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Design of novel double-layer coated ammonium polyphosphate and its application in flame retardant thermoplastic polyurethanes

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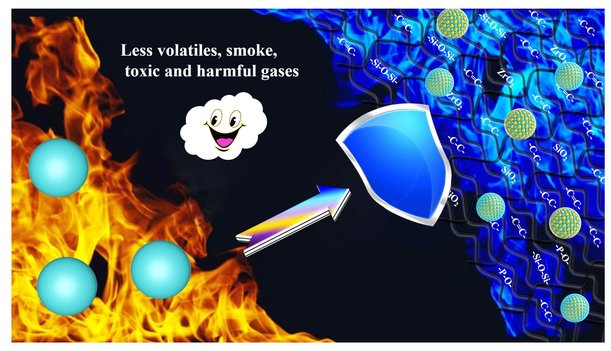
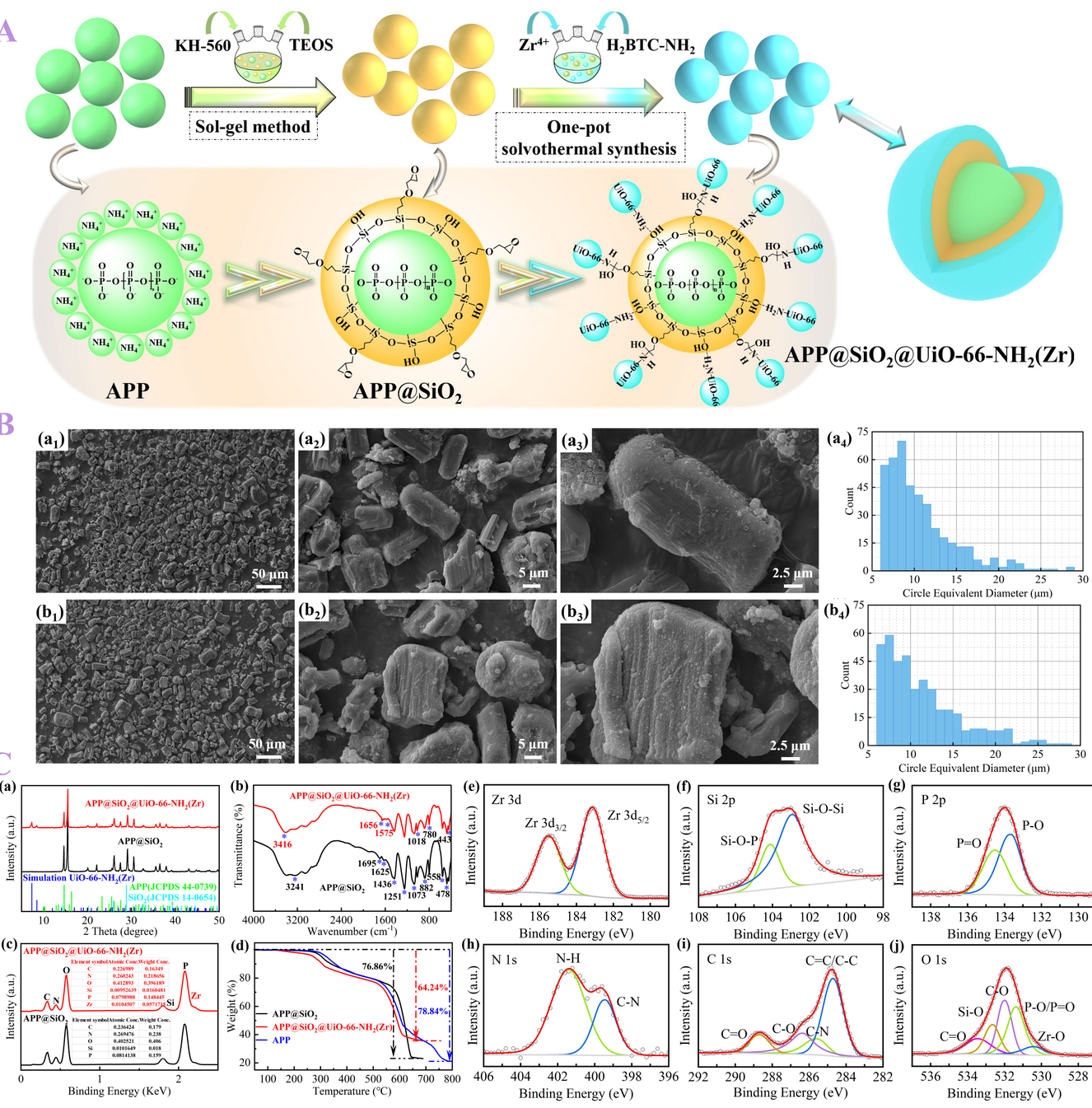
Abstract

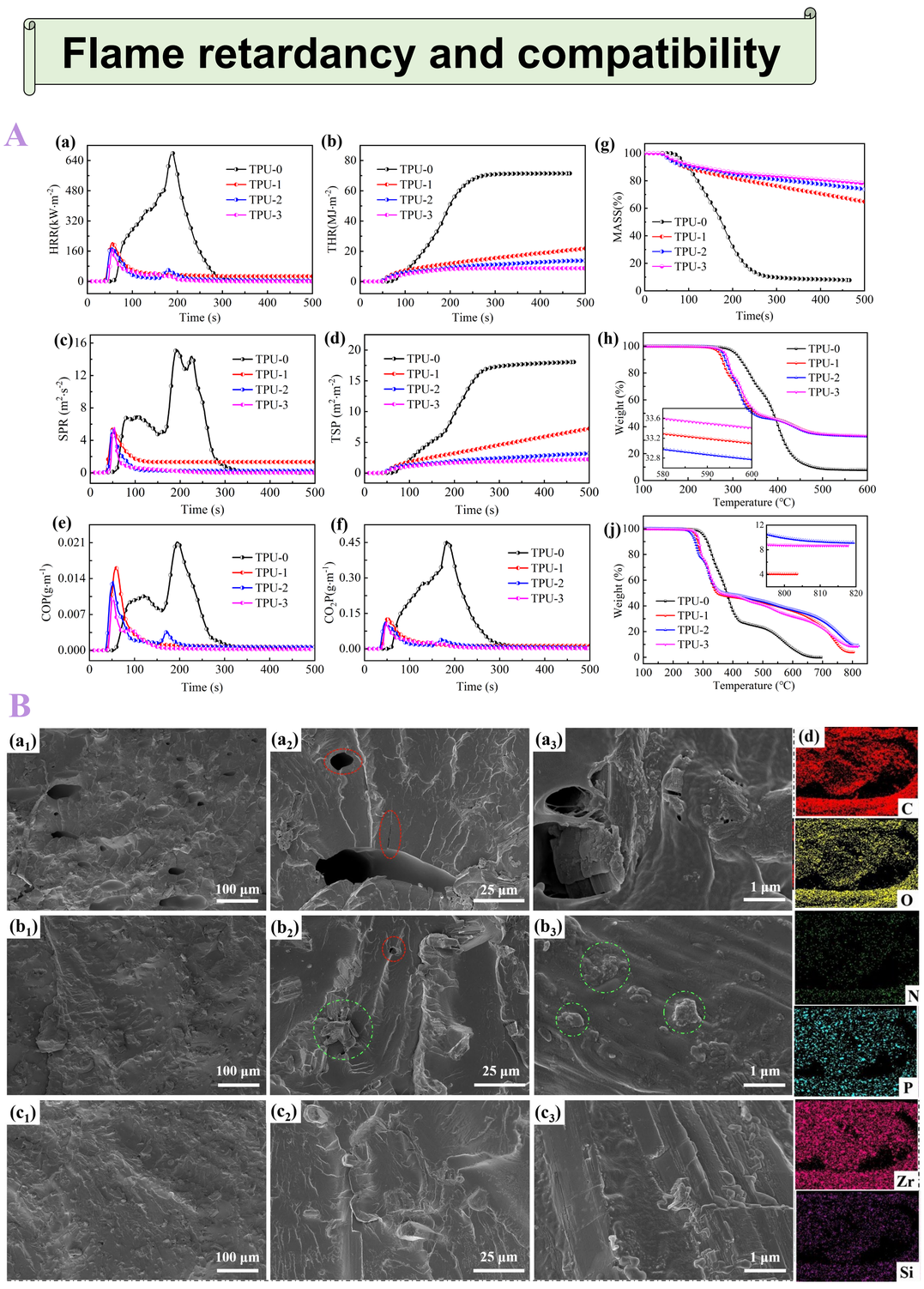
It is well established that thermal radiation and smoke are important factors leading to fire losses and casualties. A multilayer core-shell flame retardant (APP@SiO_2@UiO-66-NH_2(Zr)) was developed by wrapping ammonium polyphosphate (APP) with a zirconium-based metal-organic framework (UiO-66-NH_2(Zr)), tetraethyl orthosilicate, and γ-(2,3-epoxypropoxy) propytrimethoxysilane. The flame retardant was applied to thermoplastic polyurethane (TPU) to improve the smoke suppression and fire resistance of TPU.



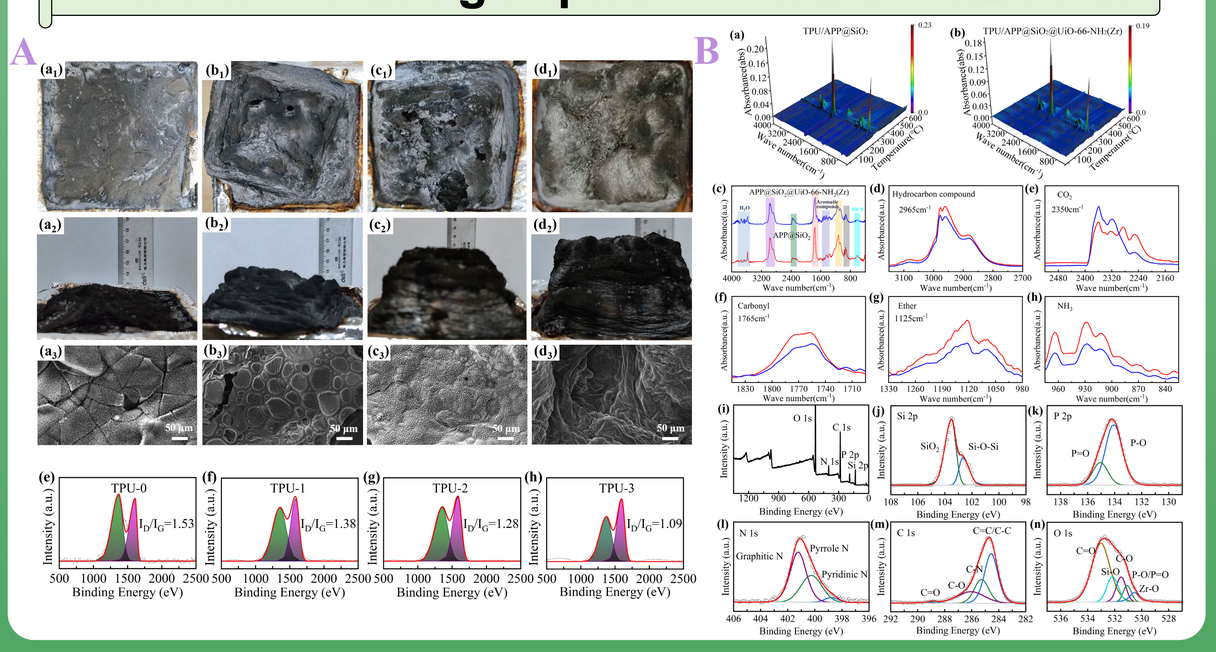
Preparation and characterization



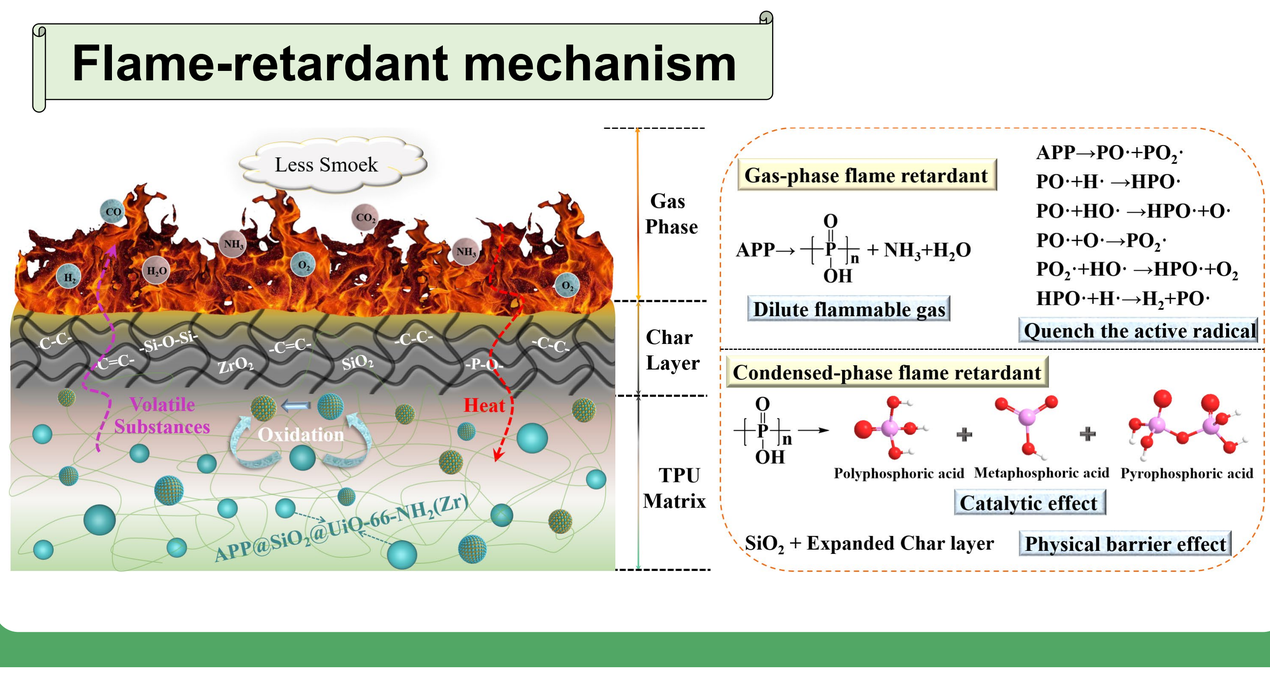
Flame retardancy and compatibility



Condensed and gas phases characterization



Flame-retardant mechanism



Conclusion

Compared with pure TPU, the pHRR, THR, SPR, TSP, and Y_{CO} of the TPU/APP@SiO_2@UiO-66-NH_2(Zr) composites were significantly reduced by 75.1%, 87.8%, 63.6%, 87.7%, and 52.4%, respectively. During combustion, the unique combination of P/N/Si/MOF produces a thicker and stronger protective carbon layer. Regarding the gas-phase flame retardant mechanism, the released radicals, such as $PO·$ and $PO_2·$, quench the reactive radicals, such as $H·$, $OH·$, and $O·$, and inhibit the chain reaction. Meanwhile, the released non-flammable gases dilute the concentration of oxygen and combustible gases, inhibiting the continuation of the combustion reaction.