4-17-2024

Phosphorus and Nitrogen-Containing Polyols: Synergistic Effect on the Thermal Property and Flame Retardancy of Rigid Polyurethane Foam Composites

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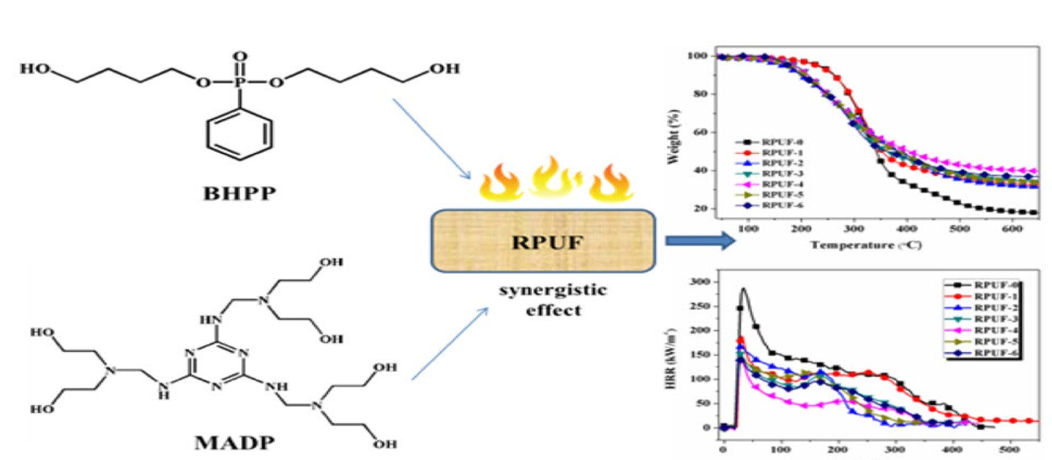
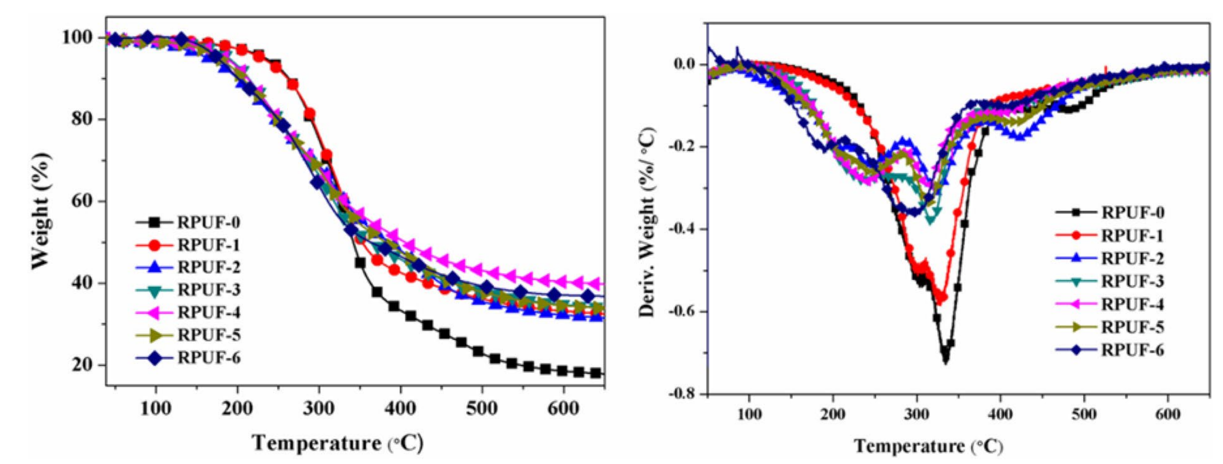
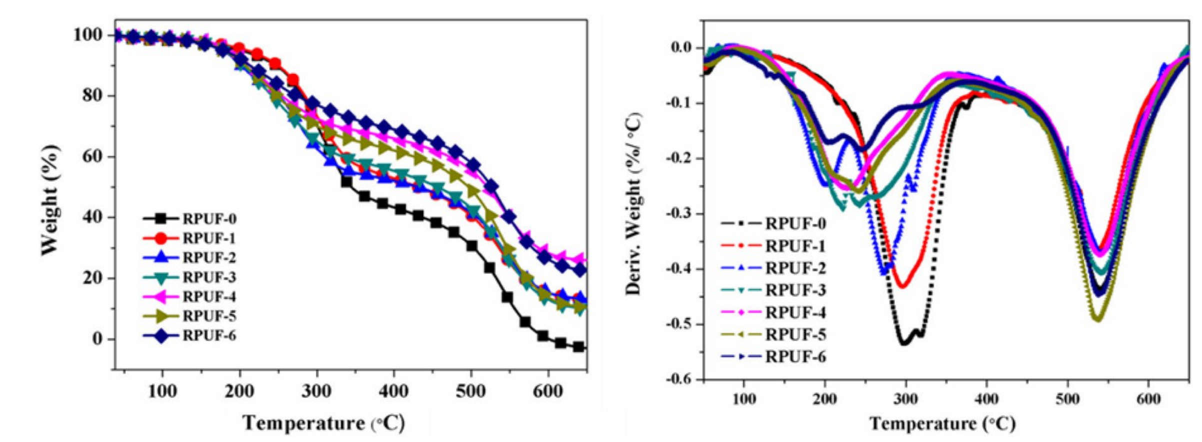
Abstract

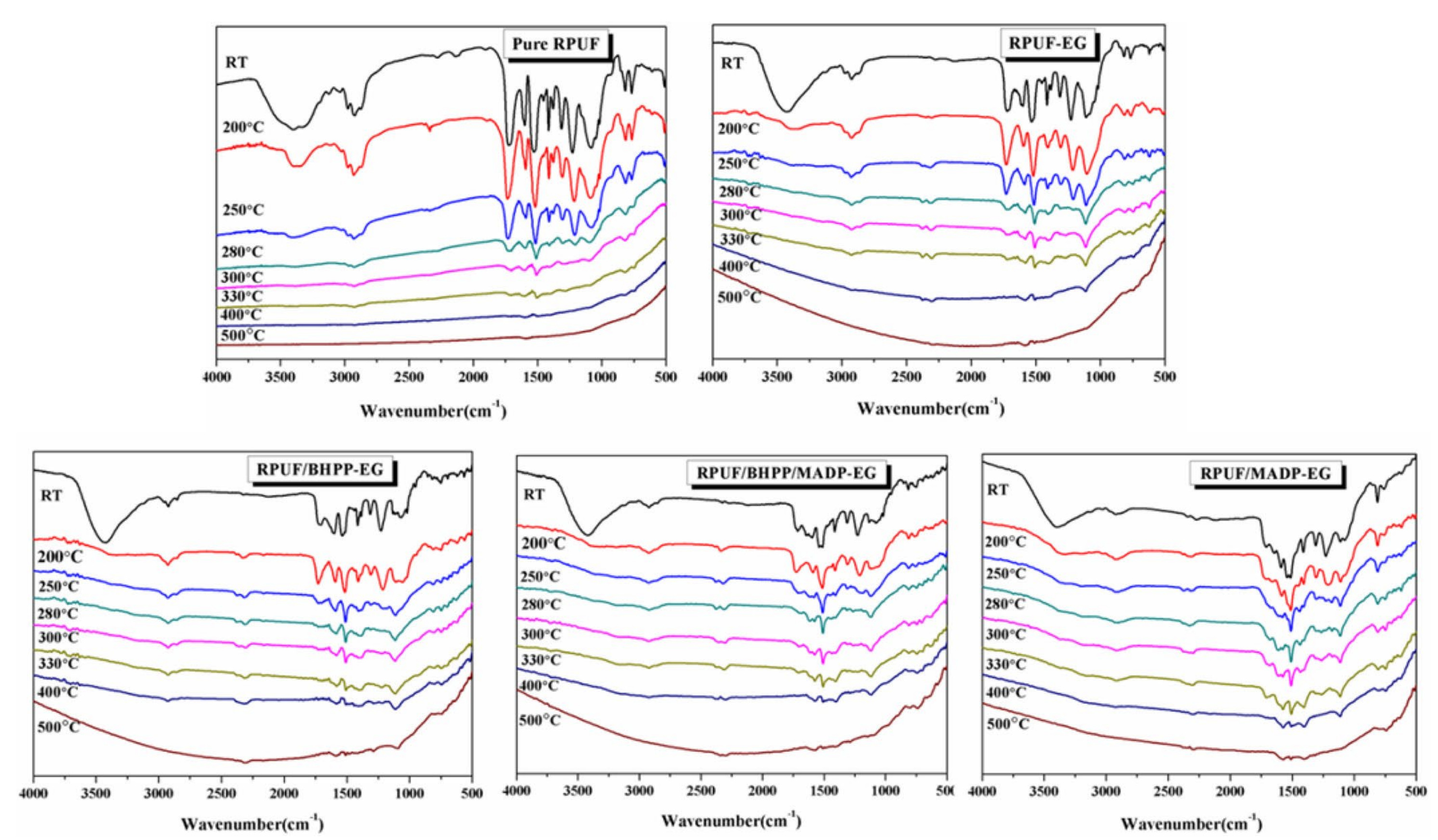
The primary focus of this study was to explore the combined impact of phosphorus-containing polyol (BHPP) and nitrogen-containing polyol (MADP) on enhancing the flame retardancy of EG/rigid polyurethane foam (RPUF). BHPP and MADP were synthesized separately using dehydrochlorination and Mannich reaction methods, respectively. The investigation involved varying the weight ratio of BHPP to MADP and assessing its effects through thermogravimetric analysis and limiting oxygen index (LOI) tests. Results indicated that the most effective weight ratio for flame-retarding RPUF was found to be 1/1 for BHPP and MADP. Moreover, the study investigated the potential enhancement in flame-retardant properties by incorporating expandable graphite (EG) into the RPUF/BHPP/MADP system. It was observed that the addition of EG significantly improved the flame-retardant characteristics of RPUF composites. For instance, at an EG content of 15wt%, the LOI value of RPUF composites reached 33.5%, indicating a substantial increase in fire resistance. Additionally, the peak heat release rate decreased by 52.4% compared to pristine RPUF, further highlighting the effectiveness of EG in reducing flammability. Based on comprehensive analysis and discussion of the experimental results, the study proposed a condensed flame-retardant mechanism. This mechanism elucidated the interactions between BHPP, MADP, and EG within the RPUF matrix, resulting in improved flame-retardant properties. The proposed mechanism provides insights into the synergistic effects of the different components and their contributions to enhancing the fire resistance of RPUF composites. In summary, this study presents a systematic investigation into the synergistic effects of BHPP, MADP, and EG on improving the flame retardancy of RPUF. The findings offer valuable insights for the development of more effective flame-retardant materials with potential applications in various industries requiring fire-resistant materials.

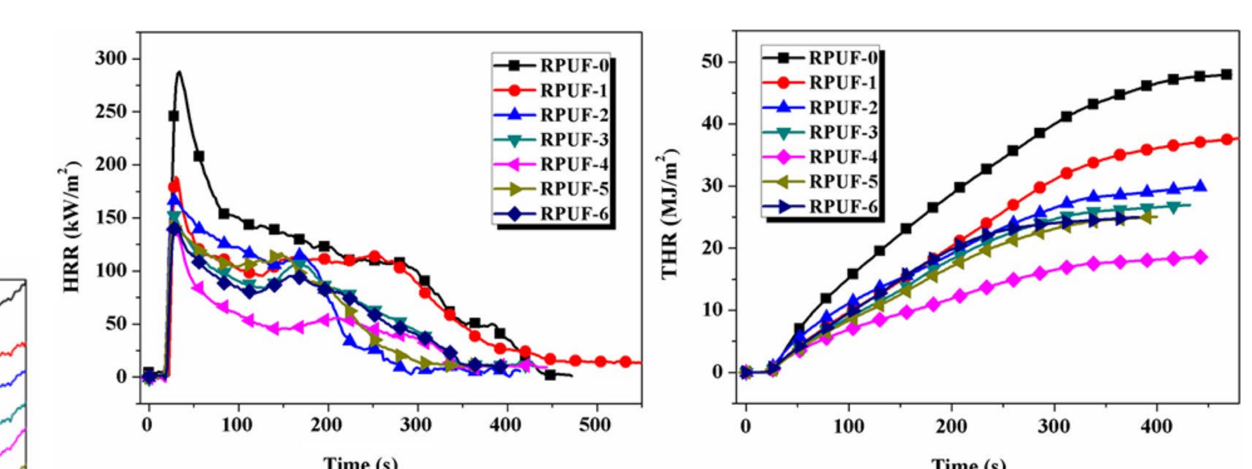


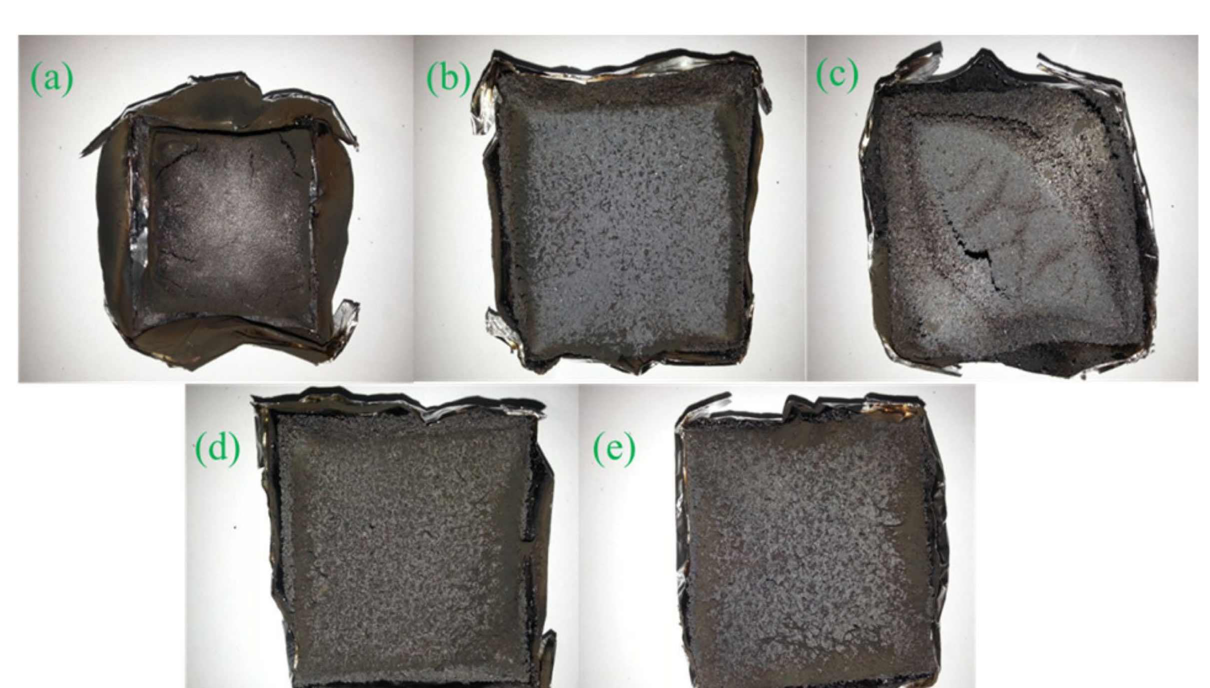
Results

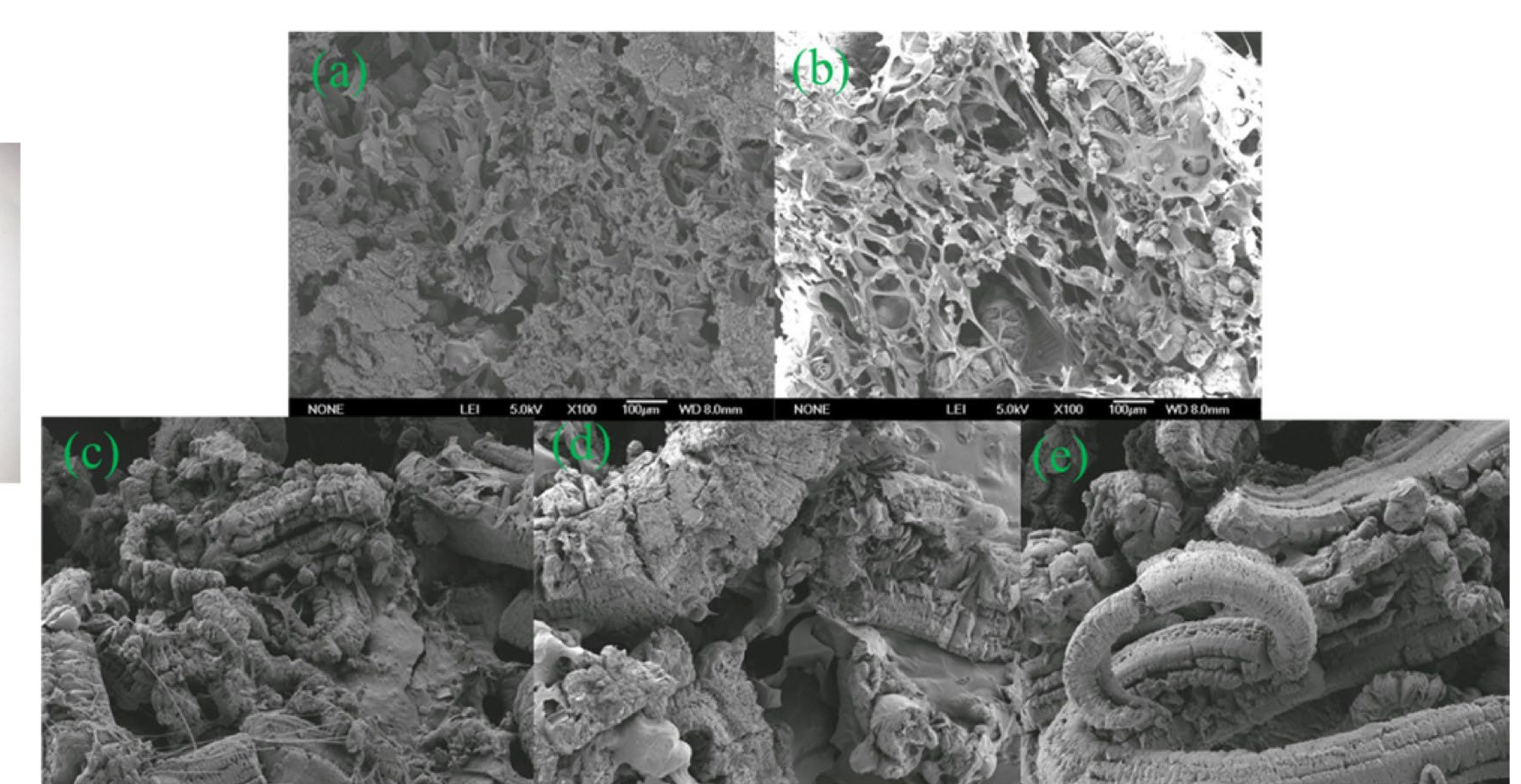




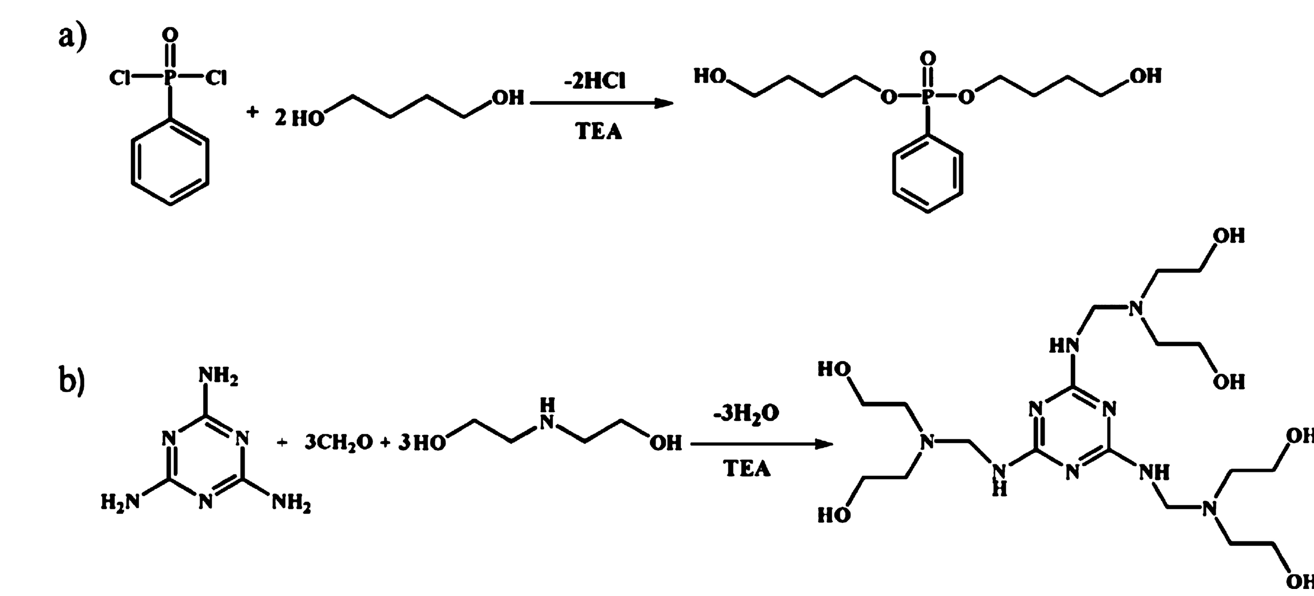








Reaction Scheme



Conclusions

1. Synthesis of phosphorus-containing and melamine-derived polyols (BHPP and MADP) for EG/RPUF composite modification.
2. Synergistic effect observed at 1:1 BHPP/MADP ratio leading to significant reductions in PHRR and THR of RPUF composites, with a 52.4% decrease in PHRR compared to pristine RPUF.
3. Enhanced flame retardancy demonstrated by an increase in LOI value from 27.0% to 33.5% for RPUF/IFR/EG, with thermal decomposition showing improved char formation due to O=P-O and triazine ring groups along with NH_3 presence, supporting proposed condensed-phase flame-retardant mechanism.

Acknowledgments

The work was financially supported by the National Natural Science Foundation of China (51323010), Fundamental Research Funds for the Central Universities (WK2320000032), the National Natural Science Foundation of China (51303167), and Fundamental Research Funds for the Central Universities (WK2320000027).

References:

DOI: 11.1021/acs.iecr.6b02942