Abstract

[Research Title]

Toward the Environmentally Sound Management of Waste Containing New Fluorinated POPs: Elucidating their Occurrence and Decomposition Behavior

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In this project, three sub-groups collaborated to investigate the sound management of wastes containing new and next fluorinated POPs with the specific objectives of developing comprehensive analytical methods for products and wastes containing fluorinated substances (subtheme 1), clarifying leaching and emission behavior during disposal and recycling treatment and estimating environmental emissions (subtheme 2), and understanding degradation behavior during waste incineration (subtheme 3).

In subtheme 1, technical advances were made in total organic fluorine analysis and comprehensive target analysis for a range of per- and polyfluoroalkyl substances (PFAS). The developed methods were applied to the analysis of water- and oil-repellent products, firefighting foams, industrial wastes, and solid waste-derived fuels, demonstrating, for example, the presence of side-chain fluorinated polymers in various products/wastes as well as the currently regulated fluorinated POPs in firefighting foams produced before the regulations were implemented.

In subtheme 2, on-site investigations at resource recovery facilities identified the Refuse derived paper and plastics densified Fuel (RPF) molding machine as the primary emission source of PFAS at the facilities. Treatment of the RPF molding exhaust is beneficial as it accounts for >90% of the total PFAS emissions in many cases. Chamber emission tests showed that UV irradiation dramatically increased the PFAS emission from repellents, indicating the importance of preventing the release of side-chain PFAS throughout waste management and treatment. Physicochemical properties related to environmental emissions such as the air/water partition coefficient (Henry's Law constant) were measured for PFAS, contributing to a significant expansion of PFAS property data.

In subtheme 3, a decomposition efficiency of 99.999% or higher was confirmed for pure substances of the tested PFAS by incineration at 850°C or higher. PFAS in firefighting foam were also decomposed at 850°C to >99.999%, although the efficiency tended to be low, making it particularly important to maintain the temperature above 850°C. Therefore, incineration at 1000°C or higher following the technical guidelines is recommended. Incineration at lower temperatures (450 and 700°C) produced various fluorinated biproducts, including PFAS with shorter and longer carbon chain lengths than the input PFAS and PFAS with ether bonds, further indicating that temperature control in the incinerator is extremely important for efficient decomposition of PFAS.

Overall, this project provided new knowledge essential for the proper management of wastes containing new and next fluorinated POPs, particularly water/oil-repellents and firefighting foams, and proposed measures to reduce their emissions, which should be useful for developing environmental policies and regulations.

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