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Reactive Flame Retardants for Aerospace Grade Epoxy + Carbon Fiber Composites

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Epoxy + carbon fiber composites are increasingly used for structural members of aircraft, with notable examples including the composite fuselages of the Boeing 787 and Airbus A380. There is increased interest in using more epoxy + carbon fiber composites in aircraft to replace aluminum metal components to reduce weight in the aircraft, and in turn gain fuel efficiency. Further, electric aviation vehicles are already moving to higher levels of epoxy + carbon fiber rather than using aluminum so that the range of the electric aircraft can be increased. However, unlike the aluminum it is replacing, epoxy + carbon fiber composites are flammable, and can burn in a post-crash event, thus contributing to fire loss in a post-crash event. Since the performance of these composites requires high levels of mechanical strength and integrity, any flame retardant chemistry to be utilized in epoxy must be compatible with the epoxy and carbon fiber, which strongly suggests it will be reactive flame retardant chemistry. In this talk, we present two phosphorus-based flame retardants which can co-polymerize with epoxy. The chemical synthesis of these two different chemistries (phosphorus hydrazine and phosphine oxide) will be discussed, along with their reaction with epoxy and thermal properties. Their fabrication (successful or otherwise) into carbon fiber composites will be discussed, along with flammability data as measured by cone calorimeter and microscale combustion calorimeter. The talk with conclude with the results obtained to date and future directions for reactive flame retardants for epoxy + carbon fiber composites.