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Rapid screening of microbial cultures and organic macromolecules to assess biomarker lipid contents using catalytic hydropyrolysis

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A catalytic hydropyrolysis (HyPy) technique was used to assess the lipid contents of a broad range of microbial cultures, encompassing algae, bacteria and archaea. The technique was particularly effective at revealing carbon number patterns of linear, branched and polycyclic aliphatic lipids in different microbial species as well as for identifying and characterising any resistant aliphatic biopolymer constituents. Functionalised and polymeric aliphatic lipid species were reductively converted into hydrocarbon form with good retention of structural and stereochemical information in the hydrocarbon skeletons. GC-MS analyses of hydrocarbon fractions revealed valuable information about the relative abundances and variety of lipid structures produced by different microorganisms.

The efficacy of HyPy at fragmenting highly crosslinked kerogen networks and recovering bound biomarker lipid signals without promoting much thermal cracking or isomerisation of released products has been demonstrated previously [1]. This is an important application in biogeochemistry since kerogen is the most abundant organic pool in the sedimentary record but yet it is difficult to obtain high yields of soluble organic products using chemical degradation techniques. Furthermore, a combination of GC-MS and solution-state NMR analyses of total HyPy products can give detailed insights into the bulk chemical structure of kerogens.

This HyPy experimental approach then aids our ability to more readily link fossil biomarker signals found in the sedimentary record with potential lipid precursors found in extant organisms. The technique complements more rigorous but time-consuming chemical approaches used for elucidating the exact chemical structures of intact functionalised lipids by providing a rapid and reproducible means to screen cultures to identify their biomarker lipid contents.

References

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Micrometer scale δ^{13}C variability in macromolecular organic matter: A criterion for a non-biological source?

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Recent ion microprobe studies of macromolecular organic matter (MOM) revealed a large microscale δ^{13}C range (up to 12‰) within bitumen from Athabasca uranium ore-deposits (Canada). Further investigation showed that a δ^{13}C range of 14 ‰ can also be observed at the micrometer scale within bitumen from Witwatersrand gold and uranium ore-deposits, whereas common MOM of various biological sources and alteration degrees exhibited homogeneous δ^{13}C values.

Fourier transform infrared microspectroscopy revealed that the less ^{13}C-depleted micrometer scale areas of samples from both Athabasca and Witwatersrand correspond to the higher aliphatic contents. This result provides constraints on the origin of the observed δ^{13}C variability: (i) Secondary alteration of MOM can not be invoked, according to carbon isotope fractionations observed during thermal alteration experiments [1], (ii) mixing between hydrocarbons from different sources with distinct δ^{13}C and aliphatic content does not appear relevant because of the low probability that mixing at two distinct localities produced exactly the same δ^{13}C vs. aliphaticity systematics.

Under these circumstances, the hypothesis of a non-biological synthesis of MOM can be considered. Indeed, a positive correlation between δ^{13}C and aliphaticity is commonly observed in volatile hydrocarbons produced through experimental non-biological reactions where the aliphatics are less ^{13}C-depleted (by 2 to 5‰) than the non-aliphatics [2]. On the contrary, the aliphatics extracted from kerogen-derived organics is commonly more ^{13}C-depleted than the related non-aliphatics (up to 3‰) [3].

The occurrence of H_2-rich fluids associated with uraniferous environments (derived from water radiolysis) supports the hypothesis of a non-biological source because H_2 has been shown to be involved in the reduction of inorganic carbon to hydrocarbons under natural conditions. Thermodynamic calculations have been carried out to determine if such abiogenic reactions may have occured under the conditions prevailing during the bitumen- and ore-forming processes [4].

References

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