

Overview of the Mechanics of Film Formation of AFFF

- Aqueous film-forming foam (AFFF) generally contains mixtures of hydrocarbon and fluorocarbon surfactants as the major surface-active components.
- This class of fire-fighting foams has the capability to spread and form a thin, uniform aqueous duplex film (10-30 μm thick) on low-surface tension organic liquids such as volatile hydrocarbons and fuels.
- The formation of an aqueous layer spread over the fuel surface provides an effective fuel vapor barrier in addition to the cooling and blanketing effect of the foam. This fuel vapor barrier also helps to protect the foam matrix from excessive degradation in the presence of liquid fuel and its vapor.
- It is also known that the spontaneously spreading aqueous layer augments the fire-extinguishing efficiency of the foam. The presence of the aqueous film improves burnback stability of the foam by its spontaneous re-spreading and "repair" mechanism.
- The spontaneous spreading property of AFFF is derived mainly from the high surface activity (low surface tension) of the fluorocarbon surfactants at the solution/air interface (15-20 dynes/cm).
- This low surface tension, coupled with the low interfacial tension (1-5 dynes/cm) at the solution/substrate interface, allows the AFFF solution, as a result of a positive spreading coefficient, to spread spontaneously on many liquid hydrocarbons and fuels (20-30 dynes/cm).
- The hydrocarbon surfactants preferentially adsorb at the solution/hydrocarbon substrate interface because of the mutual phobicity between the hydrocarbon and fluorocarbon surfactants, and therefore they are largely responsible for the low interfacial tension.
- The conventional spreading coefficient concept used as a specification (e.g. mil-spec) for qualification purposes is based on the equilibrium surface and interfacial tension. This "static" spreading coefficient is not sufficiently useful to understand the dynamics (rate) of spreading. In fact, erroneous predictions can be made based on this value as to the effectiveness of the fire fighting foam. Dynamic (time-dependent) surface and interfacial tensions and hence the "dynamic" spreading coefficient concept need to be used to better understand the relationship between the film formation phenomena and the effectiveness of fire fighting.
- The rate of spreading of the aqueous film is related to the film thickness, which in turn affects the extinguishment and burnback performance of an AFFF agent.
- The second most important role of fluorosurfactants in AFFF is the phenomena of "fuel shedding." Because of their inherent oleophobicity (i.e. oil repellency), fluorosurfactants repel fuel (oil) thus preventing or reducing the "fuel pickup" problem. In contrast, hydrocarbon surfactants "attract" fuel thus turning the foam flammable. During the firefighting application, foam gets mixed up with the fuel and the presence of fluorosurfactants in the foam reduces/prevents (depending on concentration) the fuel contamination of the foam, which can lead to "burning" foam. Fuel contamination or fuel pickup is a serious problem because it compromises not only the speed of extinguishment but also burnback effectiveness.

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