Characterization of nanoparticles and other thermal breakdown products of conventional (AFFF) and replacement fluorine-free firefighting foams (FFF)

Dhimiter Bello, ScD, MSc
Dept. Biomedical and Nutritional Sciences, UMass Lowell, 883 Broadway Street, Lowell, MA, USA
Dhimiter_Bello@uml.edu

Abstract

Per- and poly-fluoroalkyl substances (PFAS) have emerged as a major environmental health problem of our time. Aqueous Film-Forming Foams (AFFF) are traditional firefighter foams based on PFAS and a major source of PFAS environmental pollution (1). This presentation will summarize the results of a three-year research project on barriers and incentives to adopting Fluorine Free Foams (FFFs) as safer replacements to AFFF (2). The main focus will be on the chemical composition and thermal degradation behaviour of AFFFs and FFFs replacements that can influence the fundamental physico-chemical properties relevant to human exposures: phase distribution and mobility of contaminants (gas, vapor, nano aerosol, PFAS size distribution); chemical composition (generation of free radicals, chain reactions leading to new species, including fluorinated hydrocarbons, inter-species conversions, generation of HF gas and/or acid), toxic gases (CO, SO_2, NOx). These thermal degradation byproducts are biologically relevant to human exposure because they alter lung dosimetry, mode of action, and lung toxicology.

We constructed an environmental chamber testing platform suitable for characterizing thermal degradation behaviour and physico-chemical transformation of common AFFF and commercially relevant replacement FFF under controlled experimental conditions. Representative AFFF (6 of 16) and FFF (7 of 22) foam samples were burned using a standardized temperature ramp (25 ^{0}C to 800 ^{0}C) under sufficient O_2 conditions (21%). We characterized foam emissions with a suite of instruments that measure nano aerosol properties (size distribution and number concentration, HF gas and aerosols, toxic gases (CO, SO_2, NOx), VOCs, ROS by ESR). and collected samples for subsequent chemical analysis by LC-MS/MS, NMR, SERs, and other techniques. Extensive physico-chemical characterization of the raw foams (LC-MS/MS, LC-Q-TOF MS, Raman, NMR, ICP-MS, establishes a baseline for their input chemical composition, including PFAS content and foam matrix. TDP products collected are undergoing in vitro cell culture tox testing.

The presentation will cover major findings pertaining to nanoparticles generated and their composition and discuss its implications for human health. This work was funded by the US Federal Emergency Management Agency (FEMA) Assistance to Firefighters Grant Program.

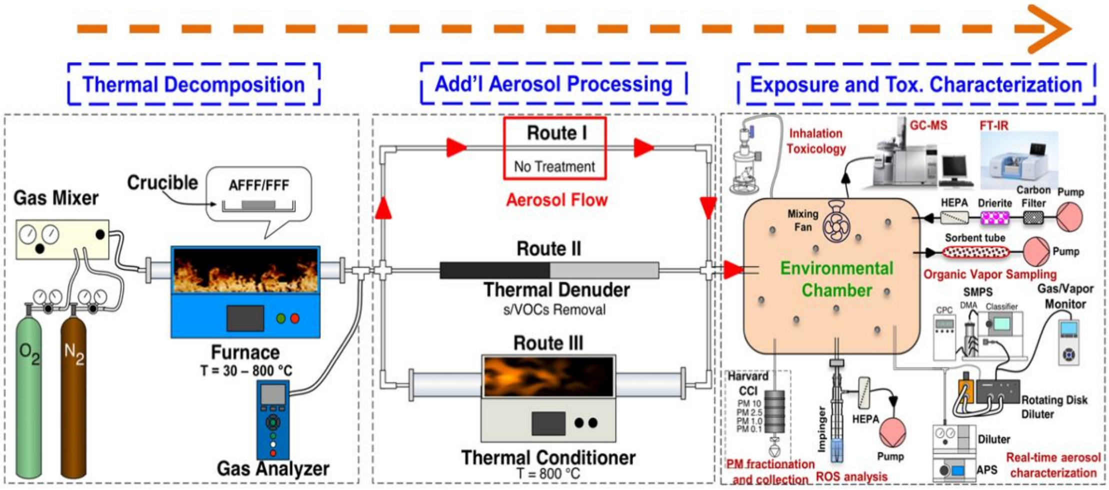

Figure 1. Schematic of the platform for comprehensive thermal decomposition studies of AFFF and FFF products

References

1.European Commission DG Environment, The use of PFAS and fluorine-free alternatives in fire-fighting foams. Stakeholder workshop background paper. 2019: Tuesday 24 September 2019 at European Chemicals Agency (ECHA), Helsinki

2. Stockenhuber, S. P., Weber, N. H., Dixon, L., Lucas, J. F. R., Grimison, C. C., Bennett, M., . . . Kennedy, E. M. Thermal degradation of perfluorooctanoic acid (PFOA). Global NEST International Conference on Environmental Science & Technology.