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Intumescent flame retardancy and smoke suppression of Eucommia ulmoides gum/natural rubber blends based on synergistic g-C_3N_4@Fe_3O_4 nanocomposites

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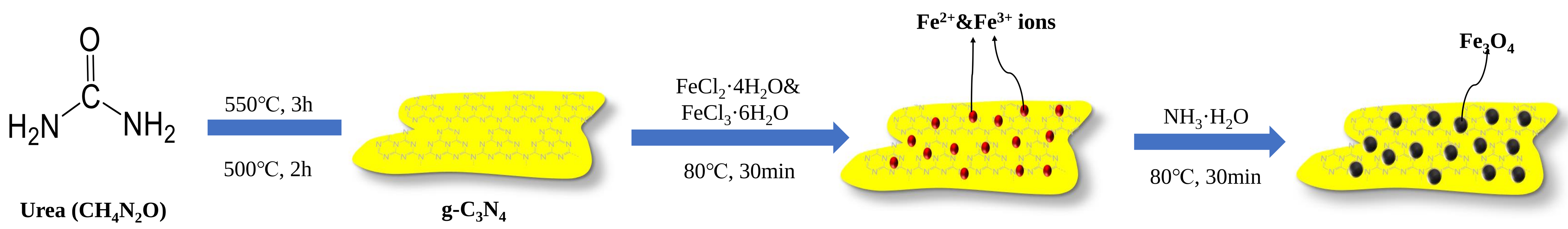
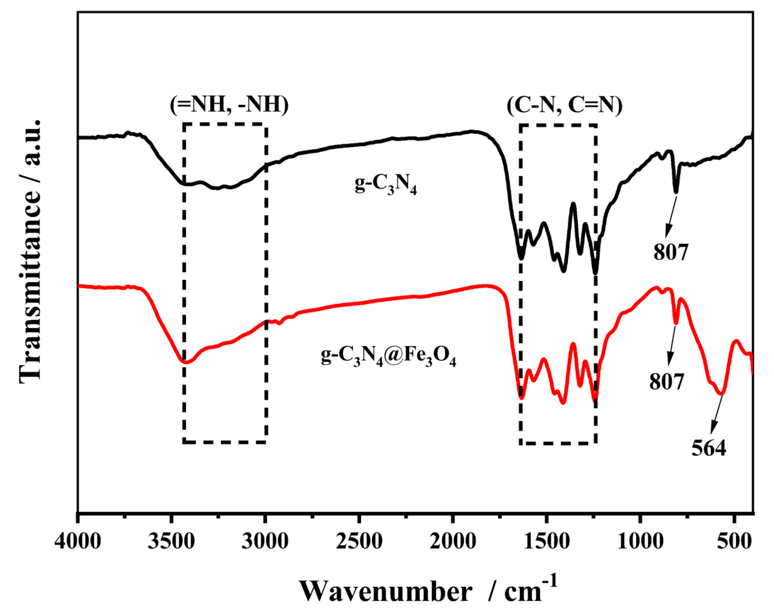
Introduction

Natural rubber (NR), which is recognized as the general rubber with the best comprehensive properties, has been widely used in our daily lives and industrial applications due to its excellent insulation, mechanical properties and chemical resistance. However, owing to the scarcity of NR resources, the production of NR is no longer sufficient to meet the expanding demand. Therefore, there is an urgent need to find materials that can replace NR. Eucommia ulmoides gum (EUG) has been recognized as a secondary source of NR due to its similar chemical structure. The molecular structure of EUG is trans-1,4-polyisoprene, which is the trans isomer of NR. Researchers have studied the influence of the vulcanization on the mechanical properties of EUG/NR blends, and their results showed that the vulcanized rubber had ideal bending fatigue life, perfect wear resistance and stress softening. Additionally, it was needed to investigate the flame retardancy of rubber, aiming to meet quite a lot of areas with high flame retardancy requirements, such as aerospace, electrical insulating products, electrical wires and cables. In this study, we presented the preparation of the g-C_3N_4@Fe_3O_4 nanocomposites by in situ co-precipitation and introduced it as a flame retardant synergist together with an IFR into the EUG/NR blend system, aiming to improve its flame retardancy. Fortunately, owing to the huge specific surface area of g-C_3N_4, the introduction of metal nanoparticles into the layered structure of g-C_3N_4 can not only exert the blocking effect of g-C_3N_4, but also catalyze the formation of a stable cross-linked char layer effectively, thus preventing the release of smoke and further pyrolysis of polymers.

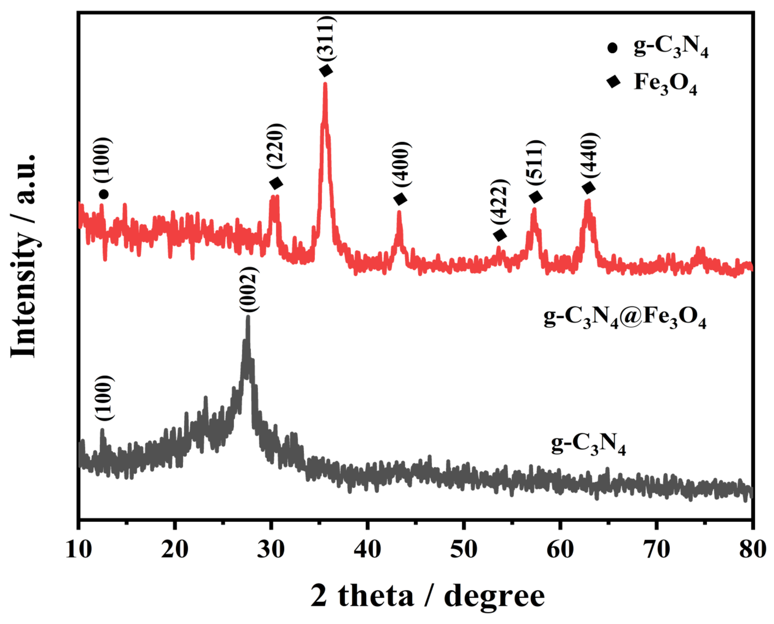
Schematic representation of the in situ co-precipitation of Fe_3O_4 nanoparticles on g-C_3N_4



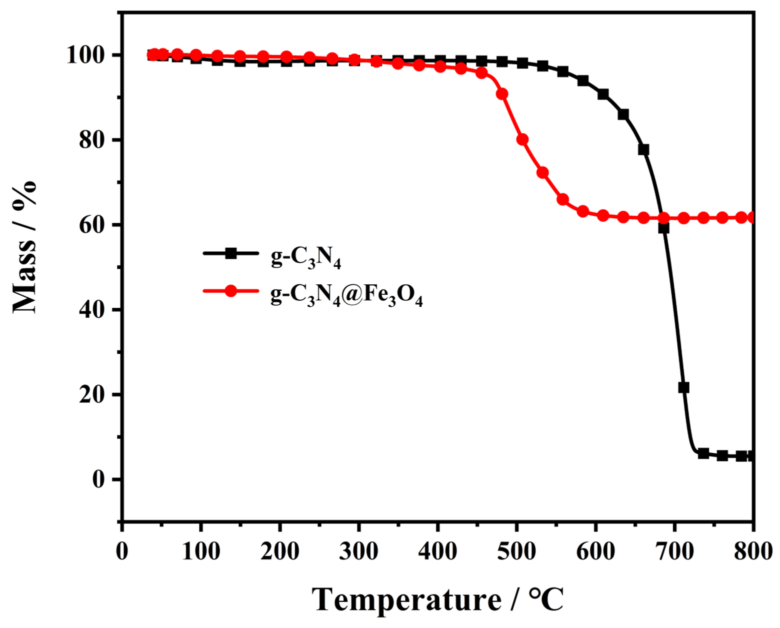
Characterization of g-C_3N_4@Fe_3O_4 nanocomposites



FTIR spectra of g-C_3N_4 and g-C_3N_4@Fe_3O_4 nanocomposites



XRD patterns of g-C_3N_4 and g-C_3N_4@Fe_3O_4

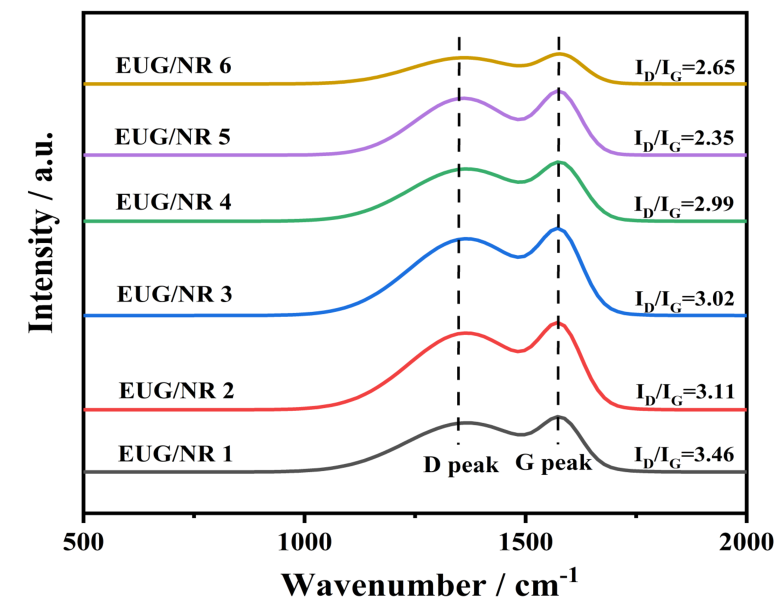


TGA curves of g-C_3N_4 and g-C_3N_4@ Fe_3O_4

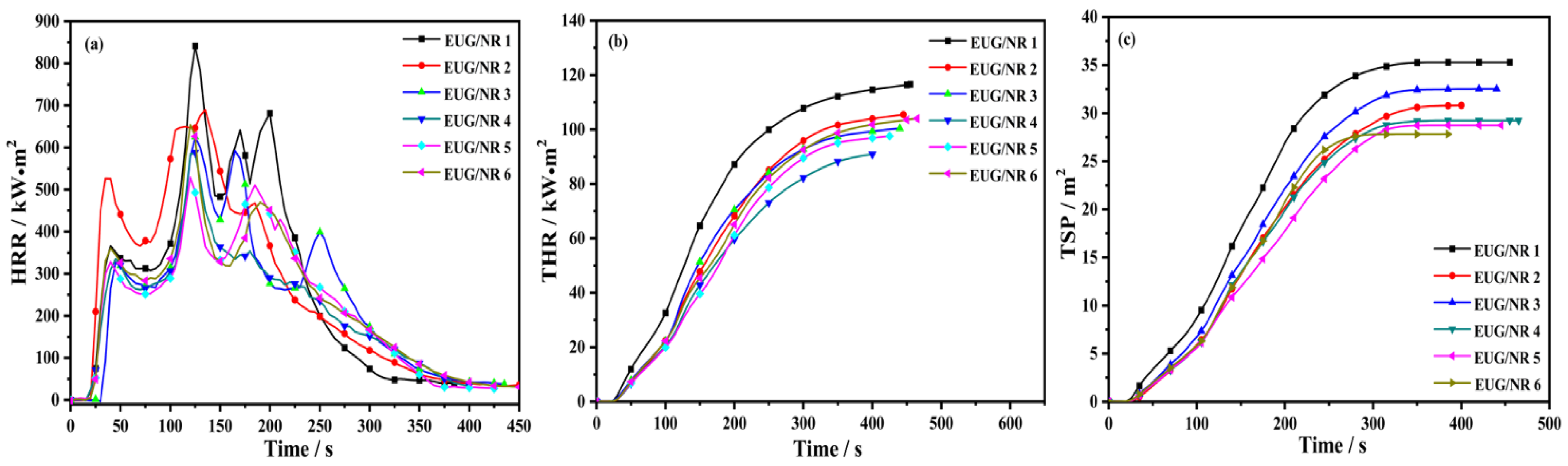
Thermal stability of flame retardant EUG/NR blends

Samples	LOI / %	UL-94
EUG/NR 1	20.0	No Rating
EUG/NR 2	25.5	V-1
EUG/NR 3	27.8	V-1
EUG/NR 4	28.5	V-0
EUG/NR 5	29.5	V-0
EUG/NR 6	28.3	V-1

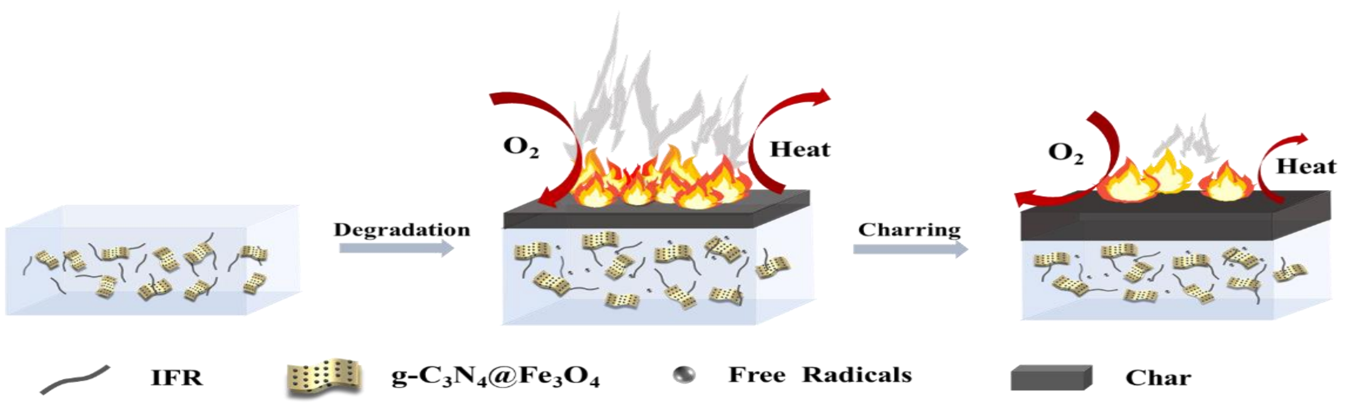
LOI and UL-94 of EUG/NR blend composites



Raman spectra of the char residues of EUG/NR blend composites



(a) HRR curves of the EUG/NR blend composites; (b) THR curves of the EUG/NR blend composites; (c) TSP curves of the EUG/NR blend composites



Fire retardancy mechanism of EUG/NR blend composites

Conclusion

- ✓ An in situ co-precipitation method to successfully prepare a g-C_3N_4@Fe_3O_4 flame retardant synergist.
- ✓ The results show that g-C_3N_4@Fe_3O_4 had a promoting effect on improving the quality of the carbon layer during the combustion process, leading to formation of a dense graphitized carbon layer with better thermal stability in the condensed phase.