

## 0.0.11

**Fellow of  
Geochemical Society and European Association for Geochemistry****Compound specific isotope analysis: New perspectives on the winds of Africa to the origins and maintenance of life**

S.A. MACKO

Dept. of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22903 USA (sam8f@virginia.edu)

Stable isotopic determinations made on bulk organic materials are weighted averages of the isotopic compositions of hundreds to thousands of compounds, each of which has its own isotopic abundance. The stable isotope analysis of individual molecular components holds great potential as a method of tracing the source, biochemistry, diagenesis or indigeneity of a material. Through advancements of continuous flow technologies, compound specific isotope analysis (CSIA) is unique in allowing for the resolution of a material's history, or for partitioning the sources of organic inputs to a product or reservoir. Inscribed in the isotopic signatures are indicators of the source material, and the pathways used in the formation of the compound. Perspectives on the use of this powerful tool will be presented.

A better resolution of food chains and trophic structure in ecosystems or of comparative biochemistry in modern and fossil organisms<sup>1</sup> is suggested through the assessment of the isotopic differences between compounds. Are chemosynthetic communities oases of energy and nutrition for the surrounding marine province? Mussels with chemosynthetic symbionts from deep ocean gas hydrate sites in the Gulf of Mexico clearly show the biogenic methane-derived carbon in fatty acid isotope compositions (about -69‰ to -76‰)<sup>2</sup>. Certain opportunistic and predatory organisms at or near these seep sites show substantial utilization of this productivity, while others show only limited dependence on the symbiont-related material. This distinction is masked in the bulk isotope analysis but is observed in the CSIA of the presumed essential fatty acids.

Are aerosols associated with fires or dusts capable of being transported between continents, across entire oceans? In a CSIA study of the fatty acids isolated from aerosol samples captured in southern Africa, urban aerosols show significant isotopic differences for C16:0, C16:1 and C18:0 fatty acids when compared to rural sites. These compositions also allowed for the resolution of the contributions of different biomass origins, including fuel sources, burning events or associated dusts, and the recognition that individual fatty acids are unaltered during subcontinental scale atmospheric transport<sup>3</sup>.

Are there isotopic and geochemical keys in meteorites to understanding the characteristics of organic matter of the prebiotic Earth? The CSIA analysis of amino acids, including the abundances of <sup>13</sup>C and <sup>15</sup>N for both stereoisomers of the amino acid, have been able to be accomplished. Analyses of the isotopic compositions of amino acids isolated from the Murchison meteorite, which showed a predominance of L-enantiomers, have confirmed the extraterrestrial origins of those components and supported the lack of contamination by terrestrial compounds in both the absolute concentrations and stereoisomer relationships. The isotopic compositions of the stereoisomers of the amino acids were essentially identical. The stable carbon isotope compositions of protein and non-protein amino acids in the Murchison meteorite range from +5 to +27‰ and the stable nitrogen isotope compositions range from +37 to +184‰<sup>4,5</sup>.

The questions as to the origins of individual molecular components, whether existing as environmental problems, or in potentially pristine materials, or serving as a proxy for questions on depositional history or climate, can now be addressed. The tool of CSIA now uniquely offers an incredibly powerful probe into the origin(s) of compound, and its history, and perhaps its eventual fate. Needless to say, the potential uses for this probe have only begun to be realized.

**References**

- [1] Engel, M.H., Macko, S.A. (1986) *Nature* **323**, 531-533.
- [2] MacAvoy, S.E., Macko, S.A., Joye, S.B. (2002) *Chem. Geol.* **185**, 1-8.
- [3] Billmark, K.A., Swap, R.J., Macko, S.A. (2003) *J. Geophysical Res.* **108** D13 8503 SAF 39-1.
- [4] Engel, M.H., Silfer, J.A., Macko, S.A. (1990) *Nature* **348**, 47-49.
- [5] Engel, M.H., Macko, S.A. (1997) *Nature* **389**, 265-268