Study on In-situ Construction of Iron-based Metal-Organic Framework Flame Retardant System and Its Mechanism of Flame Retardancy and Smoke Suppression in Wood

铁基金属有机框架阻燃体系的原位构筑及对木材的阻燃抑烟机制研究

Li Yujia (李宇佳), Guo Jingxin (郭静馨), Zhang Liangliang* (张亮亮)

College of Forestry, Northwest A&F University, Yangling, Shaanxi 712100, PR China

Introduction

➢ **Question:** Wooden materials are highly flammable and produce large amounts of toxic smoke during combustion, posing serious threats to people's lives and property.

➢ **Hypothesis:**

① **P** promotes dehydration and charring and releases phosphorus-containing radicals, thus suppressing chain reactions.

② **Fe** activates CO molecules on its surface and converts CO into CO_2.

③ **N** generates NH_3 and N_2, which dilute combustible gases and oxygen.

④ **B** forms a glassy molten layer, isolating oxygen and reducing heat loss.

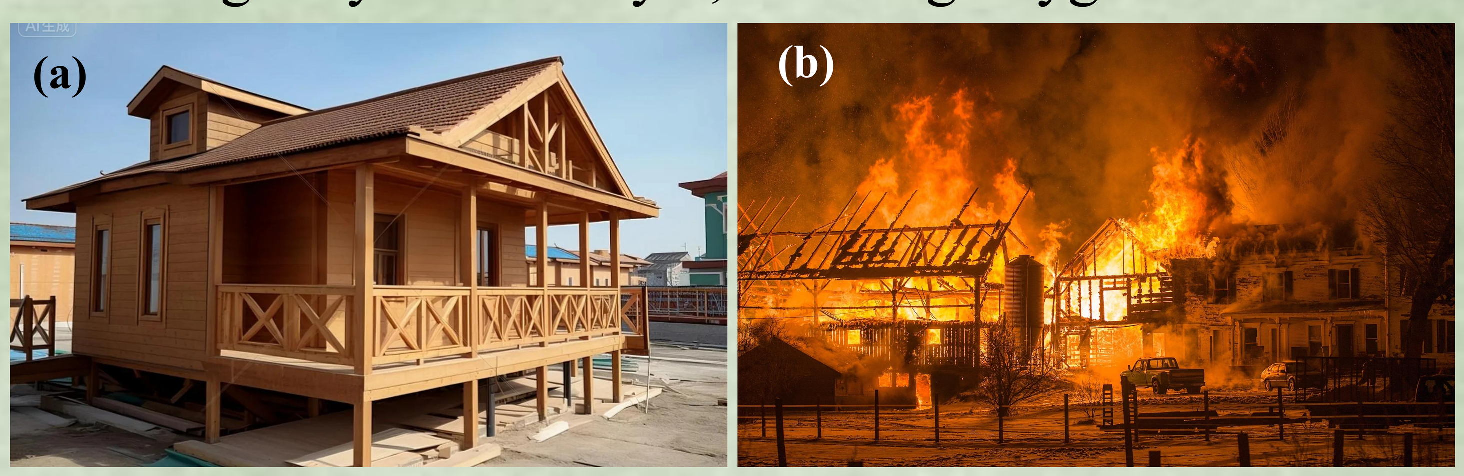

Fig.1. Wooden buildings (a) burning wooden buildings (b)

Experimental

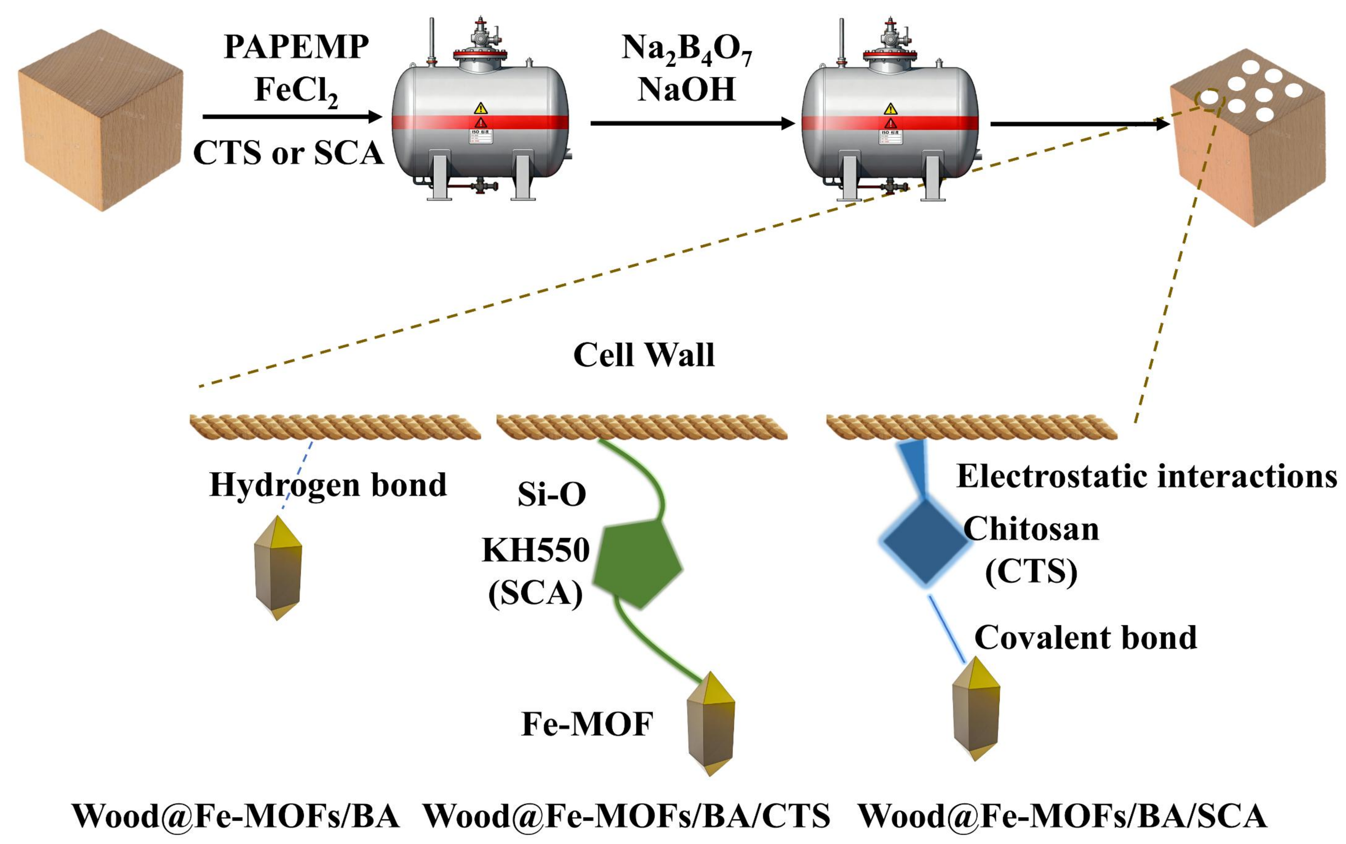

Fig.2. Preparation process for samples

Conclusion

☐ The successful construction of an Fe-MOF flame-retardant system on the wood cell wall surface imparts flame retardancy, smoke suppression, and reduced toxicity.

☐ The heat release decreased by **35.5%**.

☐ The smoke release decreased by **53.3%**.

☐ The maximum release rate of CO decreased by **32.9%**.

☐ The maximum temperature during combustion decreased by **65.7%**.

☐ The minimum oxygen concentration required for combustion increased by approximately **2.3 times**.

Result and Discussion

Part I: Morphology and Thermal stability

➢ Fe-MOF combined with BA, SCA, and CTS synergistically block wood pits.

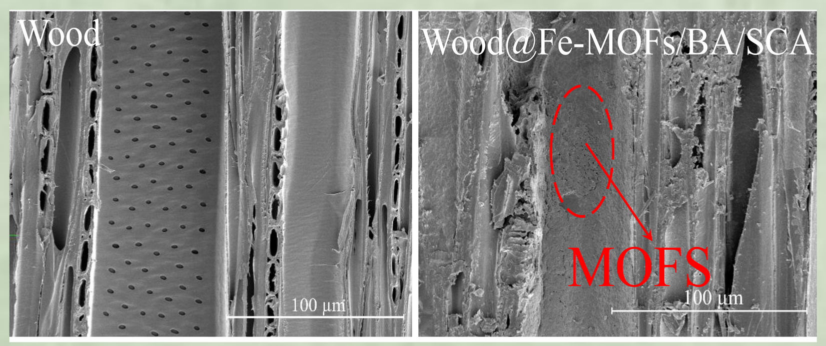

Fig.3. Scanning Electron Microscopy (SEM) images of Wood and Wood@Fe-MOFs/BA/SCA

Part Ⅱ: Combustibility

➢ The modified wood exhibited reduced smoke release upon ignition, along with decreased heat release and slowed release of the toxic gas CO.

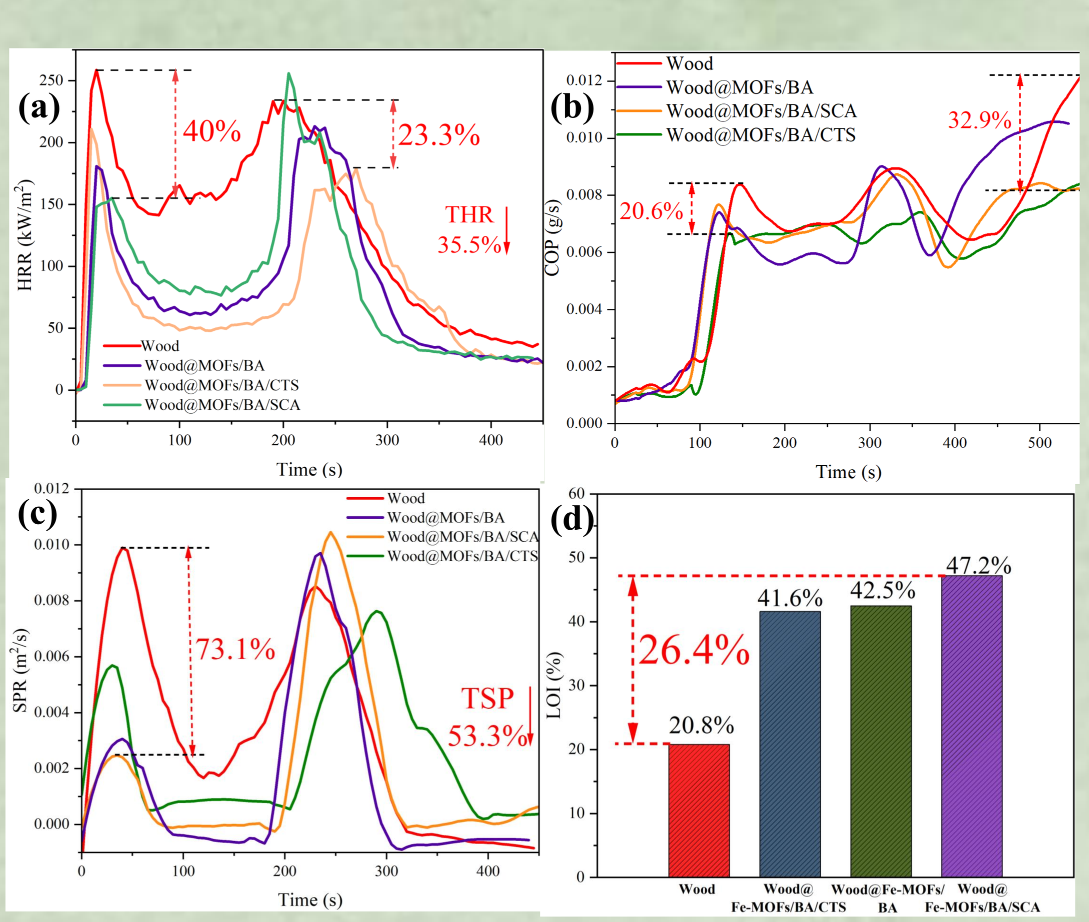

Fig.4. The HRR curves (a), SPR curves (b) and COPR curves (c) in cone calorimetry test (CCT) Limited Oxygen Index(LOI) (d) of samples

➢ In combustion experiments, the temperature of modified wood during combustion was significantly decreased, and the flame spread range was also suppressed.

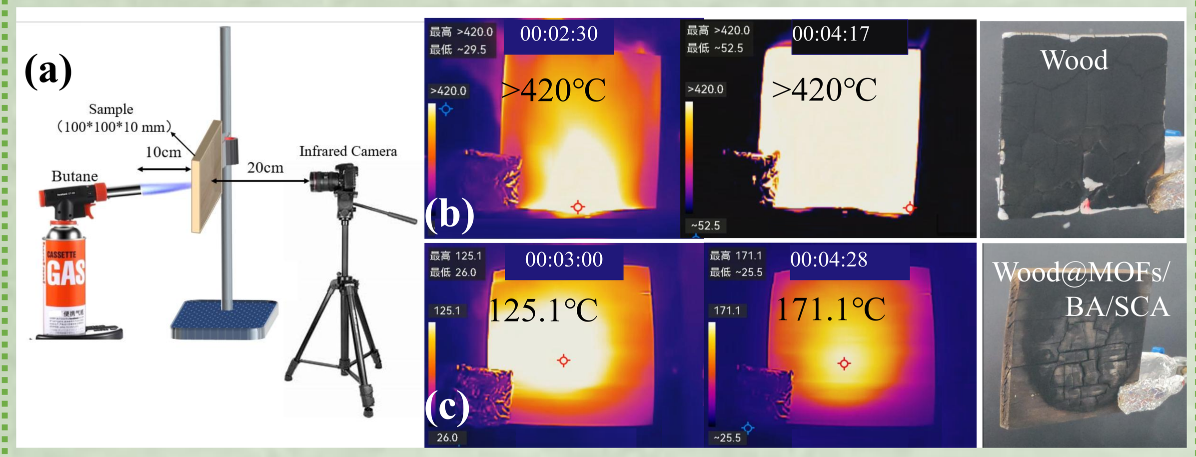

Fig.5. Schematic diagram of the test setup for evaluating flame retardant properties (a) the IR and digital photographs of Wood(b) and Wood@MOFs/BA/SCA(c)at maximum temperature

Part Ⅲ: Mechanism analysis

➢ B, Si, and P are homogeneously distributed on the surface of wood cell walls.

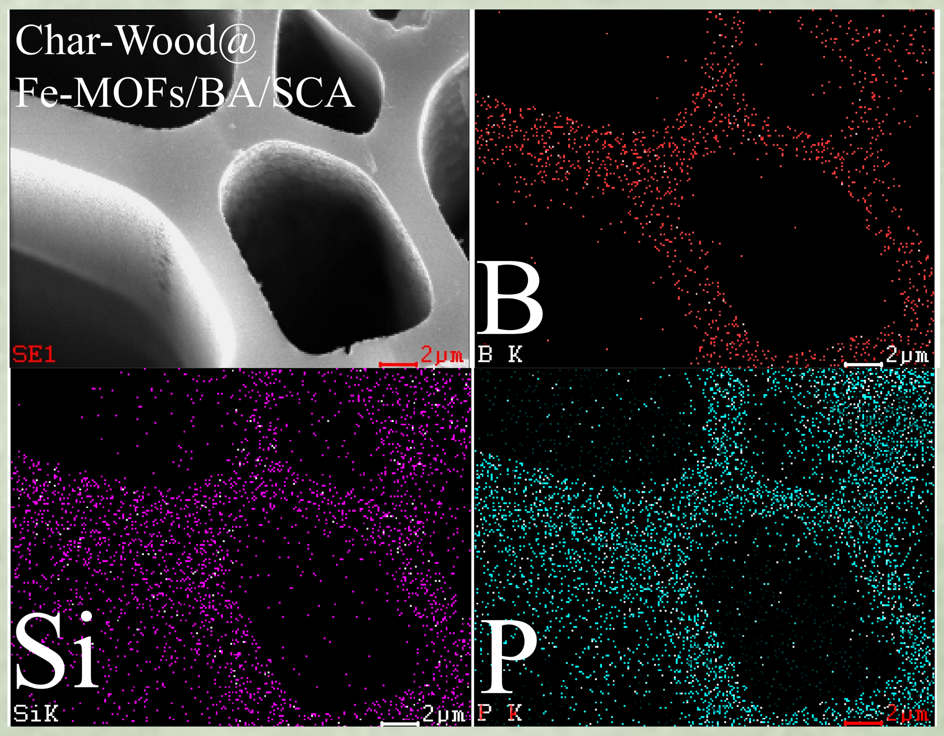

Fig.6. SEM-EDS images of Char-Wood@Fe-MOFs/BA/SCA

➢ The absorbance of the modified wood decreased significantly, indicating a reduction in the total amount of gases released during combustion.

➢ Meanwhile, the release ratios of CH_4 and CO decreased, while that of CO_2 increased.

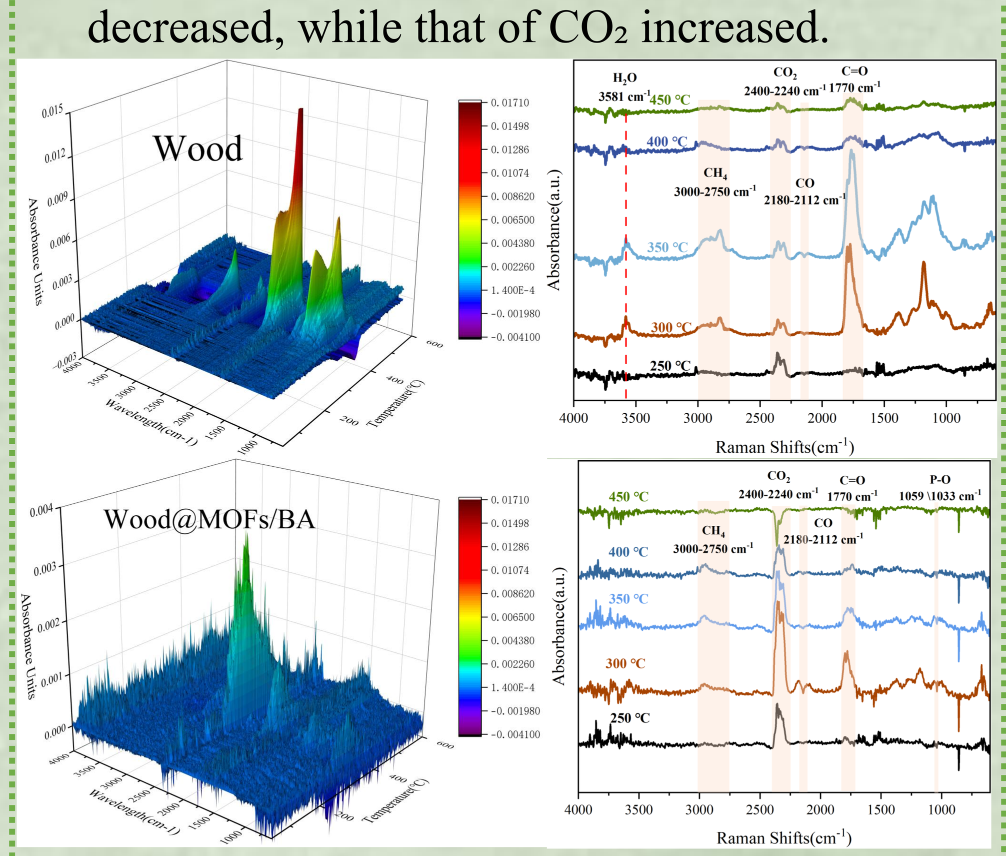

Fig.7. 3D TGA-FTIR spectra of Wood (a) Wood@MOFs/BA(b) The FTIR curves of the pyrolytic volatiles for Wood(c) and Wood@MOFs/BA(d) at the different temperature under argon.

Flame-retardant mechanism.

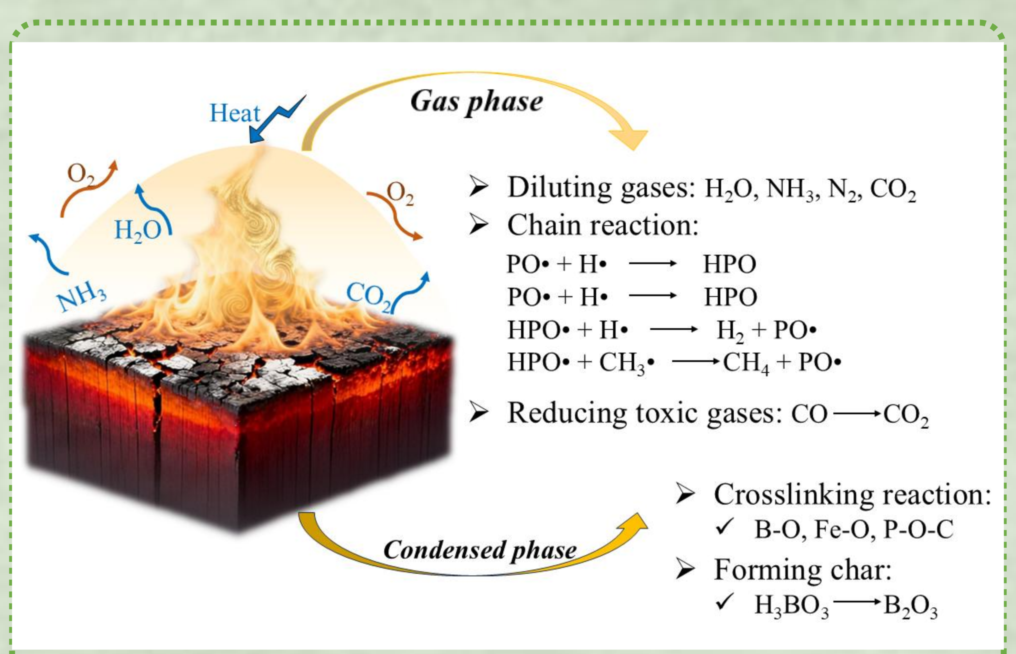

Fig.8. Schematic illustrations

Acknowledge

☐ The Undergraduate Innovation Fund of Northwest A&F University, China (XN2025006006).