Transparent self-extinguishing silica-epoxy nanocomposites based on Novolac resin

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Introduction

The increasing industrial demand, along with rising pollution and phosphorus (P) depletion, is driving the scientific community to develop flame retardant (FR) epoxy nanocomposites (ENCs) that use lower phosphorus content and more sustainable additives [1].

Results and discussion

The reaction between DGEBA (bisphenol A diglycidyl ether) or Novolac-based resins and APTES (3-aminopropyltriethoxysilane) enables the formation of organic-inorganic silanized epoxy structures. These hybrid moieties can further condense with tetraethyl orthosilicate (TEOS), a silica precursor, generating an in situ silica phase via sol-gel processes [2, 3]. High-resolution transmission electron microscopy revealed that, in DGEBA-based systems, the silica phase consists of well-organized multilamellar nanoparticles (NPs) [2]. Conversely, in Novolac-based systems, fully amorphous silica NPs are dispersed within a hybrid co-continuous polymer network [3].

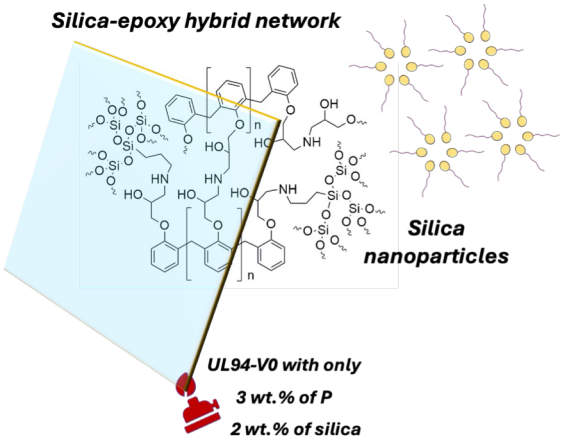

Figure 1: Main outcomes related to silica-epoxy nanocomposites based on Novolac resin

The incorporation of DOPO (9,10-dihydro-9-oxa-10-phosphaphenanthrene-10-oxide)-based flame retardants into silica-epoxy systems derived from DGEBA or Novolac resins yields nanocomposites characterized by high transparency, no-dripping behavior, and a UL-94 V-0 rating in vertical burning tests, along with a significant reduction (up to 80%) in the peak heat release rate during cone calorimetry, even at phosphorus loadings as low as 3 wt.% [2, 3].
In the case of Novolac systems, transparency is retained even at silica nanoparticle contents exceeding 4 wt.% due to their amorphous nature (see Figure 1) and the liquide nature of the employed DOPO derivative [3].

Conclusions

The in situ sol-gel generation of inorganic phases has been studied in combination with a DOPO-based flame retardant to synthesize ENCs exhibiting no-dripping behavior and self-extinguishing properties (V-0 rating in UL-94 flammability tests), while maintaining very low phosphorus contents (1-3 wt.%).

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References

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