

# Efficient Flame Retardancy and Mechanical Enhancement of a Cyclomatrix-type Polyphosphazene Microsphere for Epoxy Resin

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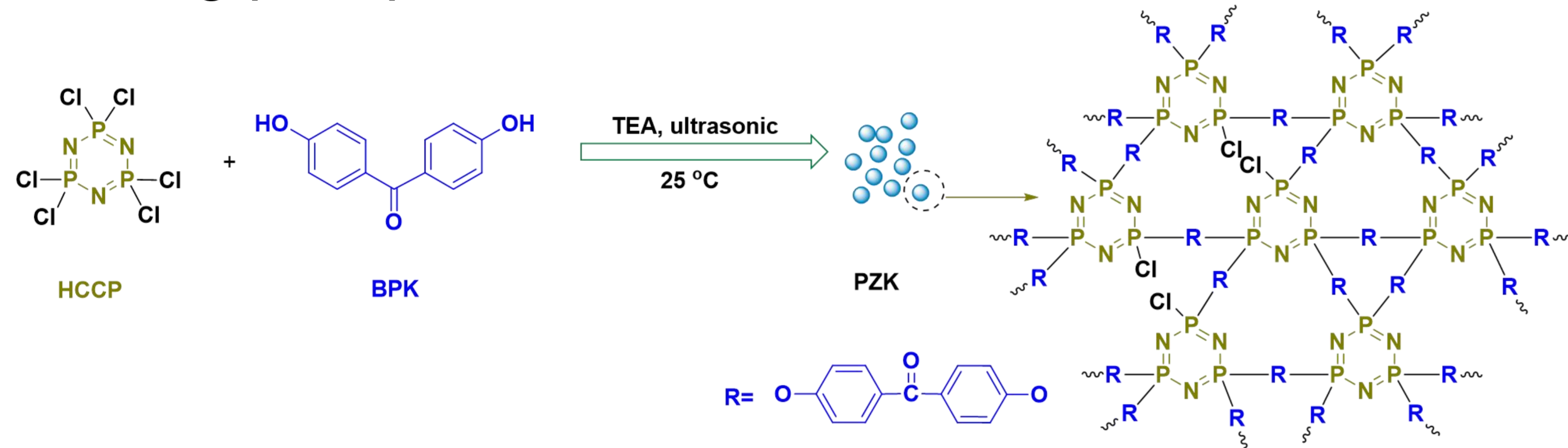
## HIGHLIGHTS

- A kind of PZK microspheres was synthesized.
- PZK microspheres have excellent thermal stability and char-forming ability.
- PZK microspheres can endow epoxy resin efficient flame retardant and enhance its impact strength.

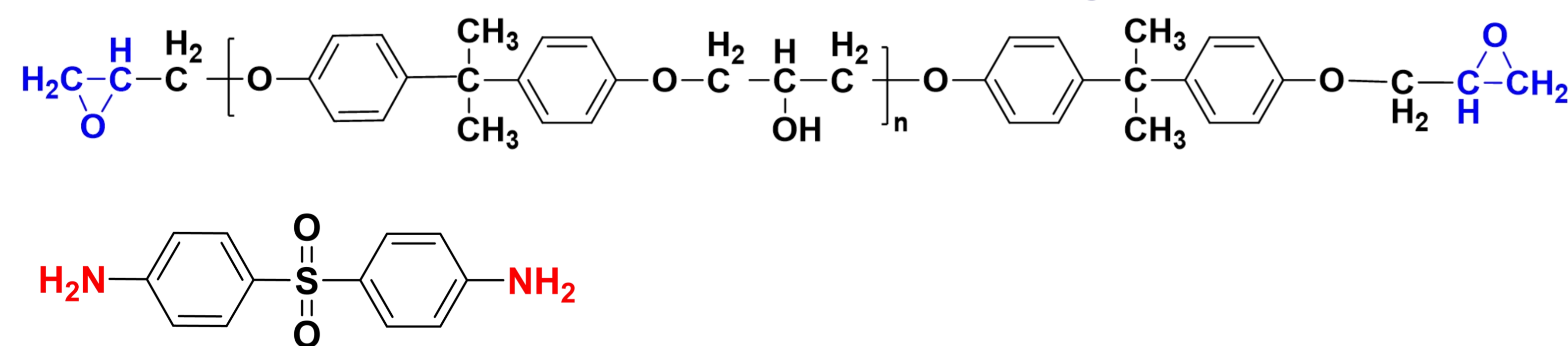
## EXPERIMENTAL

### Preparation of PZK:

- PZK microspheres were prepared by cross-linking precipitation reaction.



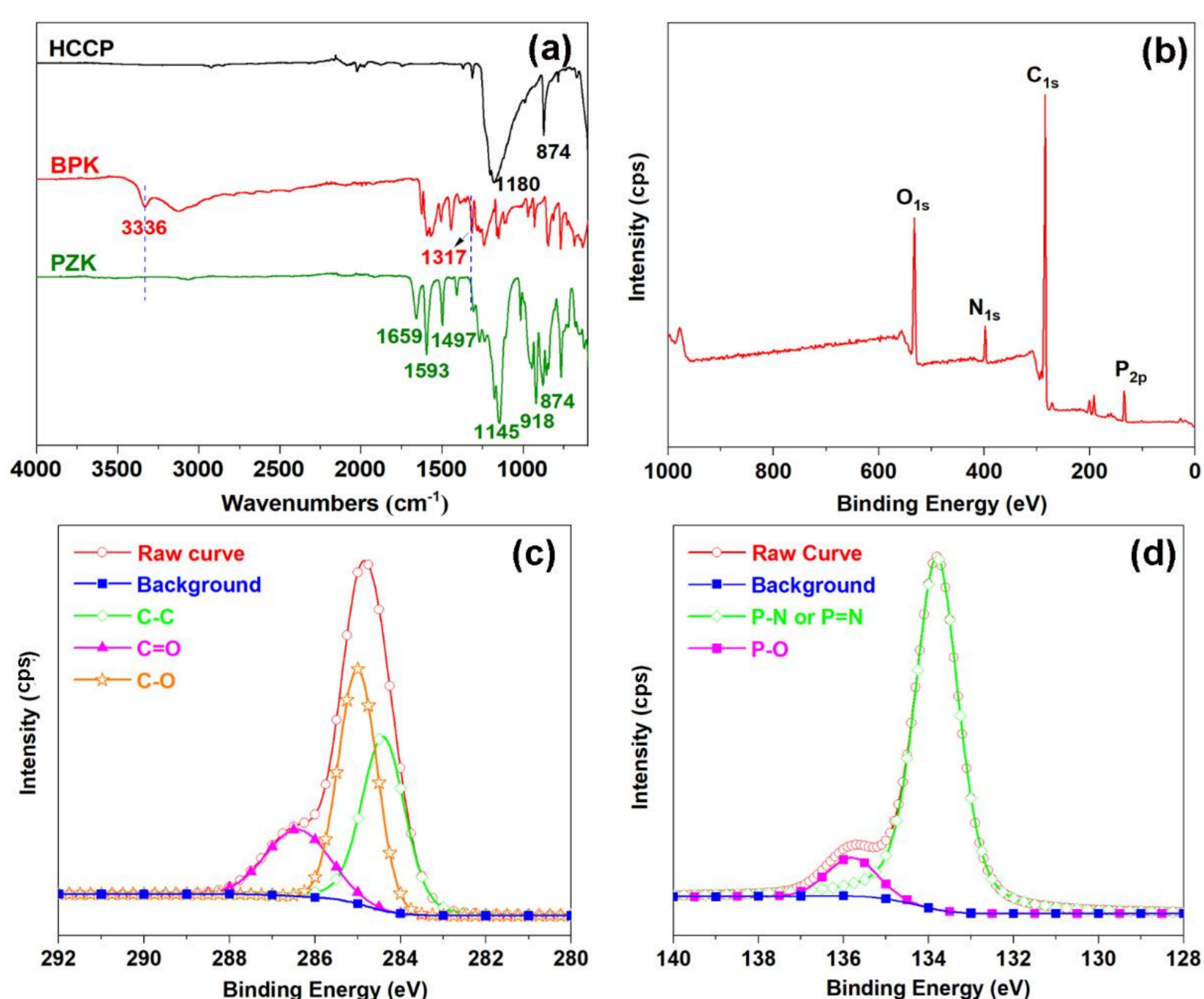
### Preparation of flame retardant epoxy resin:



- Thermosetting program: 160 °C (1 h), 180 °C (2 h), 200 °C (1 h).

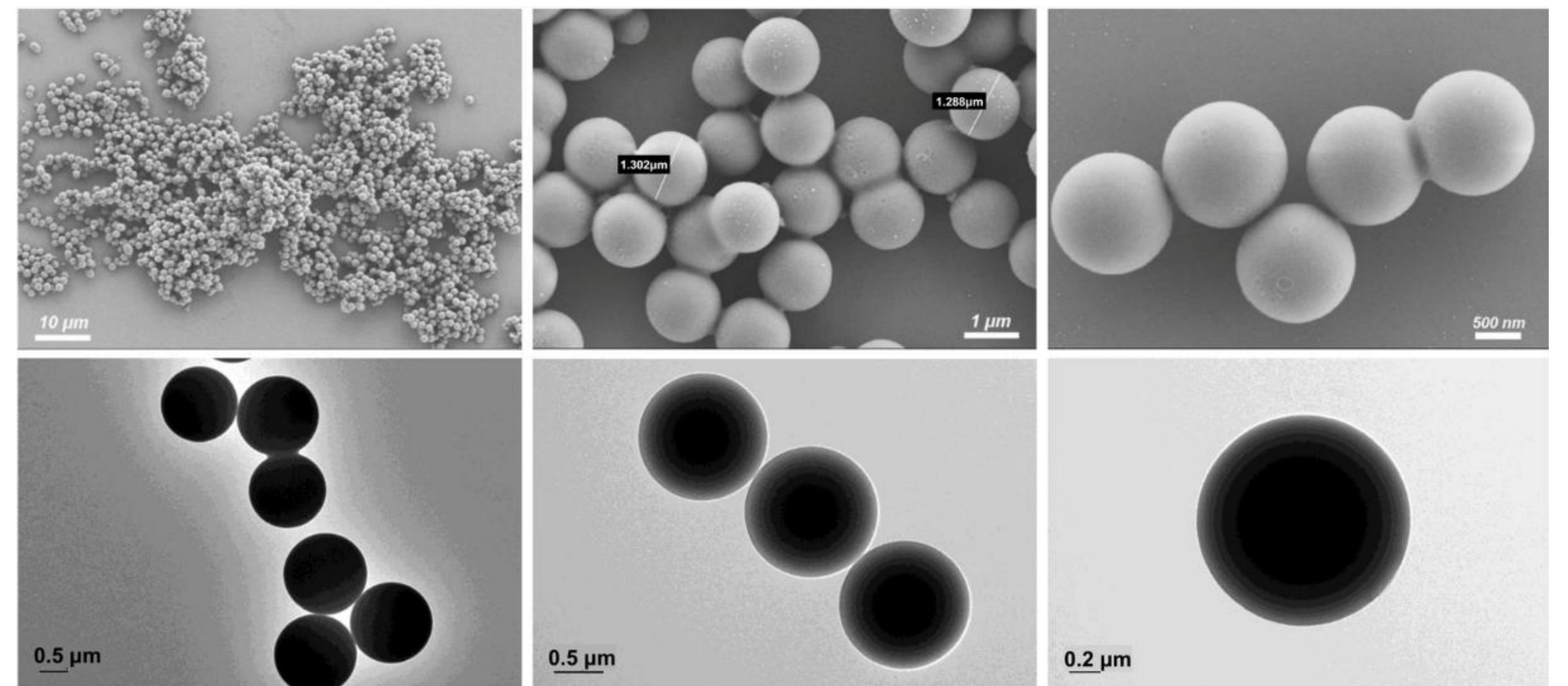
## RESULTS & DISCUSSION

### Chemical structure characterization of PZK:



**Fig. 1** FT-IR spectra of HCCP, BPK, and PZK (a); an XPS survey spectrum of PZK (b); high-resolution  $C_{1s}$  (c), and  $P_{2p}$  (d) XPS spectra of PZK.

### Micromorphological characterization of PZK:

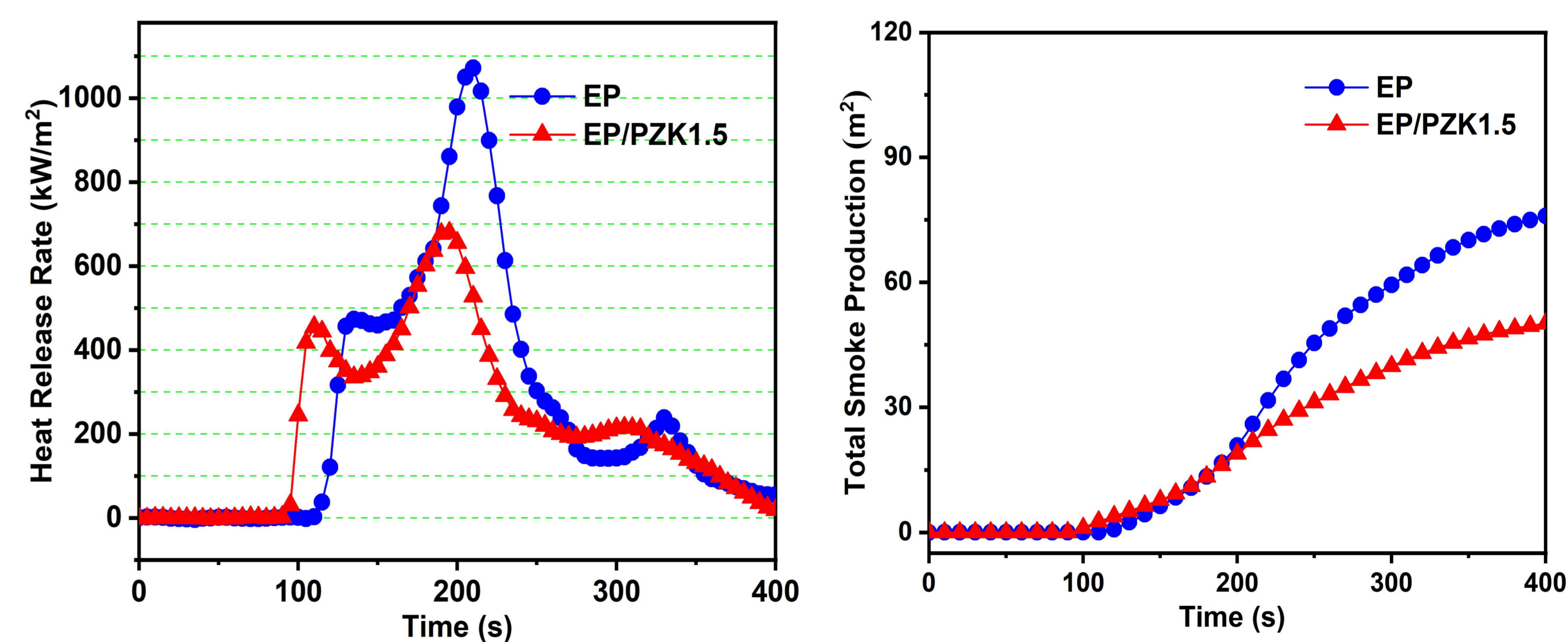


**Fig. 2** SEM (top) and TEM (bottom) images of PZK microsphere.

### Flame retardancy and fire behavior of EP/PZK:

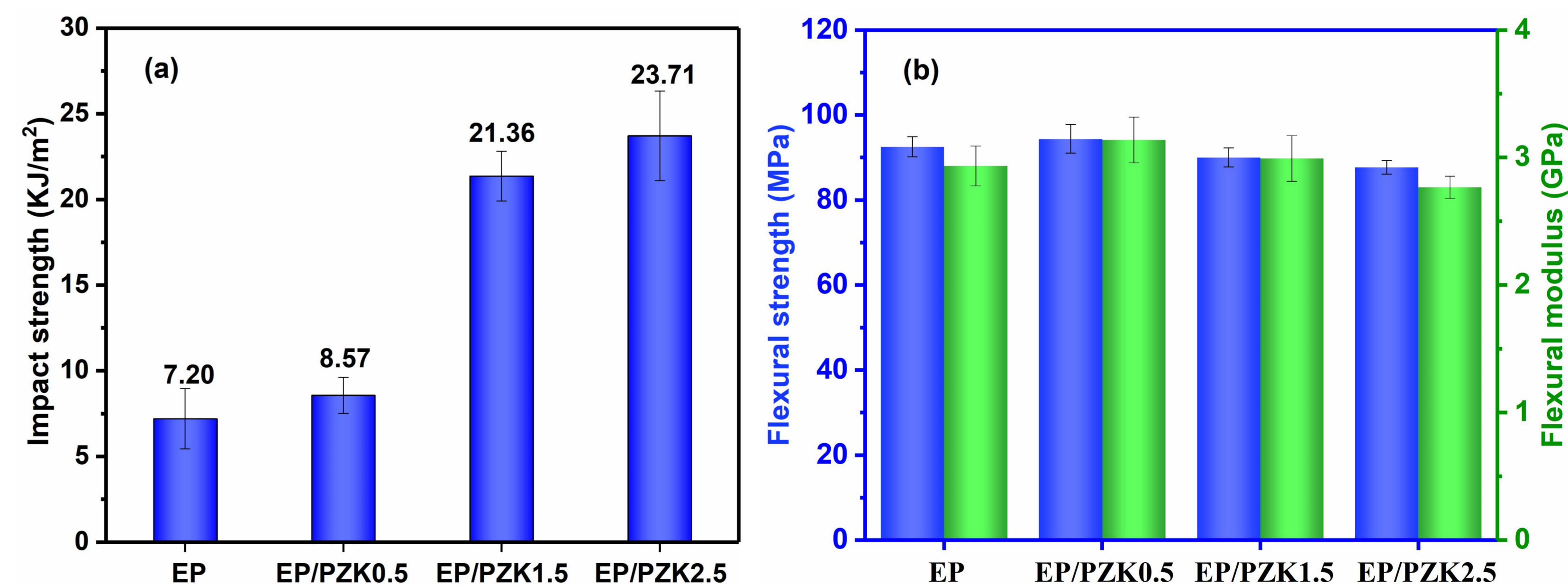
**Table 1** LOI and vertical flame testing results of EPs.

Samples	LOI(%)	UL-94(3.2 mm)			
		$t_1$ (s)	$t_2$ (s)	Rating	Dripping
EP	22.5	≥50	-	NR	Yes
EP/PZK0.5	27.0	65	0	NR	No
EP/PZK1.5	28.3	27	1	V-1	No



**Fig. 3** Heat release rate and total smoke production of EPs.

### Mechanical property of EP/PZK:



**Fig. 4** Mechanical properties of EPs ((a) impact strength (b) flexural strength and flexural modulus).

## REFERENCES

1. E. Maaskant, H. Gojzewski, M.A. Hempenius, G.J. Vancso, N.E. Benes. *Polym Chem* 2018, 9: 3169-3180.
2. C. Wan, X. Huang. *Mater. Today Commun.* 2017, 11: 38-60