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Polyoxometalate-Ionic Liquids (POM-ILs) as Highly Efficient Flame Retardants for Epoxy Resin

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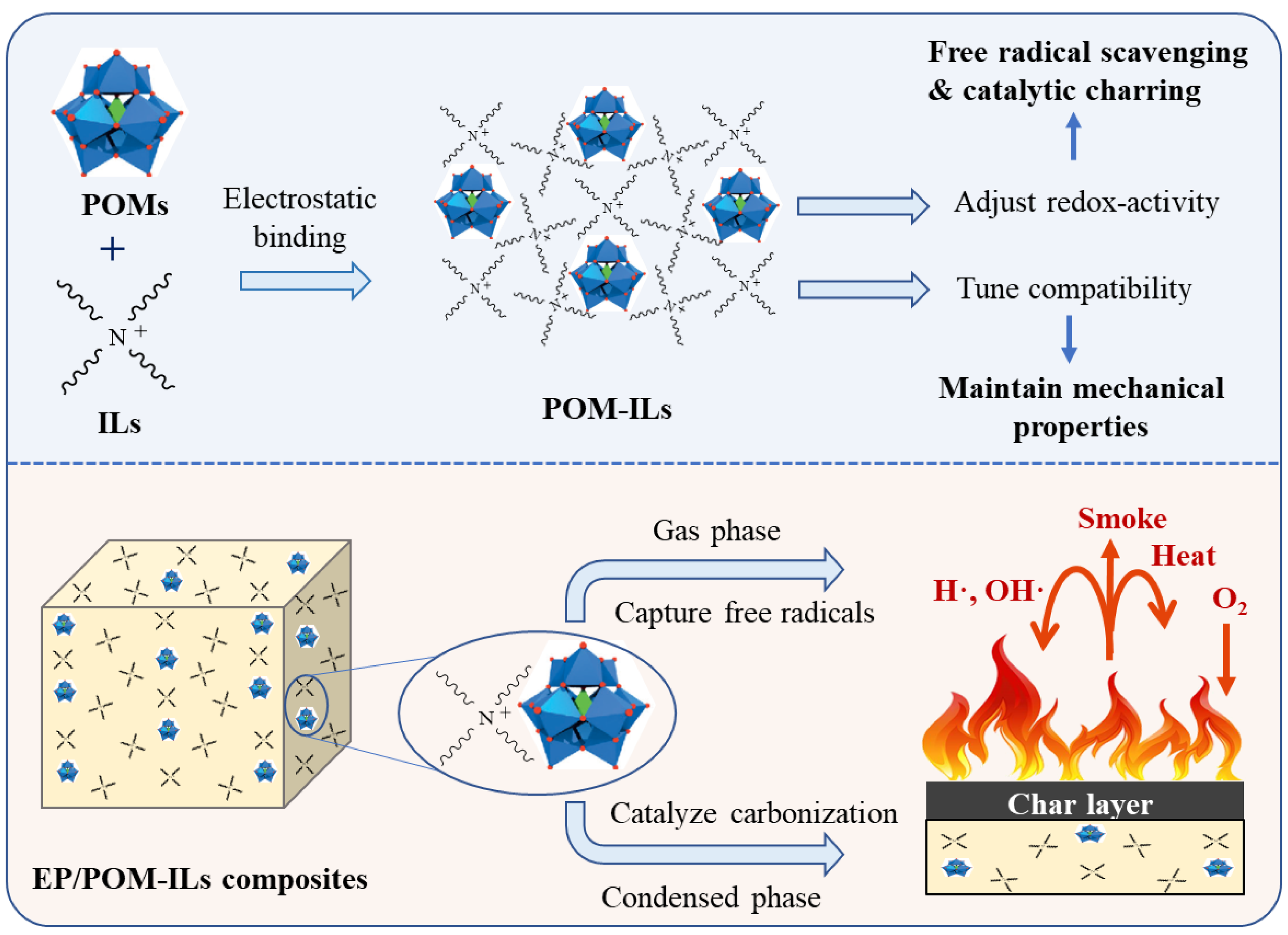
Challenges & our strategies

Flame retardancy of epoxy resin has come under increased concerns over health, environmental, and sustainability issues of conventional flame retardants, as well as the deterioration of the polymers' intrinsic properties associated with poor compatibility between additives and matrices.



Scheme 1. Polyoxometalate-based ionic liquids aiming at improving flame retardancy of epoxy resin and simultaneously ensuring compatibility of the composites.

Results & Discussion

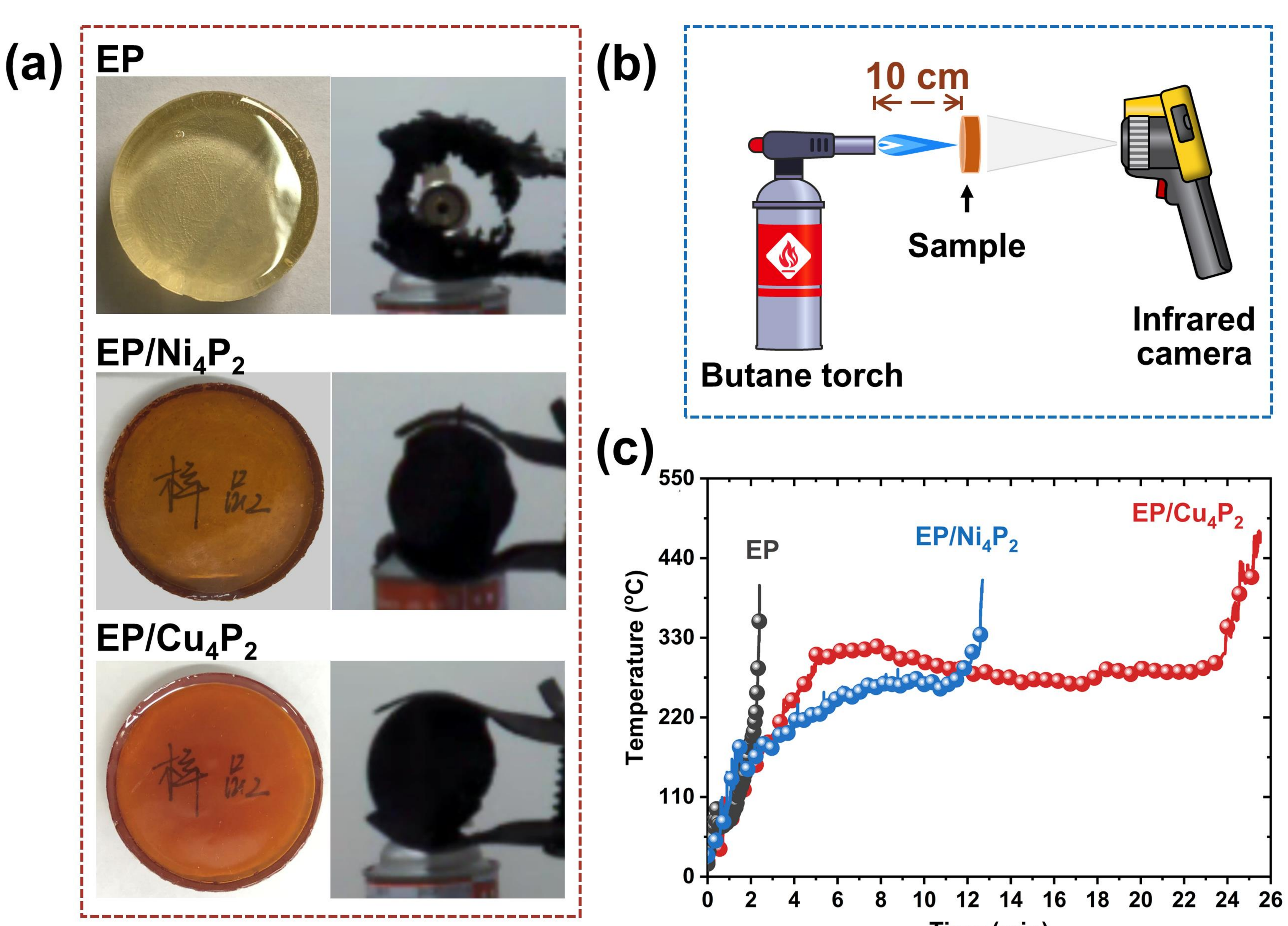


Figure 1. Fire-resistance performance of epoxy resin and its composites with exposure to a flame of a butane torch. (a) Samples before (Ø40 mm × 10 mm) and after the butane torch test. (b) Illustration of the setup for the test and the measurement of the backside temperature of the sample. (c) The average temperature of three reference points on the backside of the sample as a function of time.

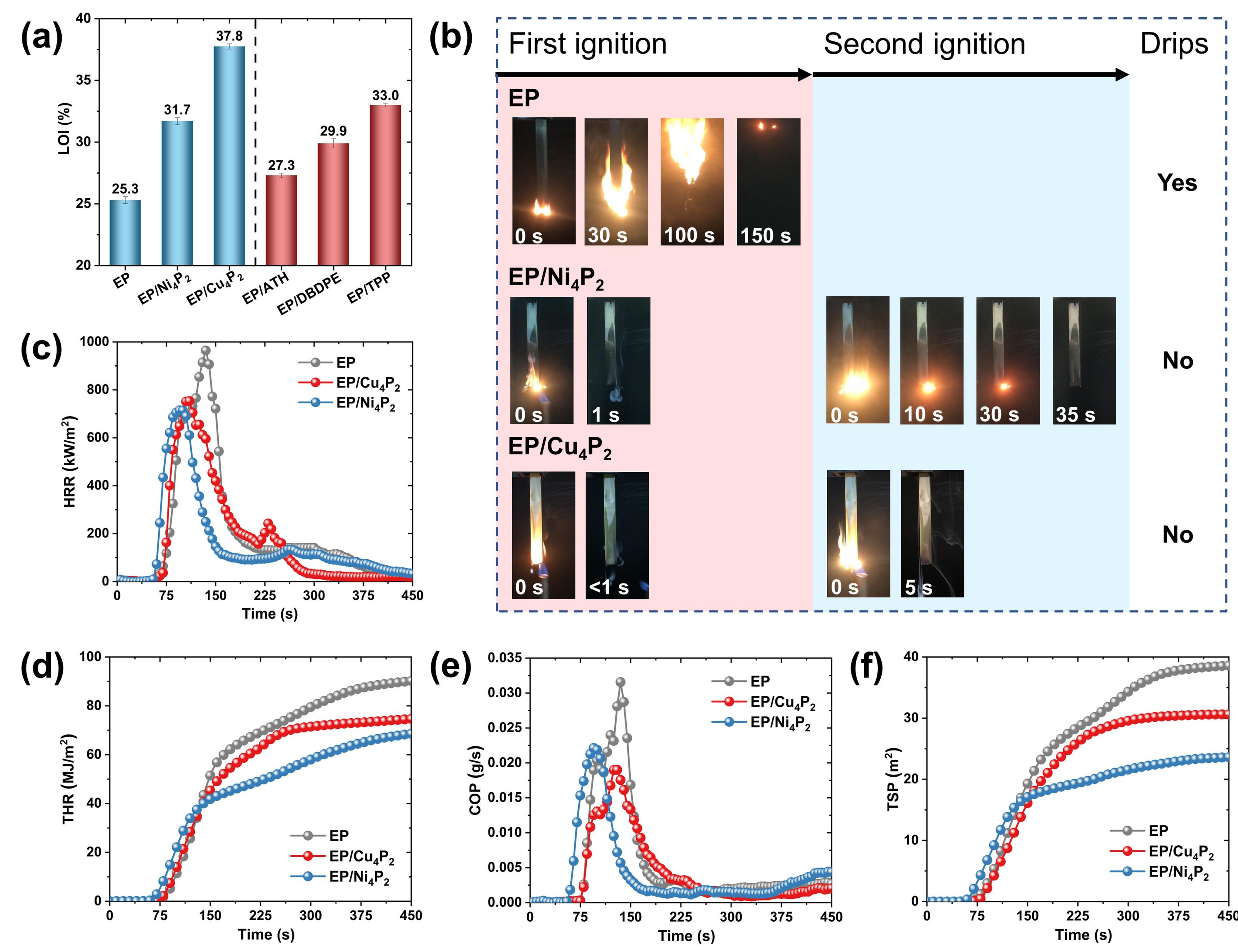


Figure 2. Effects of the POM-ILs on the flame retardancy of the epoxy resin. (a) Limiting oxygen index (LOI) of EP, EP/Cu_4P_2, EP/Ni_4P_2, and the epoxy resins flame-retarded with three commercial flame retardants. (b) UL-94 vertical burning test of EP, EP/Cu_4P_2, EP/Ni_4P_2. (c) Heat release rate (HRR), (d) total heat release (THR), (e) carbon monoxide production rate (COP), and (f) total smoke production (TSP) of EP and its composites from the cone calorimetry.

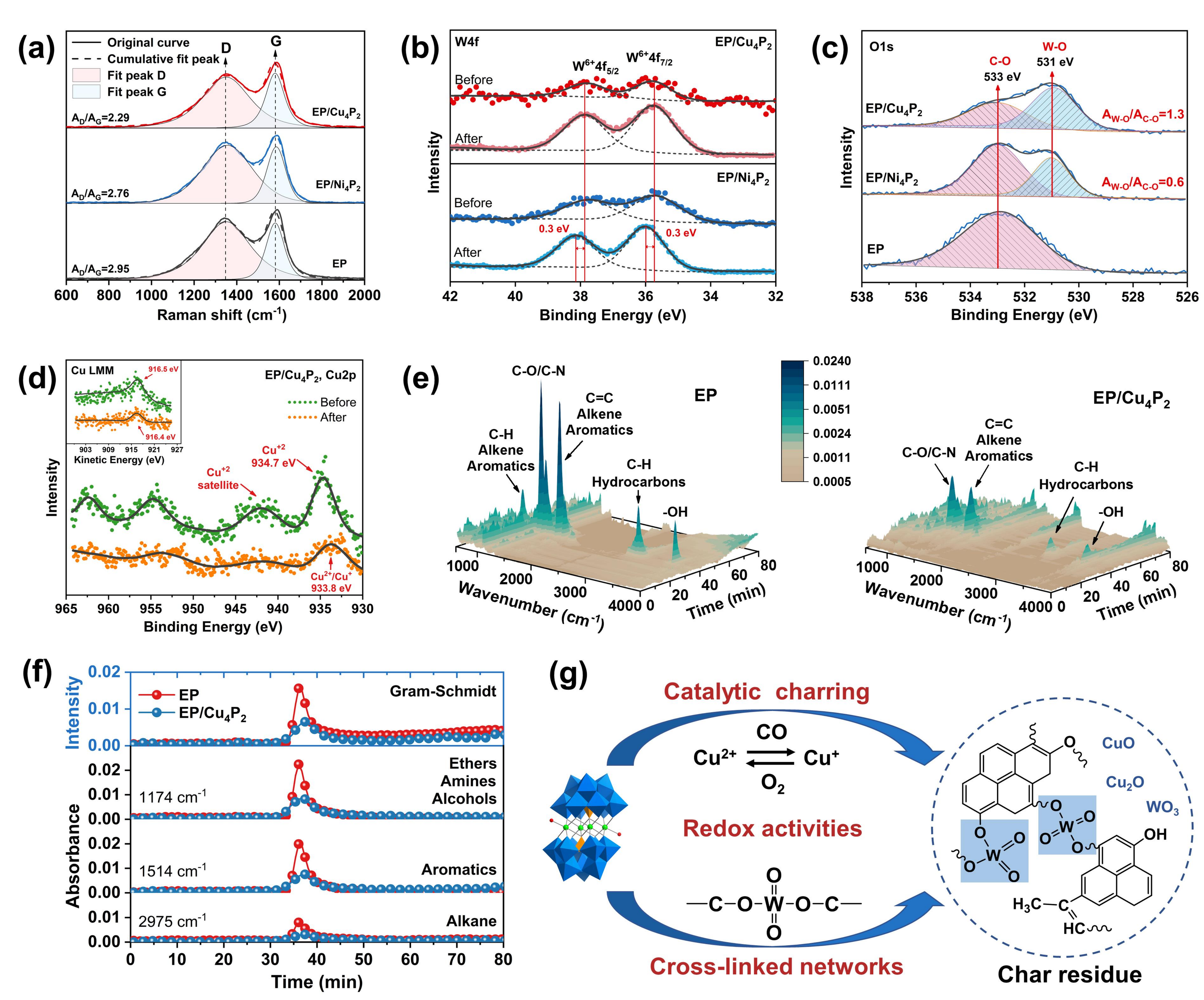


Figure 3. (a) Raman spectra of the char residues from the cone calorimetry. XPS spectra of (b) W4f, (c) O1s, and (d) Cu2p of the char residues, the data collected from the samples before the cone calorimetry are included for comparison. (e) Three-dimensional TG-FTIR spectra of EP and EP/Cu_4P_2, and (f) their corresponding Gram-Schmidt curves and absorbance intensities of main products. (g) Proposed mechanism for flame retardancy of EP/POM-ILs.

Conclusions

- The resulting POM-ILs greatly enhanced the fire-safety properties of the epoxy resin even with a rather low loading concentration of 3 wt.%, owing to the good matrix compatibility and remarkable catalytic charring ability
- This work sheds light on the propitious application of POMs-based molecular materials for flame retardancy of polymers beyond conventional phosphorus-, nitrogen-, silicon-, or halogen-containing flame retardants

Acknowledgments

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