

Isotope-Ratio Monitoring: Techniques and the Biogeochemistry of ^2H , ^{13}C , and ^{14}C (via AMS)

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During the past 15 years, developments in continuous-flow isotope-ratio mass spectrometry have made it possible to determine precisely the carbon, hydrogen, nitrogen, and oxygen isotopic compositions of individual organic compounds. Particularly for ^{13}C and ^2H , for which the attainable precisions sharply reveal wide and informative variations in natural abundance, this analytical capability has significantly affected biogeochemical research. Investigations are now focused as strongly on molecular origins and histories (*processes*) as on molecular identities (*descriptions*).

The natural abundance of ^{14}C , even in modern materials, is 10 orders of magnitude lower than that of ^{13}C . For a given sample size, levels of precision attainable at natural abundance are therefore much lower. Twenty picomoles C suffice for measurement of the $^{13}\text{C}/^{12}\text{C}$ ratio to one part in 10,000. Two hundred nanomoles C are required for measurement of the $^{14}\text{C}/^{12}\text{C}$ ratio to one part in 10. When it comes to determining the origins of molecules, however, the latter precision is far from useless. To distinguish between products of the modern biosphere and commercial chemicals made from petrochemical feedstocks, for example, it is necessary only to determine which compounds contain *no* ^{14}C . For a substance of mixed origin, a precision of 10% in the $^{14}\text{C}/^{12}\text{C}$ ratio would support a conclusion such as “64 ± 10% of the carbon in this compound derives from fossil sources.” Even at natural abundance, therefore, ^{14}C has the potential to serve as a useful *inverse tracer* of pollutant carbon in natural systems. Accordingly, at the National Ocean Sciences AMS Facility (NOSAMS) we are working toward “GCAMS.” A team lead by Robert Schneider has already described a practical, gas-accepting source of negative ions (required for AMS; Kim *et al.*, 2002). More recently, tests of this source with continuously flowing gas streams on the NOSAMS accelerator have yielded the correct relative abundances for ^{14}C standards, demonstrated an absence of memory effects, and validated the performance-*vs.*-sample size estimate reported above.

Exemplary applications of isotope-ratio-monitoring GCMS in biogeochemical research will be described. Completed applications of GCAMS techniques will not be available by the time of the conference, but the status of developments and the outlook for further progress will be discussed.

Kim, S.-W., R. J. Schneider, K. R. von Reden, J. M. Hayes, and J. S. C. Wills (2002) Test of negative ion beams from a microwave ion source with a charge exchange canal for accelerator mass spectrometry applications. *Review of Scientific Instruments* **73**, 846-848.
