Application of NMR-based Metabolomics on cells to environmental issues

Metabolomics is the comprehensive analysis of metabolites within a biological system which can be a cell, a tissue or a biofluid (e.g, blood, urine and synovial fluid). The complete set of metabolites is the metabolome, consisting of various small molecules such as sugars, osmolytes and amino acids. One of the techniques of choice for performing Metabolomics analysis is Nuclear Magnetic Resonance (NMR), which allows for a rapid and non-destructive analysis. One of the unique features of this technique is that it can analyse solid, semi-solid and liquid samples with little or no sample pretreatment, allowing the sample to be studied in its native aggregation form, thus reducing the analysis time.

My project will focus on the application of NMR-based Metabolomics to study two different environmental issues, namely the effects of short-chain PFASs on health and wastewater bioremediation with microalgae.

PFASs stands for Per-/Poly-FluoroAlkyl Substances, a group of more than 4700 organic pollutants. In their structure, there is a polar head, usually a carboxyl, sulfonate or phosphate group, bonded to a per-/poly-fluorinated alkyl residue, which classify PFAS into long-chain and short-chain, the latter containing less than six C atoms. They are considered forever chemicals, as they accumulate and spread in the environment due to the lack of an efficient degradation mechanism. [1] These compounds have received much attention because of adverse health effects reported in epidemiological studies that have looked at polluted cohorts, for example in Italy's Verona province. These studies led to the banning of several long-chain PFASs, which are now being replaced by unregulated short-chain PFASs, compounds proposed as a safer alternative because they have a shorter half-life in human. However, even for these alternatives several studies report negative impact on animals and humans. [2] Therefore, to deepen our knowledge of these substances, I plan to use an *in vitro* model to study the effects that different short-chain PFASs have on human nervous system. Two different human cell lines will be exposed to PFASs, and Metabolomics analysis will be performed to study the effect that short-chain PFASs have on these cells. Specifically, High Resolution-Magic Angle Spinning Nuclear Magnetic Resonance (HR-MAS NMR) will be used to analyse the cell pellets. Spectral data will be analysed with chemometrics to highlight possible biomarkers, which can help to understand how PFASs exert their toxic effects.

Microalgae are a group of unicellular photosynthetic microorganism suitable for the bioremediation of food industry effluents (e.g., beer, wine, dairy production). In those media, microalgae have a mixotrophic growth, that is, they use both organic and inorganic carbon sources. The advantage of using microalgae to reduce pollutants (mainly N, P, and organic C) in these wastewaters is that the process can be optimized to convert pollutant into valuable biomass, such as PolyUnsaturated Fatty Acids (PUFAs) and MonoUnsaturated Fatty Acids (MUFAs). [3] In this system, Metabolomics analysis can be used to optimize the growing conditions namely: the duration of the dark/light cycles, the intensity of radiation and its wavelength, the temperature and the composition of the culture media. NMR Metabolomics offers the advantage of avoiding the extraction step to characterize the biosynthesized lipid fraction, as it can work directly on a microalgae sample, so the analysis is faster than a GC-MS characterization. Furthermore, it also provides a more complete picture of the system, as all metabolites are detected at the same time, not just lipophilic ones.

BIBLIOGRAPHY

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