

Supporting information

Curing kinetics of phenolphthalein based polyphosphazene towards thermal stability and flame retardancy of polybenzoxazine

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Abstract Phenolphthalein type polyphosphazene (PZPT) microspheres were synthesized by ultrasonic assisted precipitation polymerization method, and their structures were confirmed by scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) spectroscopy. Benzoxazine/PZPT (Ba/PZPT) hybrid materials were fabricated and cured to prepare polybenzoxazine/PZPT (PBa/PZPT) composites. The effects of PZPT microspheres on the curing kinetics and behaviors of Ba were systematically analyzed and supported by differential scanning calorimetry (DSC) and *in-situ* FTIR. The thermogravimetric (TGA) results demonstrated good thermal stability of the PBa composites incorporating PZPT. The peak of heat release rate and total heat release values of PBa/PZPT-5% composites obviously decreased by 57.8% and 17.3% compared to those of the pristine PBa. Moreover, the smoke released from the PZPT/PBa system significantly reduced with the loading of microspheres. Finally, the dynamical mechanical analysis results demonstrated that the T_g of PBa flame retardant composites was approximately 210 °C, not affecting further applications of PBa composites.

Table S1 The curing characteristic parameters of Ba and Ba/PZPT systems at a heating rate of 5 °C/min

Samples	T_i (°C)	T_p (°C)	T_f (°C)	ΔT (°C)
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Ba	231	237	243	12
Ba/PZPT-1%	221	233	241	20
Ba/PZPT-3%	206	220	235	29
Ba/PZPT-5%	200	216	237	37

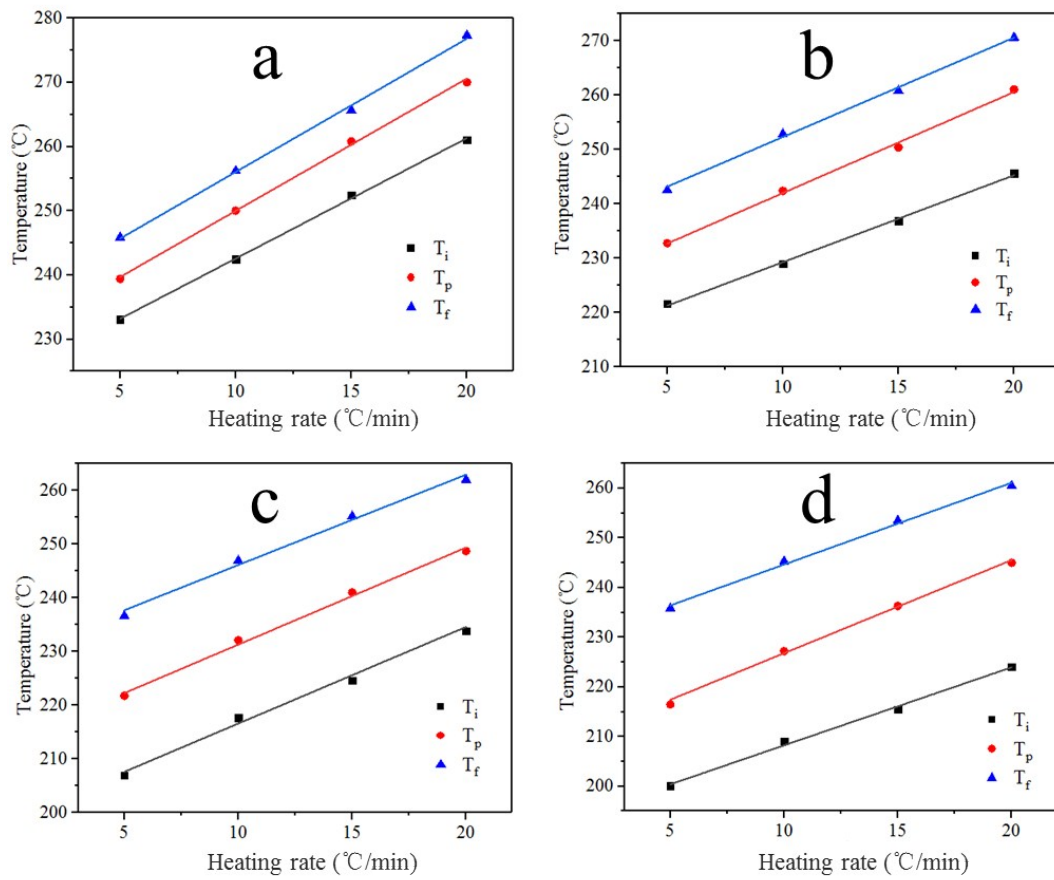


Fig. S1 T_i , T_p , and T_f versus β at different heating rates of 5, 10, 15, 20 °C/min of Ba (a), Ba/PZPT-1% (b), Ba/PZPT-3% (c), and Ba/PZPT-5%(d).

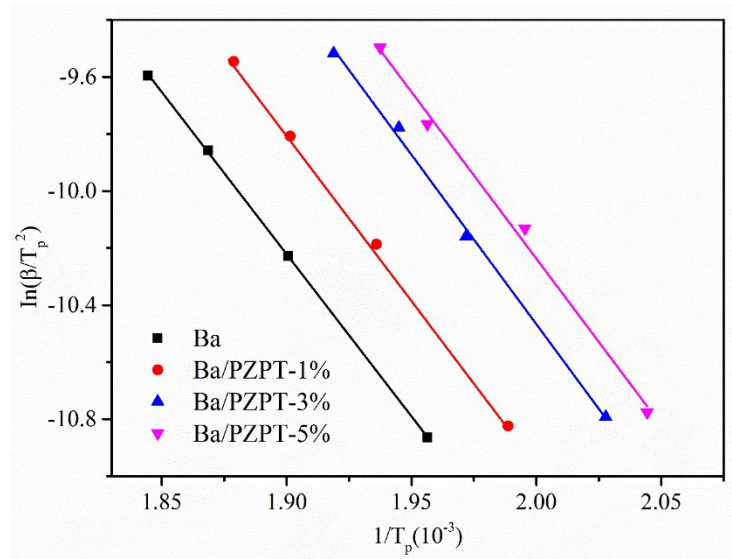


Fig. S2 Calculated kinetic parameters of the Ba and Ba/PZPT systems by the Kissinger method.

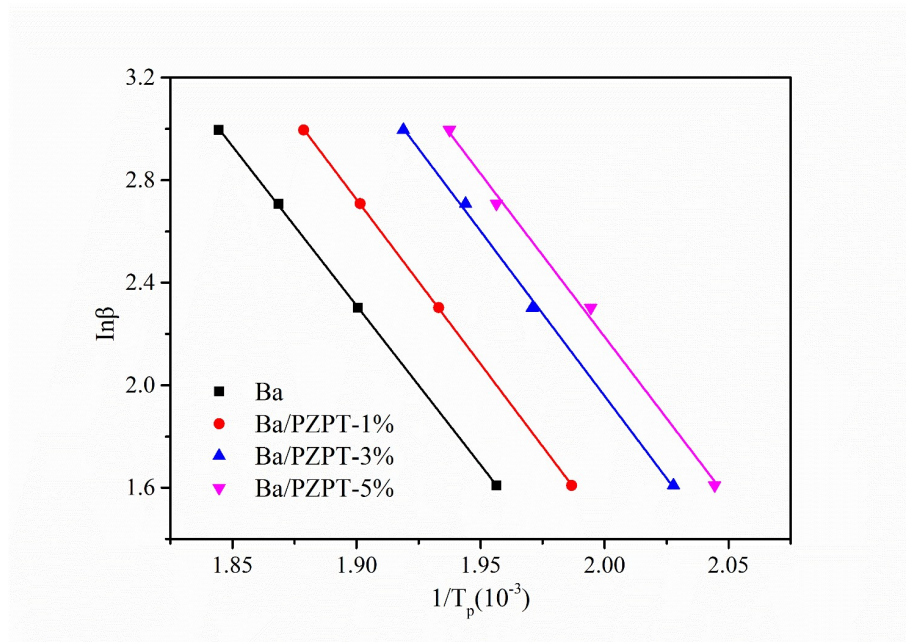


Fig. S3 Calculated kinetic parameters of the Ba and Ba/PZPT systems by the Ozawa method.