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Self-Assembling Layered Double Hydroxide Nanosheets on β-FeOOH Nanorods for Reducing Fire Hazards of Epoxy Resin

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Abstract : Epoxy resins (EP), one of the most important thermosetting polymers, is widely applied in various fields due to its desirable properties, such as excellent electrical insulation, low shrinkage, outstanding mechanical stiffness, satisfactory adhesion and solvent resistance. However, like most of the polymeric materials, EP has the fatal drawbacks including inherent flammability and high yield of toxic smoke, which restricts its application in the fields requiring fire safety. So, it is still a challenge and an interesting subject to develop new flame retardants which can not only remarkably improve the flame retardancy, but also render modified resins low toxic gases generation. In recent work, polymer nanocomposites based on nanohybrids that contain two or more kinds of nanofillers have drawn intensive interest, which can realize performance enhancements. The realization of previous hybrids of carbon nanotubes (CNTs) and molybdenum disulfide provides us a novel route to decorate layered double hydroxide (LDH) nanosheets on the surface of β-FeOOH nanorods; the deposited LDH nanosheets can fill the network and promote the work efficiency of β-FeOOH nanorods. Moreover, the synergistic effects between LDH and β-FeOOH can be anticipated to have potential applications in reducing fire hazards of EP composites for the combination of condense-phase and gas-phase mechanism. As reported, β-FeOOH nanorods can act as a core to prepare hybrid nanostructures combining with other nanoparticles through electrostatic attraction through layer-by-layer assembly technique. In this work, LDH nanosheets wrapped β-FeOOH nanorods (LDH-β-FeOOH) hybrids was synthesized by a facile method, with the purpose of combining the characteristics of one dimension (1D) and two dimension (2D), to improve the fire resistance of epoxy resin. The hybrids showed a well dispersion in EP matrix and had no obvious aggregation. Thermogravimetric analysis and cone calorimeter tests confirmed that LDH-β-FeOOH hybrids into EP matrix with a loading of 3% could obviously improve the fire safety of EP composites. The plausible flame retardancy mechanism was explored by thermogravimetric infrared (TG-IR) and X-ray photoelectron spectroscopy. The reasons were concluded: condense-phase and gas-phase. Nanofillers were transferred to the surface of matrix during combustion, which could not only shield EP matrix from external radiation and heat feedback from the fire zone, but also efficiently retard transport of oxygen and flammable pyrolysis.

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