

【Grant-in-Aid for Scientific Research (S)】

Integrated Disciplines (Environmental Science)



Title of Project : Environmental diagnosis with isotopologue tracers

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Research Project Number : 17H06105 Researcher Number : 60174942

Research Area : Environmental Cycle Analysis, Environmental Chemistry

Keyword : Material cycle, Biogeochemistry, Stable isotope, Isotopomer, Isotopologue

【Purpose and Background of the Research】

Since the 1950's, the stable isotope composition of natural samples has proved to be a unique tool for the study of geological and biological processes, their evolution and effect on Earth's surface environment. However, due to technical and conceptual limitations, the complete set of information potentially contained in the different modes of isotopic substitution remains largely unexplored. In this project, using new methodological developments that allow analysis of more isotopically substituted molecules, we will develop new tracers in 3 isotopologue modes (Fig.1), fully integrated in the study of geological, biological and anthropogenic processes which affect the evolution of the Earth's surface environment.

【Research Methods】

1) Position specific isotope analysis (PSIA): Our group has pioneered PSIA of N_2O ^{1,2)} and organic molecules using classic isotope mass spectrometry³⁾

and nuclear magnetic resonance^{4,5)}. We have shown that PSIA of hydrocarbons and organic acids allows to distinguish between biological and non-biological processes^{4,6)}.

2) Mass-independent fractionation (MIF): The discovery of MIF of sulfur and oxygen in terrestrial samples has revolutionized environmental geochemistry and our understanding of the evolutionary history of the Earth's environment and life⁷⁻⁹⁾.

3) Clumped isotopes (i.e. isotopologues with 2 minor isotopes) provide unique information about the temperature history of molecules such as carbonates¹⁰⁾ or organic compounds¹¹⁻¹³⁾.

We will develop new and improved tracers of environmental and biogeochemical processes and apply them to the environmental diagnosis (Fig. 2).

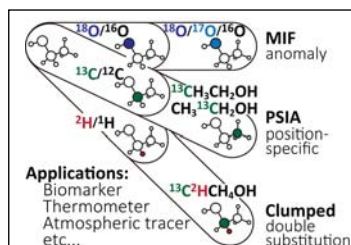


Fig.1. Et-OH isotopologues

【Expected Research Achievements and Scientific Significance】

We will establish and standardize new methods for the analyses of every 3 complex modes of isotopic substitution, and unifying them to develop ultimate environmental

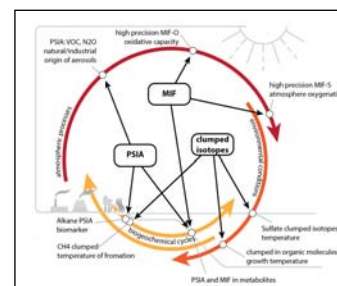


Fig. 2. Ultimate diagnosis

diagnosis. The development and application of these new isotopic tools to the environment evolution, in modern and more ancient eras, represents an important conceptual advance in Earth and life sciences. This will open new areas of research about, for example, the geological production of some atmospheric gases, metabolic processes and the biological fixation of atmospheric CO_2 , the production and cycling of pollutant gas by industrial processes.

As a whole, these new tracers will be integrated together for diagnosis of the Earth's environment.

【Publications Relevant to the Project】

1)Yoshida & Toyoda, 2000 *Nature*; 2)Yamazaki, Toyoda, Yoshida, et al., 2014 *Biogeosciences*; 3)Yamada, Yoshida, et al., 2002 *RCM*; 4)Gilbert, Yamada, Yoshida, 2013 *Anal. Chem.*, and 5) 2014 *Anal. Chim. Acta*; 6)Gilbert, Yamada, Ueno, Yoshida 2016 *Geochim. Cosmochim. Acta*; 7)Danielache, Ueno, Yoshida et al., 2008 *J. Geophys. Res.*; 8)Hattori, Danielache, Ueno, Yoshida et al., 2013 *PNAS*; 9)Ueno, 2015 *Science*; 10) Yoshida, Abe, Yamada et al., *RCM*, 2013; 11)Tsuji, Yamada, Yoshida et al., 2012 *Sensor*; 12)Ono et al., 2014 *Anal. Chem.*; 13)Stolper et al., 2014 *Science*.

【Term of Project】 FY2017-2021

【Budget Allocation】 162,400 Thousand Yen

【Homepage Address and Other Contact Information】

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