Interpreting long chain *n*-alkyl lipids in lake sediments: A critical evaluation of their sources and isotope signals

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Stable carbon and hydrogen isotopic values of *n*-alkyl lipids extracted from lake sediments have been widely used for the reconstruction of ancient vegetation, climate, altitude, hydrology, etc. Compound-specific isotope analysis has taken the advantage of source-specific environmental signals from both autochthonous and allochthonous lipids, assuming that long chain *n*-alkyl lipids are primary derived from terrestrial plants. In recent years, substantial progresses have been made toward lipids produced by lacustrine macrophytes (aquatic plants and macro-algae) regarding their abundance, metabolism, chain length distribution, and isotope values.

Accumulating evidence indicates that long chain (C_{26}–C_{31}) *n*-alkyl lipids in lacustrine sediments are derived from diverse sources, including terrestrial plants, aquatic macrophytes, and microbes; some emerged aquatic plants and macro-algae produce similar or even higher concentrations of long chain *n*-alkyl lipids as they are from terrestrial plants. Abundant long chain *n*-alkyl lipids from submerged aquatic plants with C_4-like metabolism suggested an underlying cause for the large discrepancies of $\delta^{13}C$ values and uniformed δD value variations among homologous lipids with different chain lengths, complicating the estimate of ancient C_3/C_4 vegetation and the reconstruction of paleohydrology. The significant correlations between δD values of long-chain *n*-alkyl lipids from aquatic macrophytes and lake water (*vs* δD values of precipitation) found in lakes at the Tibetan Plateau further highlight both challenges and opportunities for paleohydological reconstructions.

The assessment of relative contributions of long-chain *n*-alkyl lipids from various sources in a particular lacustrine site becomes a critical prerequisite for the application of their isotope values as proxies. To discriminate the sources of these lipids, we found that some traditional indicators, such as Paq, ACL, and CPI, are of limited values, while inter-molecular isotope offsets among *n*-alkyl lipids with different chain lengths show promising results. Knowledge gaps exist regarding factors that influence lipid biomass from aquatic macrophytes, their molecular isotope behaviors, and implications as lacustrine environmental proxies.