] Shaheen et al. (2010), PNAS, 47, 20213-20218. [3] Velivetskaya et al. (2016), GCA, 193, 54-65. [4] Velivetskaya et al. (2018), Chem. Phys. Lett., 693, 107-113.