一种含有壳聚糖和磷腈单元的聚电解质及其阻燃环氧树脂

A polyelectrolyte containing chitosan and phosphazene units and flame retardant epoxy resin thereof

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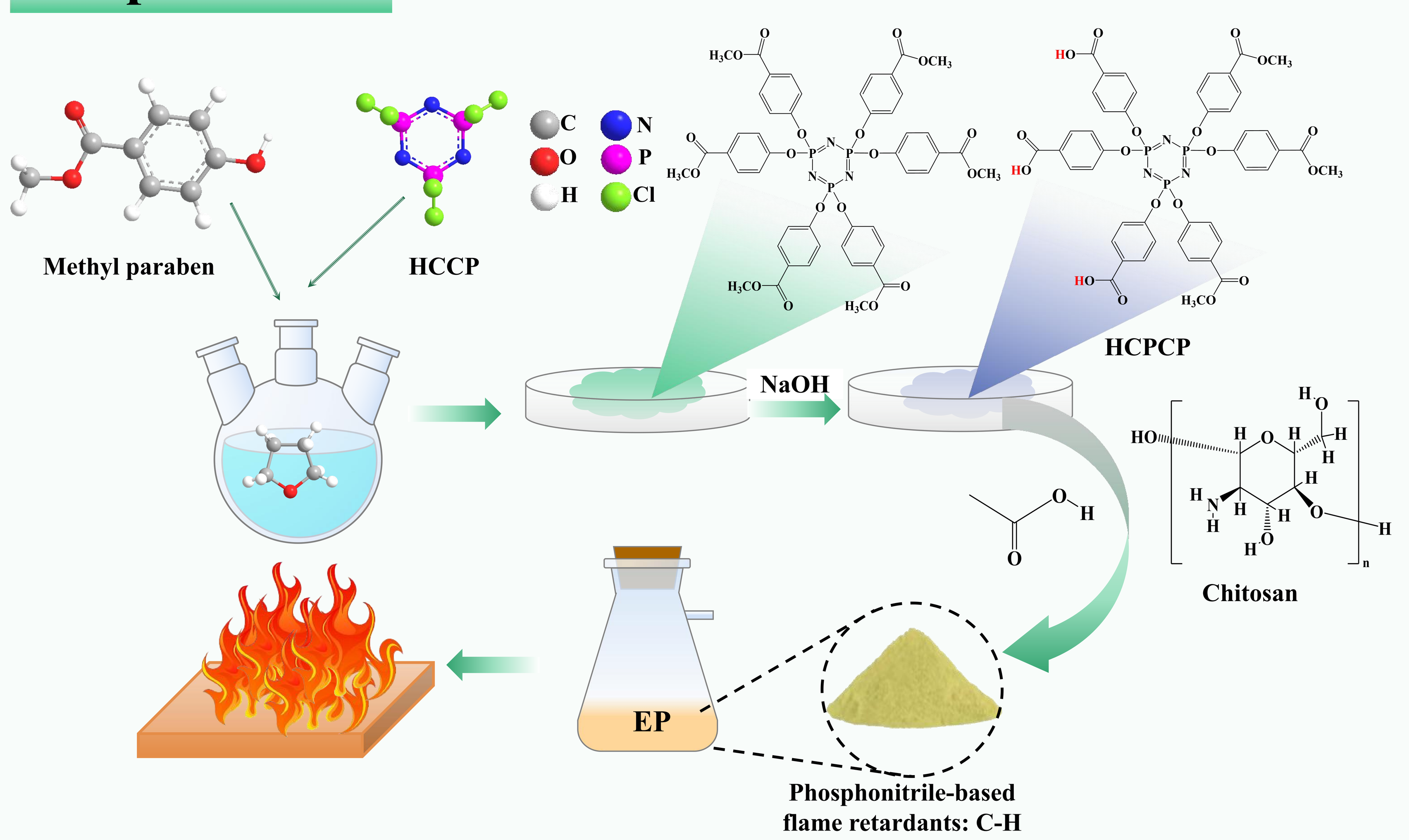
Introduction

Phosphonitrile flame retardants have the advantages of non-toxicity and high efficiency, high thermal stability, and their molecules are rich in phosphorus and nitrogen elements, which provide good synergistic flame retardant effects. Chitosan (CS) is a natural green polymer with properties such as non-toxicity and biocompatibility, and its electrical properties can be further adjusted by acidity and alkalinity to allow multi-substitution reactions with other ions. And the active amino group in its structure can improve the compatibility of the flame retardant with the epoxy resin. In this experiment, hexachlorocyclotriphosphonitrile (HCCP) underwent a nucleophilic reaction with nipagin methyl ester, followed by acid-base modulation and CS reaction to prepare an efficient and environmentally friendly polyelectrolyte flame retardant.

Experiment



Results and discussion

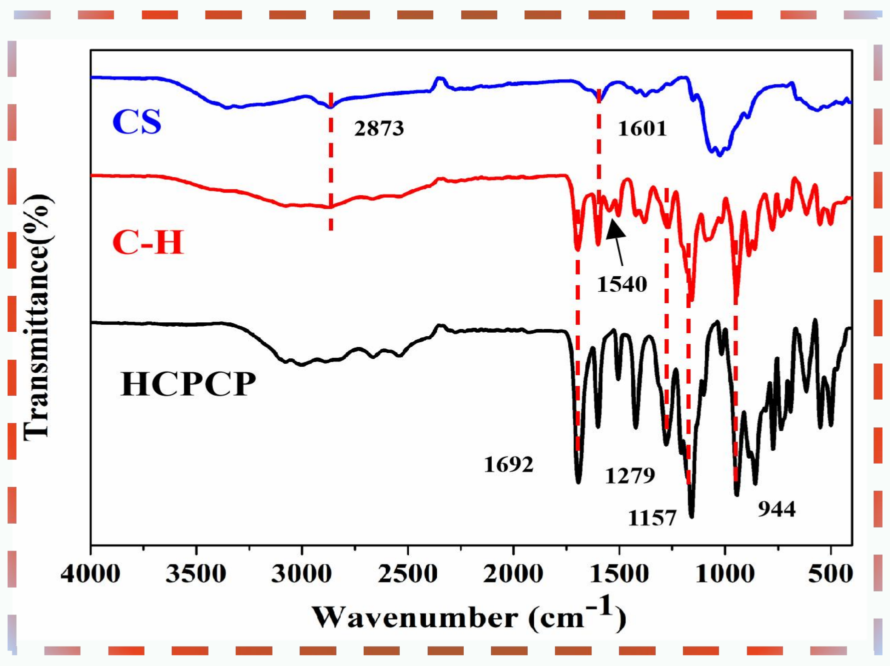


Figure 1. FT-IR spectra of C-H

- ✓C-H shows a new small peak at 1540 cm^{-1}, which is assigned to the vibrational absorption of NH^{3+}.
- ✓Acidification of CS by hydrochloric acid protonates some of the NH_2 groups and the positively charged CS can then form ionic complexes with the negatively charged HCPCP.

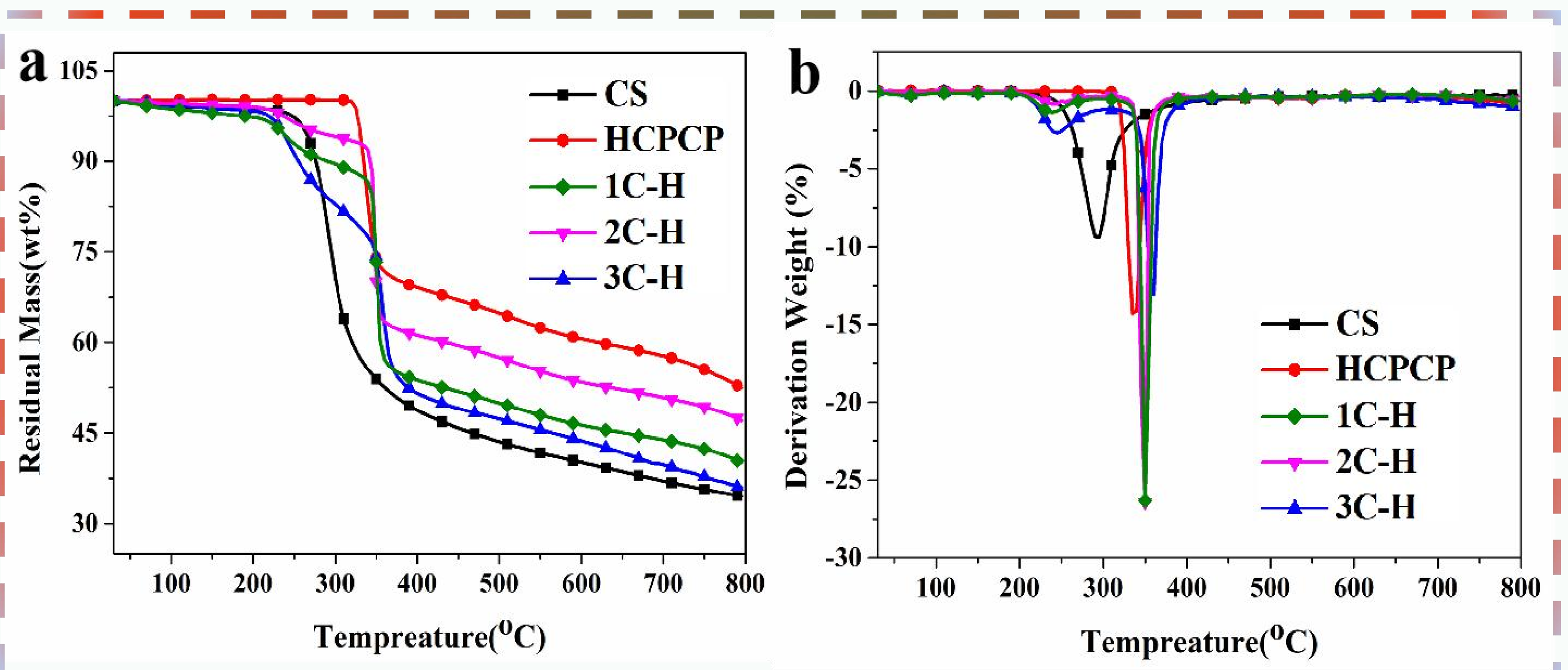


Figure 2. TG-DTG plots of CS, HCPCP and C-H under N_2 atmosphere

- ✓The first stage of degradation occurs at 220-340°C, which is probably due to the pyrolysis of CS in the flame retardant, forming a carbon layer to protect the base material.
- ✓The second step of pyrolysis occurs at around 350°C. This step may be the decomposition of HCPCP to produce a protective layer of phosphoric acid, pyrophosphate.

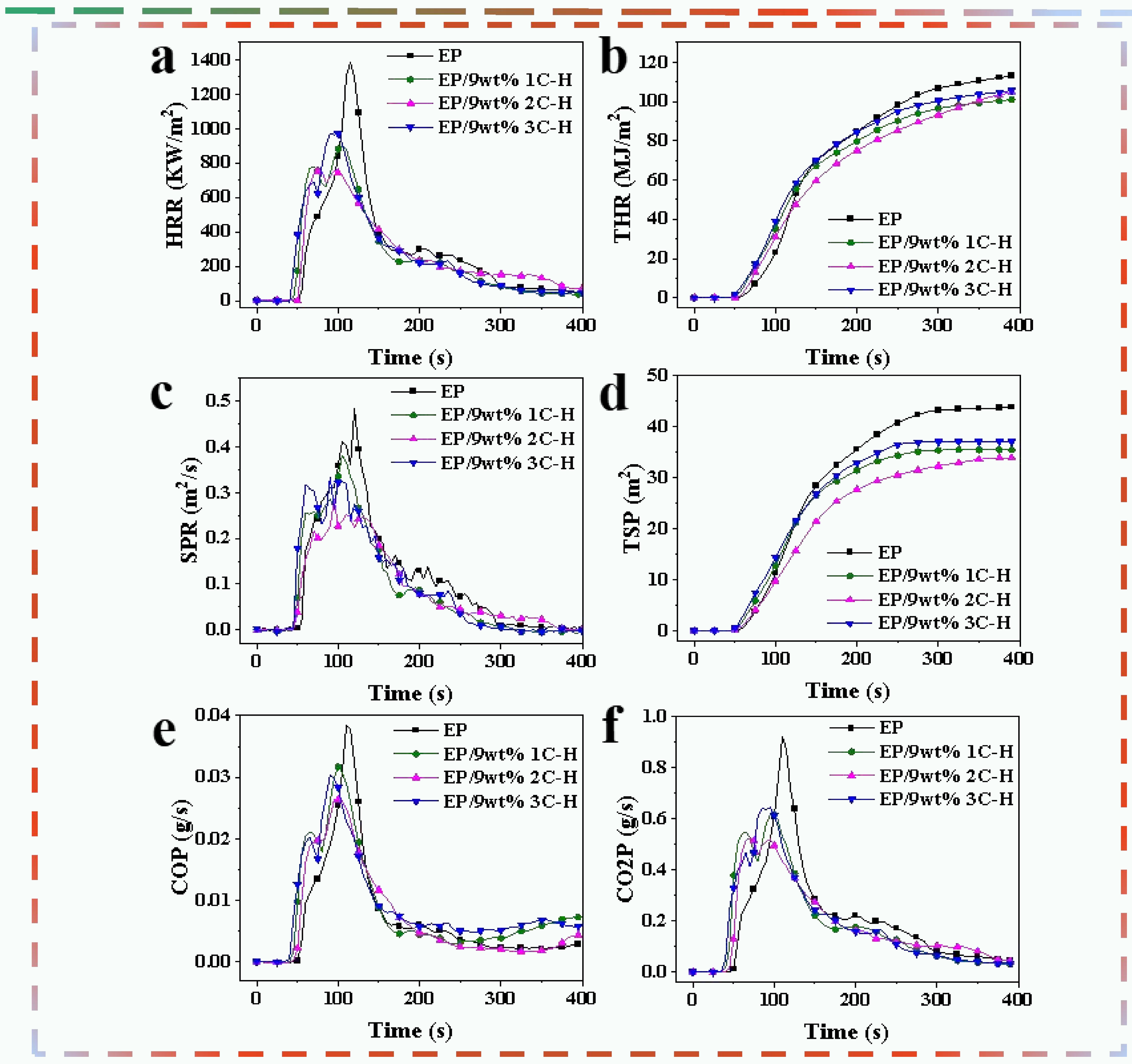
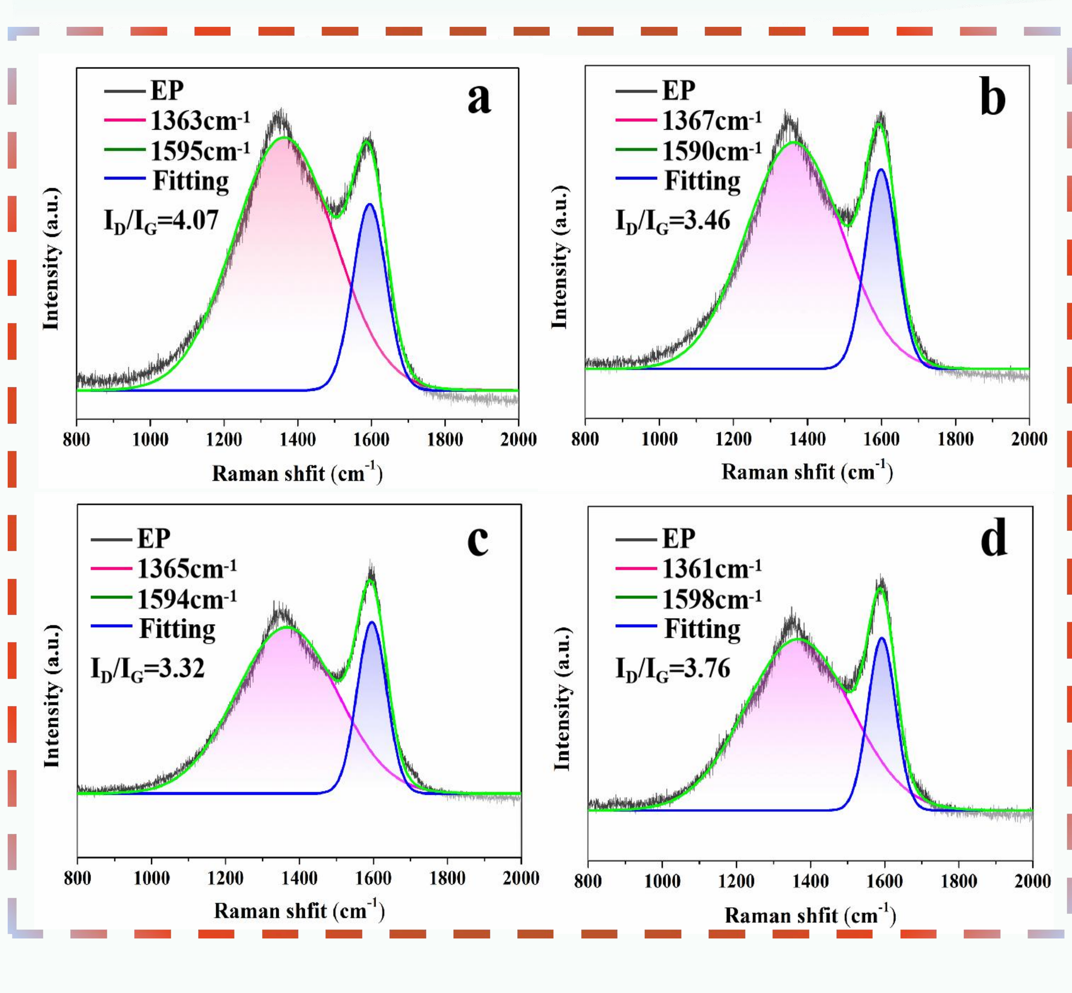


Figure 3. HRR (a), THR (b), SPR (c), TSP (d), COP(e) and CO_2P(f) curves of EP and its composites.

- ✓As the HCPCP content increases, the thickness of the carbon layer increases, providing a better barrier to combustible gases and heat.
- ✓As combustion proceeds, some of the carbon layer begins to collapse and the HHR curve rises again



- ✓As the proportion of HCPCP in the flame retardant increases, the graphitization of the char layer also increases.
- ✓Pure EP residual carbon has an I_D/I_G value of 4.07 and an EP/1C-H of 3.46, a decrease of 15.21%.
- ✓The carbonization of CS produces a stable char layer, which hinders the combustion process

Conclusion

In this study, a, highly efficient polyelectrolyte flame retardant, C-H, was prepared by acid-base modulation with CS and applied to EP resin. The results show that by adding 9 wt% of 2C-H, the PHRR of the composite is reduced by 45.42% compared to pure EP and the release of toxic gases CO and CO2 is significantly reduced. the addition of HCPCP increases the content of the acid source in the flame retardant and makes the carbon layer more dense. CS acts as a carbon forming agent and can hinder the combustion process by carbonisation in the polymer during thermal decomposition.