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Mid-Infrared Spectroscopic measurements of stable chlorine isotope compositions in mixed halogenated organic compounds

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Release of halogenated organic compounds (HOCs) could negatively impact human health and water quality. Stable chlorine isotope analysis provided a valuable tool identifying unknown sources and elucidating underlying processes of different HOCs, but traditional methods, such as IRMS methods, often suffer the corrosive nature of the HCl analyte. Concerning the IRMS based approaches, the instrument is not widely available and is set to analyze only a limited number of target compounds chlorine isotopologues. Our study developed a novel method to determine stable chlorine isotopic compositions in HOCs using an isotope ratio infrared spectrometer coupled gas chromatography that is resistant to the corrosive HCl.

This work utilizes an interband cascade laser as the light source and a hollow waveguide as the gas absorption cell, combined with a mid-infrared detector and other components, to construct a spectrometer for detecting the chlorine isotope ratio ($\delta^{37}Cl$) in HCl gas. The spectrometer measures the Cl isotopic ratio of HCl gas with a deviation of less than 0.5‰. When paired with a hydrogenation furnace and a gas chromatograph, the spectrometer detects chlorine isotopes in mixed HOCs. Tests show that the detection limit for dichloroethane samples is approximately 2~4 g/L. Figure shows the sketch of the apparatus developed in this study for chlorine compound-specific isotope analysis. The target chlorinated compounds are injected into a gas chromatograph using H2 as carrier gas, and later enter an alundum tube in a combustion interface (800℃), where target compounds are converted into hydrogen chloride (HCl) gas. Later, the HCl is diluted with H2 gas before entering the isotope ratio infrared spectrometer (IRIS), and the stable chlorine isotope ratios were calculated according to intensities of H35Cl and H37Cl signals. Additionally, we also developed a custom made pretreatment vessel that helps to determine the chlorine isotope ratio ($\delta^{37}Cl$) in inorganic compounds such as NaCl with similar accuracy.