

A NEW REACTOR FOR OXIDATION OF ORGANIC GASES IN ISOTOPIC ANALYSIS

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Continuous Flow Isotope Ratio Mass Spectrometry (CF-IRMS) analysis of gases and compounds is widely used in organic geochemistry. In spite of the fact that the up-to-date level of the CF-IRMS developments is rather high, it needs to be improved and updated.

Accuracy of the resulted isotope analysis data depends essentially on the properties of the being used oxidation reactor capable to oxidize a wide variety of hard oxidizable compounds. Incomplete combustion leads to a considerable distortion of these data.

So, we took an effort to design a simple and reliable oxidation reactor suitable for complete oxidation of organic compounds.

For this particular purpose, we have proposed a novel method of the CF-IRMS analysis based on the oxygen-promoting oxidation of volatile compounds on a surface of platinum electrode of the solid electrolyte reactor (SER). Oxygen penetrates from outside atmosphere throughout the ZrO₂-based oxygen transmitting ceramics at 800-950°C and joins helium flow. The solid electrolyte reactor employed in our device consists of a thin zirconium dioxide ceramic tube and is located right between the standard oxidation and reduction reactors of the CF-IRMS. The design provides a fast change-over from one operating regime to another. Both external and inner surfaces of this tube, coated with porous platinum, serve as electrodes. A source of direct electric current applies the electrical potential to the electrodes. The input of oxygen into the gas-carrier depends on the value of this potential. Since platinum is known to be a perfect catalytic material, the extensive oxidation of compounds being studied takes place on the reactor inner electrode surface at high temperatures.

A mixture of CO₂, CH₄, C₂H₄, C₃H₈, C₄H₁₀ with known carbon isotopes composition estimated by a standard GC-C-IRMS technique has been used as a test sample. The data obtained by our new analytical technique matches nicely the results on carbon isotope ratio measurements carried out by standard oxidation reactor procedure. This confirms the fact of a complete combustion of organic compounds in the new SER we have proposed. Noteworthy, an incomplete combustion leads to an essential error in the isotope ratio measurement.

We have made an actual model of a device designed to develop the optimal conditions of the organic compounds oxidation. The application of our new method involving SER in the CF-IRMS procedure makes it possible to improve the accuracy and precision of isotope analysis. This has been reached due to a relatively small size of the SER as well as to a sufficient amount of oxygen leaked into a helium gas flow and to a well-developed porous catalytic surface of electrode ($<100 \text{ mm}^2$) on which the oxidation takes place. A continuous oxygen flow along with a high temperature regime eliminates a necessity to perform a control over the gas carrier purity and to restore the reactor oxidative capability with no risk of its possible contamination. A long lasting mode of the proposed device work is confirmed by the fact of a numerous practical application cases described for similar solid electrolyte sensors in automobile engines.

Besides, the use of our new SER device allows one to estimate simultaneously concentration and composition of organic gases flowing through the reactor simply from the electric charge transmitted by oxygen ions across the ceramic reactor wall. The sensitivity of our device is very high. At the same time, it is possible to monitor the level of the gas carrier purity.

The data on the organic compounds analysis we obtained are certainly a good reason to consider both method and device as a novel promising approach useful in a wide range of further applications of the CF-IRMS technique.