A Novel Approach to Aquatic Ecotoxicology: Applications of FTIR Spectroscopy

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Given their widespread distribution in aquatic and terrestrial ecosystems, there is an ever increasing concern about the effects of chemical contaminants on human, wildlife and ecosystem health. Ecosystems function on the basis of interactions between abiotic (such as contaminants) and biotic factors. This biotic component may be examined at many levels. This report is based on the fact that organismal changes are preceded with molecular changes and here it is suggested that Fourier Transform Infrared (FTIR) spectroscopy is a promising candidate for revealing toxicant-induced modifications at the molecular level.

As biomolecules absorb infrared (IR), FTIR spectroscopy can be employed non-destructively to generate signature vibrational spectra revealing structural and functional information. In light of this, this study reports the cypermethrin- and NaCl-induced alterations in the molecular profile of zooplankton by ATR-FTIR (Attenuated Total Reflectance) spectroscopy and the toxic effects of nonylphenol on fish liver samples by FTIR spectroscopy.

Daphnia pulex neonates (24-48 hrs) were exposed to either cypermethrin (CM) test solutions (0.00, 0.04, 0.10, 0.30, 0.90, 1.80, and 3.60 μg/L) or NaCl test solutions (0.00, 0.05, 0.10, 0.20, 0.40, 0.80 and 1.50 g/L) for three weeks. Afterwards, the daphnids were subjected to a minor dehydration step to be analysed by means of ATR-FTIR spectroscopy [1,2]. On the other hand, juvenile (8 mo) rainbow trout (*Oncorhynchus mykiss*) were exposed to nonylphenol (NP) test solutions (0.0 and 220.0 μg/L) for two weeks, after which their liver tissues were removed to be spectrally analysed by means of the KBr pellet technique [3].

Resultant IR spectra revealed that exposure of daphnids to both CM and NaCl resulted in reduced protein and saturated and unsaturated lipid contents, where the decreased unsaturation in fatty acyl chains is likely due to CM-induced lipid peroxidation. On the other hand, the spectral results from NP-treated fish liver tissues revealed an increased population of hepatic lipids, especially triglycerides, and nucleic acids, and a decrease in protein and glycogen levels. In addition, an increased population of unsaturated lipids was observed likely due to an accumulation of lipid peroxidation end products. These findings demonstrate that the investigated toxicants can mediate a number of toxic effects or cellular alterations at environmentally relevant concentrations.

This report shows the power of FTIR spectroscopy in describing the macromolecular pool of lipids, proteins, carbohydrates and nucleic acids simultaneously of environmentally relevant samples. It is put forward that this tool is capable of detecting early molecular alterations induced by even low doses of toxicants, the effects of which may not always be observable at the organismal level, and has great potential as a novel monitoring tool for contamination.

References:

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