Zebrafish as a model to assess the toxicity of environmental toxicants

Raissa Novais Rodrigues[1], Jessica Legradi[1] and Pim Leonards[1]
[1]Dept. of Environment & Health, VU University, Amsterdam, The Netherlands
E-mail: pim.leonards@vu.nl

1. Introduction

Perfluorinated compounds (PFCs) have been widely used as organic surfactants in industrial and consumer products, commonly as repellants in textiles, fire retardants and food packaging. PFCs are composed of a long carbon backbone that is fully fluorinated with either a carboxyl, alcohol, or sulfonate terminal group. They are stable at very high temperatures, non-flammable and non-volatile. While these properties made PFCs very appealing to manufactures, they also caused PFCs to be non-degradable and in turn, persistent in the environment. Generally, the toxicity of individual PFCs has been suggested to be determined by the carbon chain length as well as the functional group attached. In this study, chronic and acute exposures of PFOA and its alternatives PFHxS, PFBS, D4, D5 and TMS were assessed. Additionally, PFOS and its alternative GENX were also tested for toxicity effects.

2. Approach

PFOA, PFHxS, PFBS, PFOS, D4, D5 and TMS at the concentration of 10 µM were performed on zebrafish embryos to evaluate the developmental effects of these compounds. Swimming activity analysis was performed with zebrafish embryos at 5 days post fertilization (dpf), based on alterations in locomotor activity due to changes of light/dark cycles. No significant effects in mortality, developmental abnormalities, and swimming activity were observed in the exposed groups of all compounds. These embryos were then subjected to further investigation in an attempt to address potential genetic and metabolomic effects.

3. Results and discussion

Transcription of the DNA damage gene gadd45ba was significantly up-regulated by over 2-fold relative to the control in the PFOA, PFHxS, PFOS and Genx exposure groups. Interestingly, the lipid metabolism gene adipoqb was up-regulated by over 2-fold in the embryos exposed to PFOS and GENX. Analytical analysis based on liquid chromatography coupled with high resolution mass spectrometry was applied to quantify the metabolites present in the exposed zebrafish embryos. In the acute exposure, all tested compounds significantly affected the concentration of phosphatidylcholines (PC). Exposure to PFOA, PFHxS and PFBS also affected the concentration of phosphatidylethanolamines (PE). In the chronic exposure, PC and PE also displayed significantly different concentrations when comparing the exposed groups to the control. However, in contrast to the acute exposure, chronic exposure to the perfluorinated compounds also affected the concentrations of triacylglycerols (TAG) and sphingomyelins (SM). TAG represent the main energy reserve in eukaryotes and their metabolism plays a key role in cellular energy balance, lipid homeostasis, growth, and maintenance. Furthermore, both PC and PE are important components of the glycerophospholipid metabolism. The observed results revealed that exposure to PFCs and their alternatives may induce changes in lipid metabolism pathways, mainly involving glycerophospholipids. Based on the results of this study, alterations in glycerophospholipid metabolism may be a metabolic footprint of toxicity effect of perfluorinated compounds and their alternatives.