Bio-derived Tannic Acid-Eu(III) Coordination Synergizes with Aluminum Diethylphosphinate for Low-Loading, High-Efficiency Flame Retardancy in PA66

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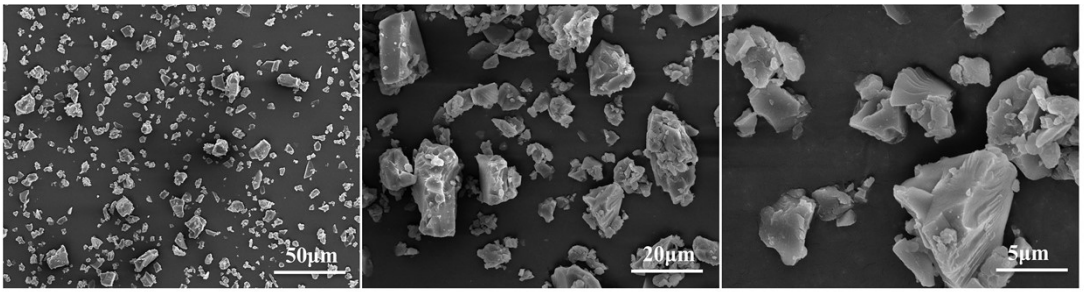

Fig. S1. SEM images of Eu@TA at different magnifications.

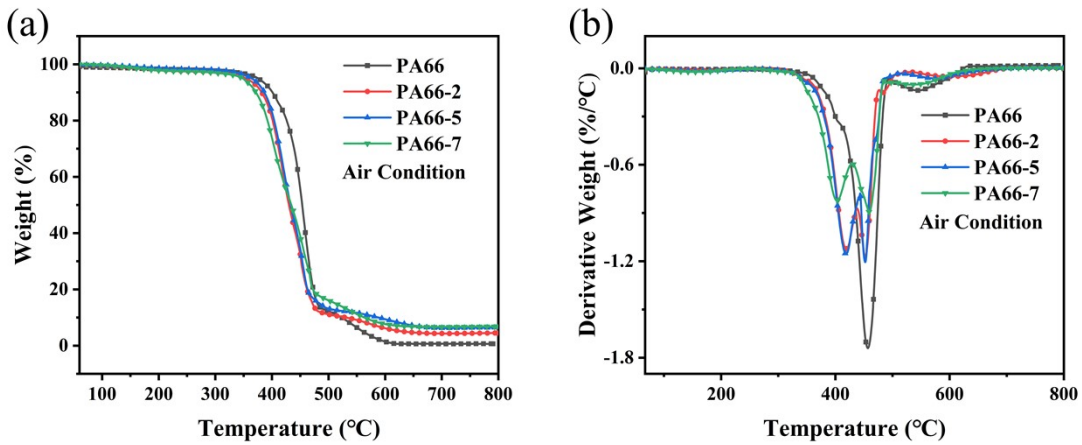

Fig. S2. (a) TG and (b) DTG curves of PA66 and PA66 composites under air atmosphere.

Table S1 Typical thermal decomposition parameters of different samples under air atmosphere.

Sample	PA66	PA66-2	PA66-5	PA66-7
$T_{5\%}$(°C)	375	353	363	346
T_{max}(°C)	457	452	452	459
V_{max}(%/°C)	1.74	1.17	1.21	0.89
RC(wt.%)	0.65	4.51	6.38	6.83

To compare the pyrolysis processes of the composites under different atmospheres, the thermal decomposition behavior of PA66 and its composites in air was investigated, as illustrated in **Fig. S2** and **Table S1**. Pure PA66 exhibited a residual weight of only 0.65 wt.% at 800 °C, reflecting its limited inherent

char-forming capacity in air. Upon the incorporation of ADP, the initial decomposition temperature decreased, a phenomenon consistent with the thermal decomposition observations of PA66 flame-retardant composites under an argon atmosphere.

This early mass loss corresponds to the decomposition of ADP into phosphoric acid, polyphosphoric acid, and phosphorus-containing radicals. These species catalyze the chain scission of PA66 and promote dehydration reactions that initiate at temperatures lower than those required for pure PA66. Consequently, the lower onset temperature reflects the catalytic effect of ADP on the decomposition pathway of PA66 rather than a deterioration of thermal stability. Notably, the presence of Eu@TA led to further alterations in the decomposition characteristics. PA66-7 achieved a higher char yield of 6.83 wt.% at 800 °C, which is significantly higher than those of PA66-2 and PA66-5. This marked increase in residual char is likely attributable to the presence of metal oxides.

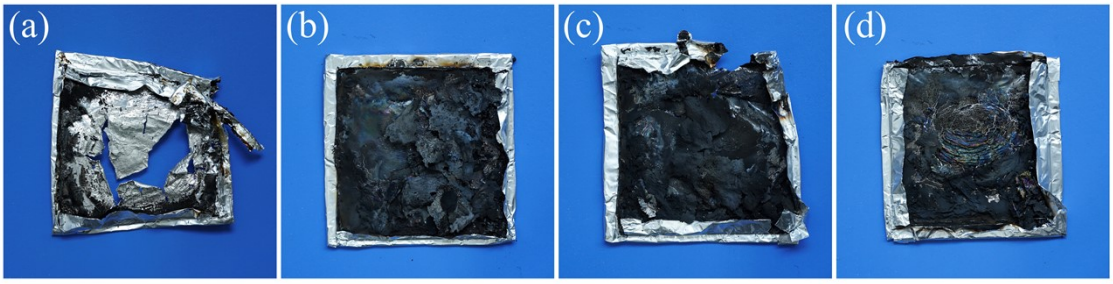

Fig. S3. Digital photographs of the outer surface of residual chars for PA66 (a), PA66-2 (b,), PA66-5 (c,), and PA66-7 (d).

* Fig. S4-S8 can be found in the document of Supplementary Information-2.