

Small core of piperazine/silane aggregation initiate efficient charring flame retardant effect in polypropylene composites

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In this work, small amounts of piperazine/phenyl-silicon charring skeleton NSi-n (n=1, 2, 3) with varied aggregation degrees were respectively inserted into a hydrogen-bonded macromolecule fabricated with melamine and cyanuric acid, to prepare a series of nitrogen/silicon-based macromolecules MNSi-n (n=1, 2, 3).

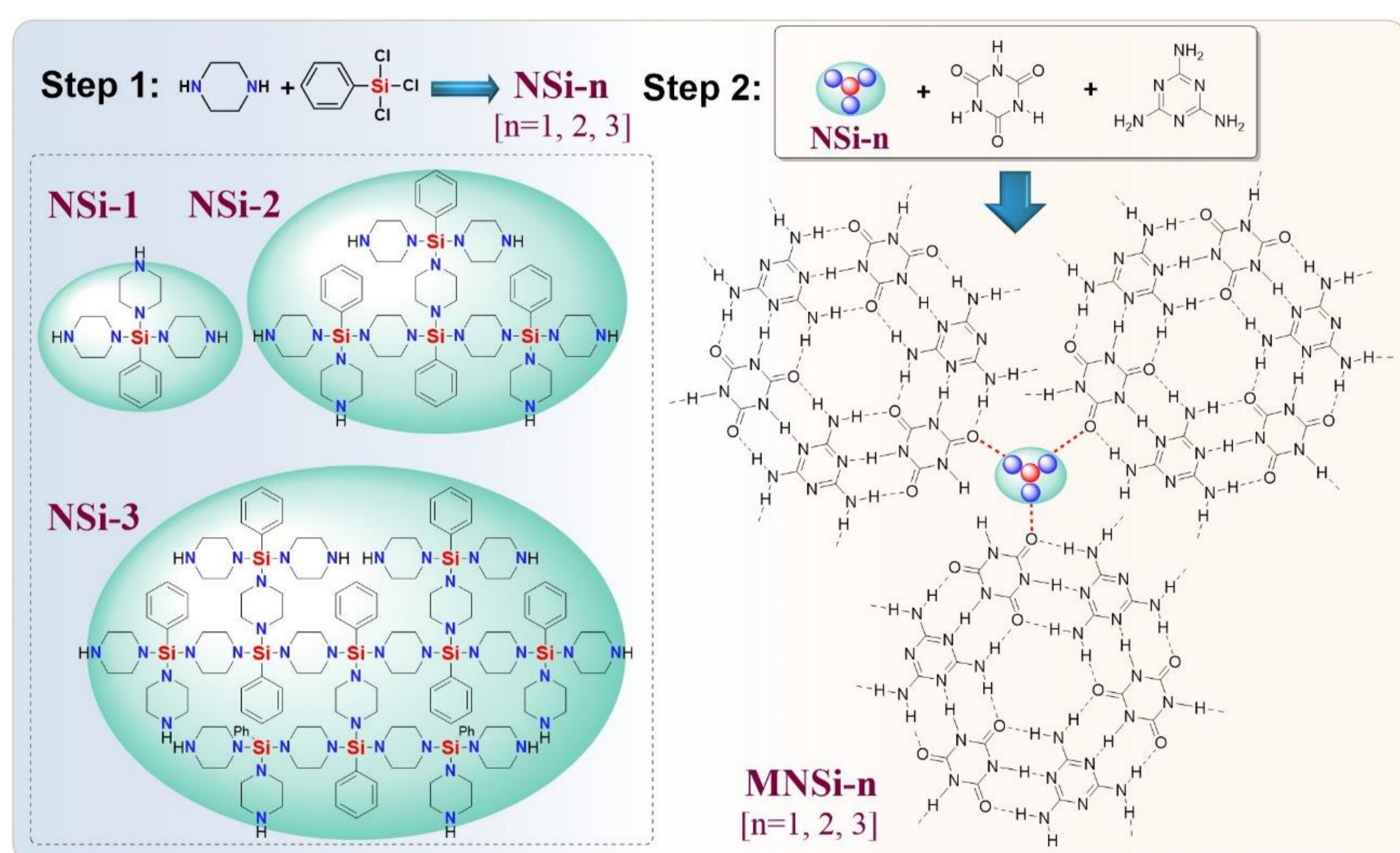


Fig.1 The synthesis routes of NSi-n and MNSi-n.

Compared with MCA/APP, MNSi-n/APP endowed PP with higher LOI, glow wire flammability index (GWFI), glow wire ignition temperature, and UL 94 V-0 level. Meanwhile, (MNSi-n/APP)/PP also performed lower PHRR. Further, the PP composites containing MNSi-3 or MNSi-2 with a larger aggregated piperazine/phenyl-silicon structure obviously exhibited higher intumescent flame retardancy, including higher LOI, GWFI, FPI, and residue yield, and lower THR and FGI values, compared with (MNSi-1/APP)/PP sample.

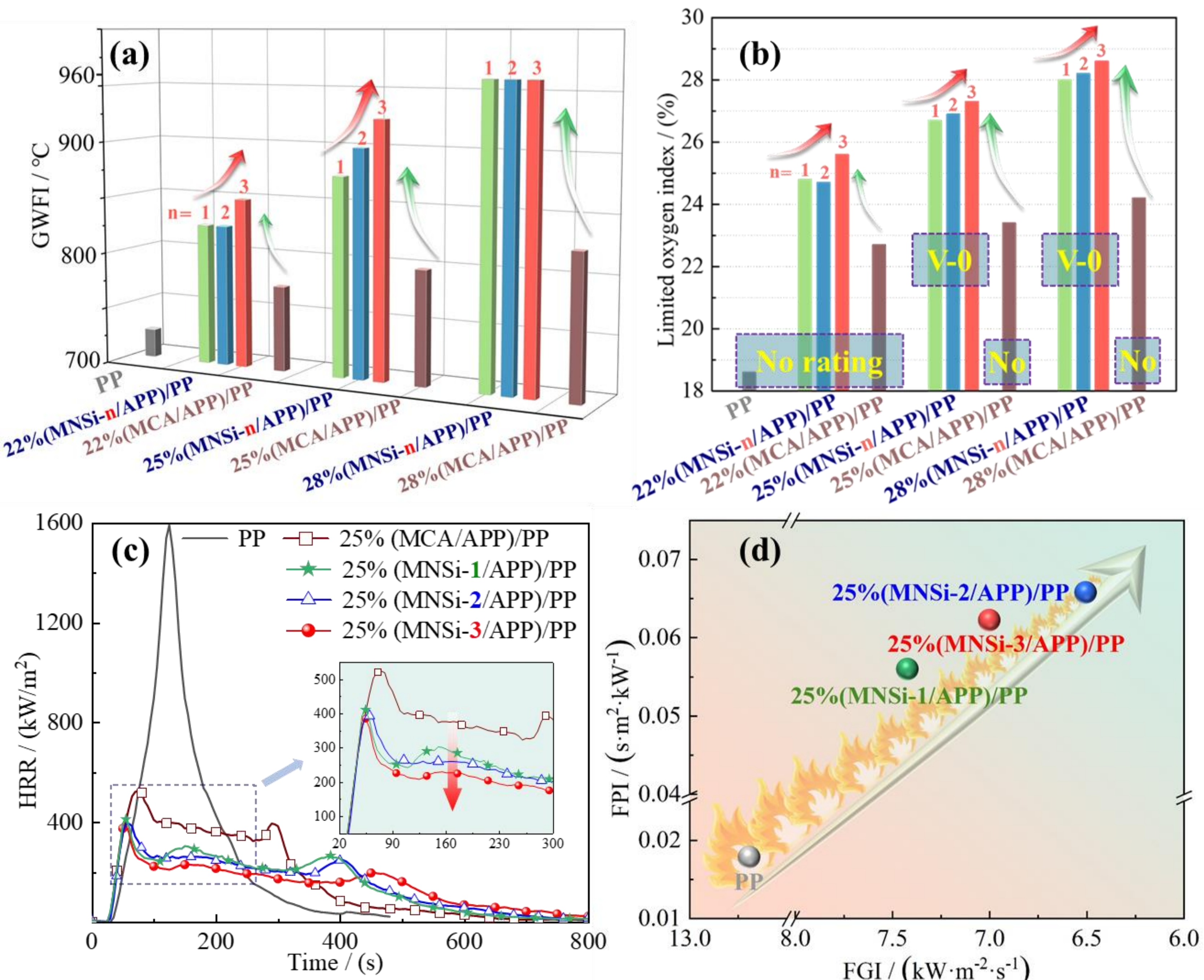


Fig.2 The results of GWFI, LOI, UL 94, and cone calorimeter tests.

Besides, an intuitive method of measuring back temperature was adopted to assess the heat barrier capacity of char layers formed under high temperatures. Fig. 3 proved that the char layers formed by MNSi-n/APP/PP performed much better barrier effect than MCA/APP/PP. And the MNSi-3/APP system exerted the best insulation capacity in PP.

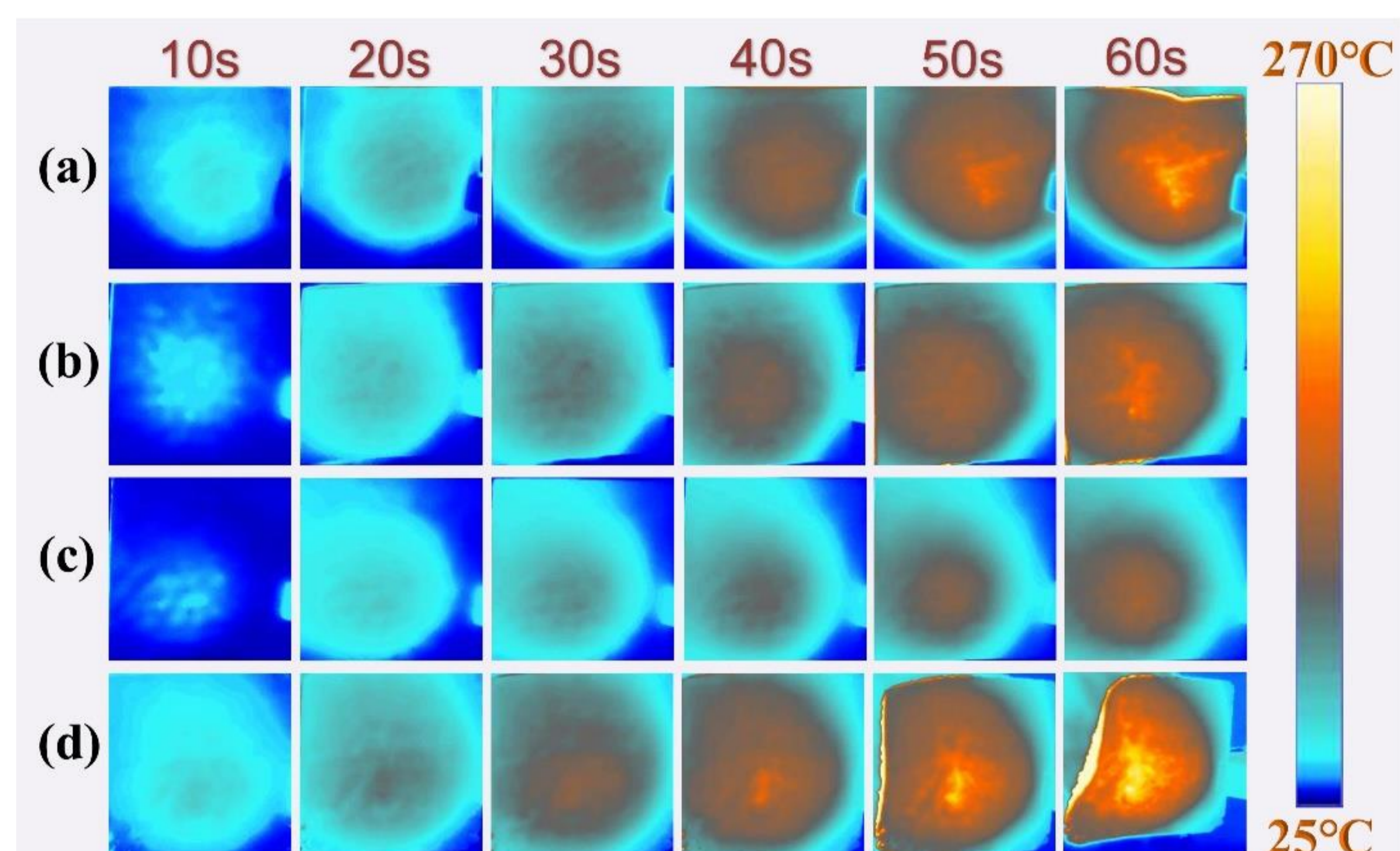


Fig.3 The infrared thermal different flame application times:(a) 25%(MNSi-1/APP)/PP; (b) 25%(MNSi-2/APP)/PP; (c) 25%(MNSi-3/APP)/PP; (d) 25%(MCA/APP)/PP.

The high aggregation degree of NSi-n structure strengthened the full interaction between macromolecules MNSi-n and APP, thus forming more char layers and decreasing the release of hydrocarbon fragments.

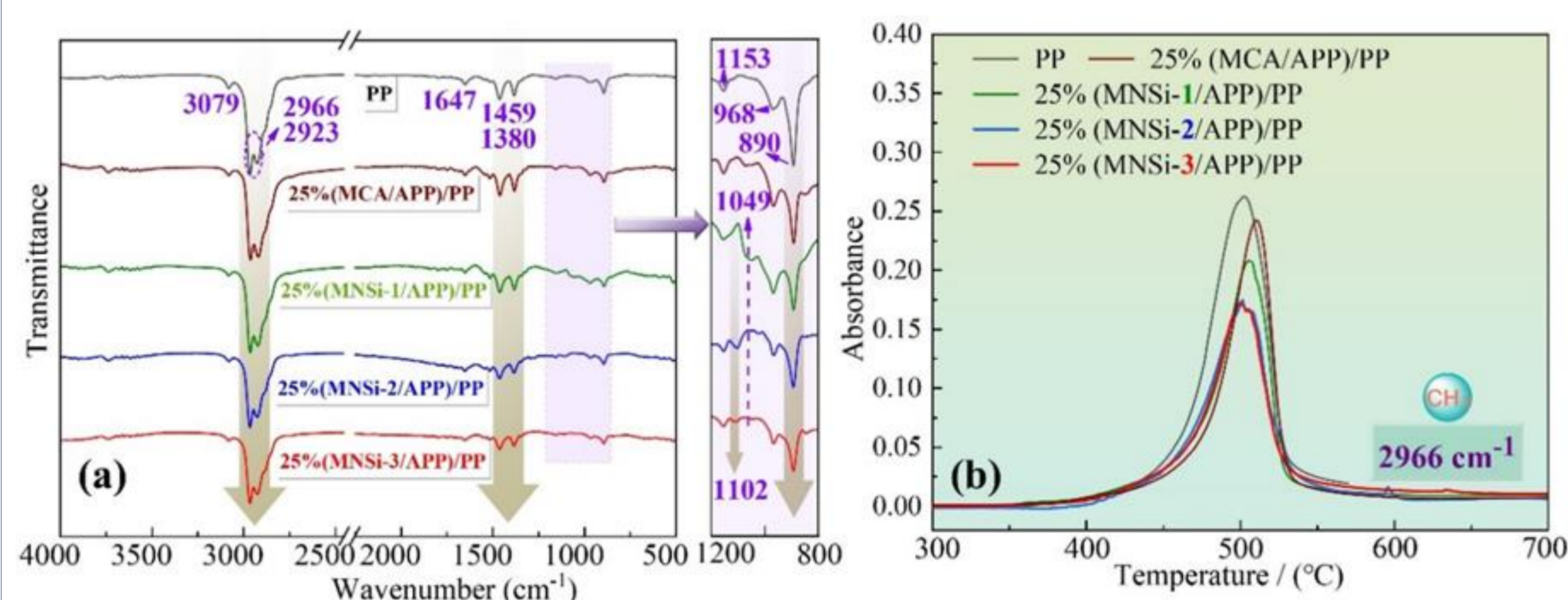


Fig.4 The real-FTIR spectrum of PP composites.

To sum up, this work disclosed an effective way to enhance charring flame retardancy by small changes in molecular structure.

