

## LIFE IN A NUTSHELL: BIOTIC AND ABIOTIC CHEMISTRY IN NATURAL COMPLEX SYSTEMS

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Understanding complex organic mixtures in bio- and geosystems at the molecular level is a major challenge in modern science. From the perspective of analytical scientists it requires continuous development and adaptation of high resolution analytical technologies, along with innovative solutions for detailed numerical analysis. Our aim is to highlight the chemical diversity and complexity of natural mixtures subjected to both biotic and abiotic processes. Here, we present concepts and experimental results that illustrate chemical complexity and diversity, with examples in biomes and abiomes expanding the concept across life (Metabolomics), after-life (organic Geochemistry), and even pre-life stages (Astrochemistry). These systems pose major challenges for analytical chemistry in describing their dynamic complex chemistry.

In particular, direct-injection FTICR/MS enables high-throughput characterization of highly complex mixtures and holobiont metabolomes at the level of compositional space. FTICR/MS will be presented as a powerful tool for understanding chemical diversity across various fields, ranging from food chemistry and biology to microbiome research. Examples and applications will be shown such as in metabolomics in the Foods/Microbiomes/Health continuum with the focus on biotic and non-enzymatic processes ruling/linking the chemistry in these super-systems.

FTICR-MS is presented as a universal tool in non-targeted foodomics, enabling molecular profiling of complex biomes and abiomes. The analysis of exact masses as absolute physical values is the key feature of this instrumentation. By applying appropriate quality controls (QC), it is possible to integrate data generated years ago with present and future datasets. No other instrumentation offers this level of long-term data integration, which makes FTICR-MS particularly suitable for longitudinal analyses of body fluids (plasma, urine, gut/fecal water extracts) in large cohorts, with the resolution of thousands of metabolites.

### Keywords

FTICR-MS, direct injection, longitudinal analysis, metabolomics, foodomics.