Tracing lipid biosynthesis in higher plants with carbon and hydrogen isotope analysis

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An understanding of stable isotopic compositions (and associated fractionations) of plant biomolecules can contribute significantly to the expanding of knowledge in many fields of studies including biology, ecology, and geochemistry. Plant biomolecules have a large variation in the isotopic compositions for hydrogen, carbon, nitrogen and oxygen, which is closely related to the isotopic fractionations associated with biosynthetic pathways. Although plant biosynthesis is a extremely complex network composed of a great number of enzymatic reactions, in many case the principal isotopic fractionations of biomolecules are simply controlled by the isotope effect and relative flux of substrates at key process(es) (e.g. branching points and redox reactions) in the pathways. In other words, the isotopic compositions of plant biomolecules are highly useful for tracing biosynthesis and discriminating alternative pathways in plant. Alternatively, marked variations in the isotopic compositions are also observed in ecological (e.g. animal) and geological (e.g. soils and sediments) samples. The isotopic compositions (and modification of those) of plant-derived biomolecules have been employed as powerful proxies not only for tracing sources and delivery of the molecules but also for providing a number of critical information such as trophic level of animals in ecological food webs as well as climate and environment changes on the earth. In higher plants, typical lipid biomolecules are related to three different biosynthetic pathways. The straight-chain molecules, termed n-alkyl lipids, are biosynthesized in the acetogenic pathway with an acetyl coenzyme-A (acetyl-CoA) biosynthetic precursor. In contrast, all isoprenoid lipids are constructed from isopentenyl pyrophoshate (IPP) produced by two distinct pathways: the mevalonic-acid (MVA) pathway for C15 and C30 isoprenoids or 2-C-methyl-D-erythritol-4-phosphate (MEP) pathway for C20 isoprenoids. Comparison of the isotopic compositions of these molecules is straightforward in terms of primary understanding the correlations between isotopic fractionations and biosynthesis. Here I review recent finding on the correlation in higher plants.