High-precision optical measurements of $^{13}C/^{12}C$ in inorganic, bulk organic material, and individual organic compounds

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Cavity Ring-Down Spectroscopy (CRDS) is a laser optical spectroscopic technique used for high precision gas phase concentration measurements of isotopologues of simple compounds such as CO2 and H2O. Currently, high-precision isotope ratios of light stable isotopes are primarily determined using Isotope Ratio Mass Spectrometry (IRMS) instruments that are very expensive in relative capital cost terms, require experts to operate and maintain, and are not portable. These properties have significantly limited the wide applicability of isotope ratio measurements. However, with its low cost, ease of use, and high precision, CRDS has recently presented a credible challenge to the many IRMS-based techniques utilizing water isotope measurements of D/H and 18O/16O and 13C/12C measurements of carbon dioxide. The appropriate coupling of commercially available front-ends, such as elemental analyzers and gas chromatographs, to the isotopic CO2 CRDS analyzer has widened the applicability of this optical technique to more complex samples in gas, liquid or solid forms. In addition, the applicability of CRDS is further widened because it is an excellent portable tool for field measurement and for vehicle or ship-bound analyses, something usually not possible with IRMS in spite of the technological advances achieved with online sample preparation and conversion. We present an alternative and novel approach to IRMS for making high-precision 13C/12C isotope ratio measurements of inorganic carbon, bulk organic material and individual organic compounds, which enables the high precision measurement of complex molecules in various matrices using CRDS based technology. The technique relies on the conversion of each inorganic and organic material into carbon dioxide and the precise measurement of the 13C/12C isotope ratio in the carbon dioxide gas. Applications including dissolved inorganic carbon in marine aqueous samples, food authenticity and geographical location of gourmet oil as well as compound-specific isotope analysis of short chain hydrocarbons will be discussed.