Supplementary Information

Modification of epoxy resin through the self-assembly of a surfactant like multielement flame retardant

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We analyzed the reaction mechanism in detail. Based on the literature\(^1\), the pathway of the Kabachnik-Fields reaction depends on the nature of the reactants. Generally, the basicity of the amine is the crucial factor that determines the reaction pathway. In this paper, POSS-NH\(_2\) as an aliphatic primary amine, which can nucleophilic interaction of the pre-reaction complex so in this condition the reaction follows the ‘hydroxy phosphonate’ pathway. As show in Scheme S1, the reaction starts with the addition of a phosphite to formaldehyde to form \(\alpha\)-hydroxyl phosphate \(3\), followed the hydroxyl group was replaced by the amino group and release the water molecular, finally the target product was obtained.

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\begin{align*}
1 \quad \text{RNH}_2 & \quad \text{H} \quad \text{PO} \quad \text{O} \\
2 & \quad \text{PO} \quad \text{OH} \\
\end{align*}
\]

Scheme S1. The proposed mechanism for the synthesis of POSS-bisDOPO.
Figure S1. $^{13}$C NMR spectrum for POSS-bisDOPO.

Figure S2. 2D NMR spectra for POSS-bisDOPO.
Figure S3. Mass spectra of POSS-NH$_2$ (a) and POSS-bisDOPO (b).

Figure S4. TGA and DTG curves of POSS-bisDOPO under air (a) and under nitrogen (b).
Figure S5. The TGA and DTG curves of control samples (a, b nitrogen atmosphere, c, d air atmosphere, 10 °C min⁻¹).

Figure S6. SEM images of fracture surface of Control Samples.