Self-assembly of binary mixtures as potential replacements for per- and polyfluoroalkyl substances (PFAS) in firefighting foams

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A critical use of per- and polyfluoroalkyl substances (PFAS), known as "forever chemicals," is in the aqueous film-forming foam (AFFF), which could lead to significant public health risks [1] . As shown in **Fig. 1** , the foam blanket isolates heat and oxygen from the fire and vapour, with fluorocarbon surfactants and compounds located at the gas-liquid interface and the liquid-liquid interface in contact with the fuel.

Current PFAS alternatives in AFFFs include partially perfluorinated surfactants [1] , mixtures of silicone and hydrocarbon surfactants, hydrolysed proteins, nanocellulose-stabilised gel foams, and thermo-responsive triblock copolymers [2] . These potential replacements, however, face less-than-optimal properties and economic viability. This study aims to systematically investigate binary surfactant-polymer mixtures as a PFAS alternative.

Aerosol-OT (AOT), a hydrocarbon surfactant, is effective in stabilising water-in-oil (W/O) microemulsions [1] . Amphiphilic triblock Pluronic copolymers containing PEO-PPO-PEO can form temperature-responsive nanostructures, transforming between micellar assemblies at ambient conditions and mechanically rigid films with ordered micellar packing at elevated temperatures (e.g. 45°C) [2] , rendering them suitable for fire suppression. Pluronic F127, a tri-block copolymer exhibiting surface tensions of 36 $mN{\cdot}m^{-1}$ at 1 wt% (above its CMC), is chosen for the binary mixture with AOT.

The preliminary small-angle neutron scattering (SANS) and surface tension measurements revealed a dynamic micellar architecture under different experimental conditions of AOT-based binary mixtures (Fig. 1C). F127 was found to synergise with AOT, achieving a reduced surface tension of 29 $mN{\cdot}m^{-1}$ in the binary system (Concentration: 10.5 mM dm^{-3} AOT + 1 wt% F127). SANS data show that the AOT-F123 binary mixture formed spherical nanostructures. These results demonstrate the potential to systematically investigate micellar microstructures across single- and multi-phase media using SANS to establish general principles governing optimal design parameters using the binary system to replace PFAS. This study ultimately aims to optimise the performance of these alternatives and eventually develop a design guide for the environmentally friendly classes in fluorine-free surfactants.

Keywords:
PFAS, self-assembly, thermal response, SANS

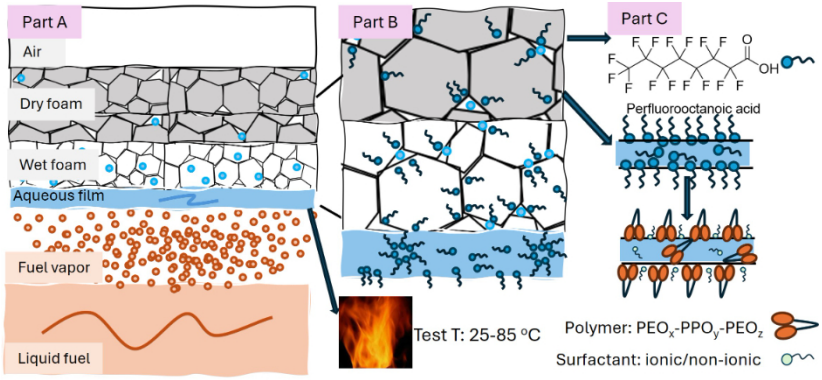

Figure 1

References:

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