FM-200® : Theory of Fire Extinguishment

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The extinguishment of fires has traditionally been attributed to three actions: removal of heat (e.g., water), the physical separation of the fuel and the oxidizer (e.g., foams), or the removal of the oxidizer (e.g., oxygen depletion by carbon dioxide). These three mechanisms of fire extinguishment form the basis of the well-known "fire triangle" - heat, fuel and oxygen [1].

The high extinguishing efficiency of halon agents such as CF_3Br (Halon 1301) and CF_2BrCl (Halon 1211) cannot be explained solely on the basis of the above *physical* mechanisms, and the theory of fire extinguishment required modification as the extinguishing mechanisms of these agents became better understood. The halon agents extinguish fires by chemically interacting with key flame species, leading to the breaking of the chain reactions of the combustion process. This *chemical* mechanism of fire extinguishment has led to the concept of the "fire tetrahedron" - heat, fuel, oxygen, and the uninhibited chain reaction of the combustion process [2]. Removal of any one of the four required items will lead to flame extinguishment.

In the case of Halon 1301 and Halon 1211, the contribution of the chemical mechanism to fire extinguishment predominates over the physical mechanisms. It has been shown that these agents react with the combustion products responsible for rapid flame propagation (H, O, and OH radicals), thereby terminating the combustion chain reactions and stopping flame propagation. For example, introduction of CF_3Br to a flame results in an initial thermal decomposition of the agent to form CF_3 and Br radicals. The Br radical then reacts with key flame species such as the H radical, interrupting the chain reactions required for combustion.

In the case of FM-200® , the contribution of physical mechanisms to the extinguishment of fires predominates over the chemical mechanism. Due to its efficient heat absorbing abilities, extinguishment is due primarily to the physical mechanism of heat removal.

Although the physical mechanism of heat removal is the predominant mechanism of flame extinguishment for FM-200®, there is also a chemical contribution to flame extinguishment which arises from the thermal decomposition of small amounts of FM-200® in the flame. Studies have shown that chemical flame inhibition with FM-200® arises from the consumption of the key combustion chain-propagating species H, O, and to a lesser extent OH radicals, by fluorinated fragments such as CF_3 and CF_2 formed via the thermal decomposition of FM-200® in the flame[3-5]. Because of the removal of H and O by fluorinated species, the rates of the chain-branching combustion

reactions decrease, and flame propagation is halted. This chemical mechanism of flame suppression is supported by numerous previous studies on hydrofluorocarbon-inhibited flames [6,7].

References

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