

# Intra-/inter-molecular synergistic effect of flame retardant groups on thermal insulation of intumescent coatings for steel structure

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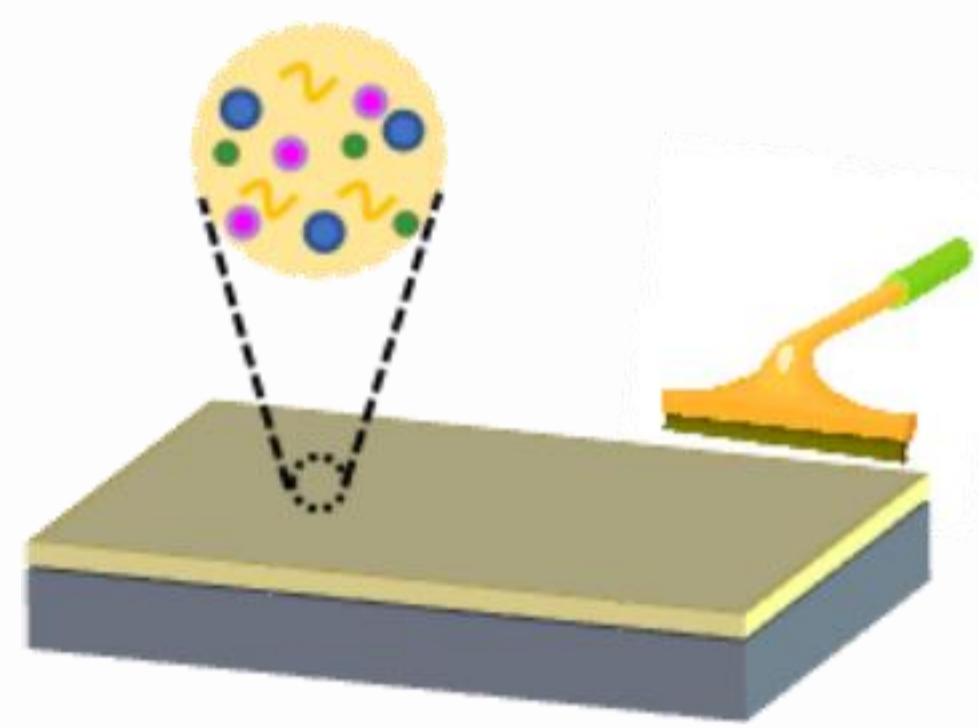
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● : MPP    ● : TiO<sub>2</sub>  
● : PAPP    ~ : SAE



This study to investigate the effect of intra-/inter-molecular synergistic flame retardant groups on the performance of steel in fire. Pyrophosphate (PAPP) is a typical mono-component flame retardant that plays a synergistic role in the intra-molecular group. A new combination of PAPP and melamine polyphosphate (MPP) was applied to the fire retardant coatings based on silicone acrylic emulsion (SAE). The fire performance, water resistance, and thermal stability of MPP/PAPP and APP/PER/MEL coating were systematically studied.

Torch test (Figure 1(A)) was used to evaluate the fire protection effect of the coatings before and after water-immersion. The results (Figure 1(B)) showed that the temperature at the back side of the steel with MPP/PAPP-IC was lower than 170°C after 2h burning, lower than that with APP/PER/MEL-IC (326°C).

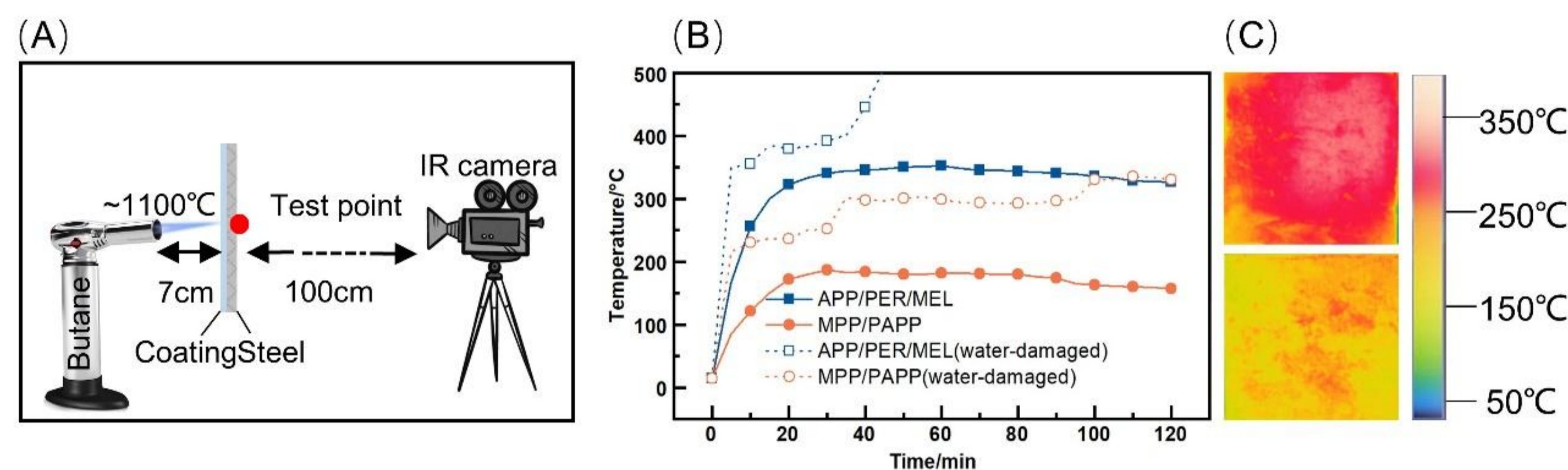


Figure 1 (A) Schematic representation of the fire performance test. (B) The backside temperature curves of the steel boards with coatings in the torch test. (C) Thermal maps on the backside of the steel boards in the torch test after 120min.

Water destroyed the fire resistance of APP/PER/MEL-IC (Figure 1(B), blue dot line). The fire resistance of MPP/PAPP-IC decreased but still kept the temperature under 350°C. MPP increased the coating water resistance with the largest contact angle of 125° (Figure 2(A)), resulting the lower down of water absorption rate (Figure 2(B)).

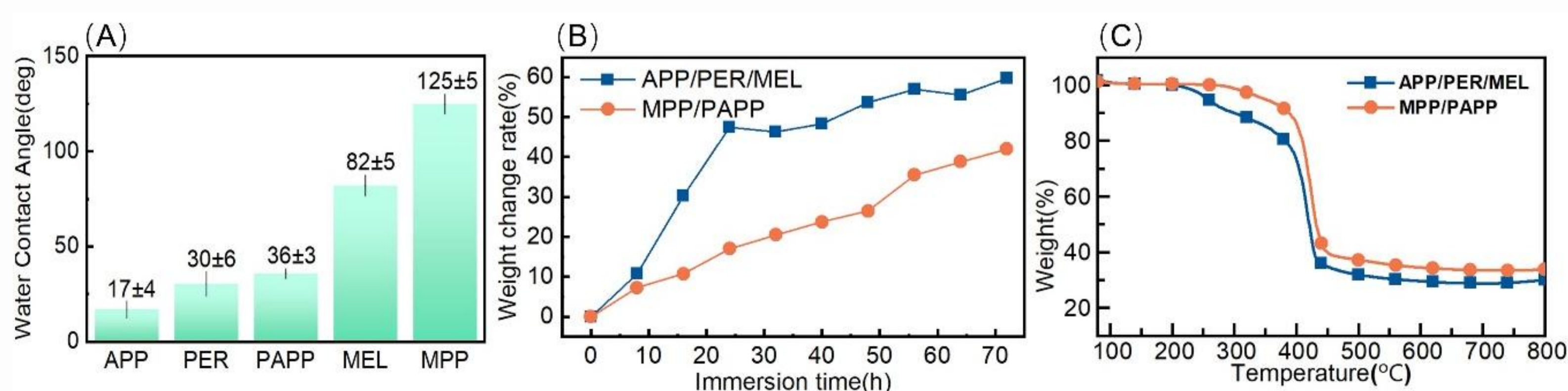


Figure 2 (A) Water contact angle of IFR. (B) The weight change of the coatings immersed in distilled water. (C) TGA curves of coating samples.

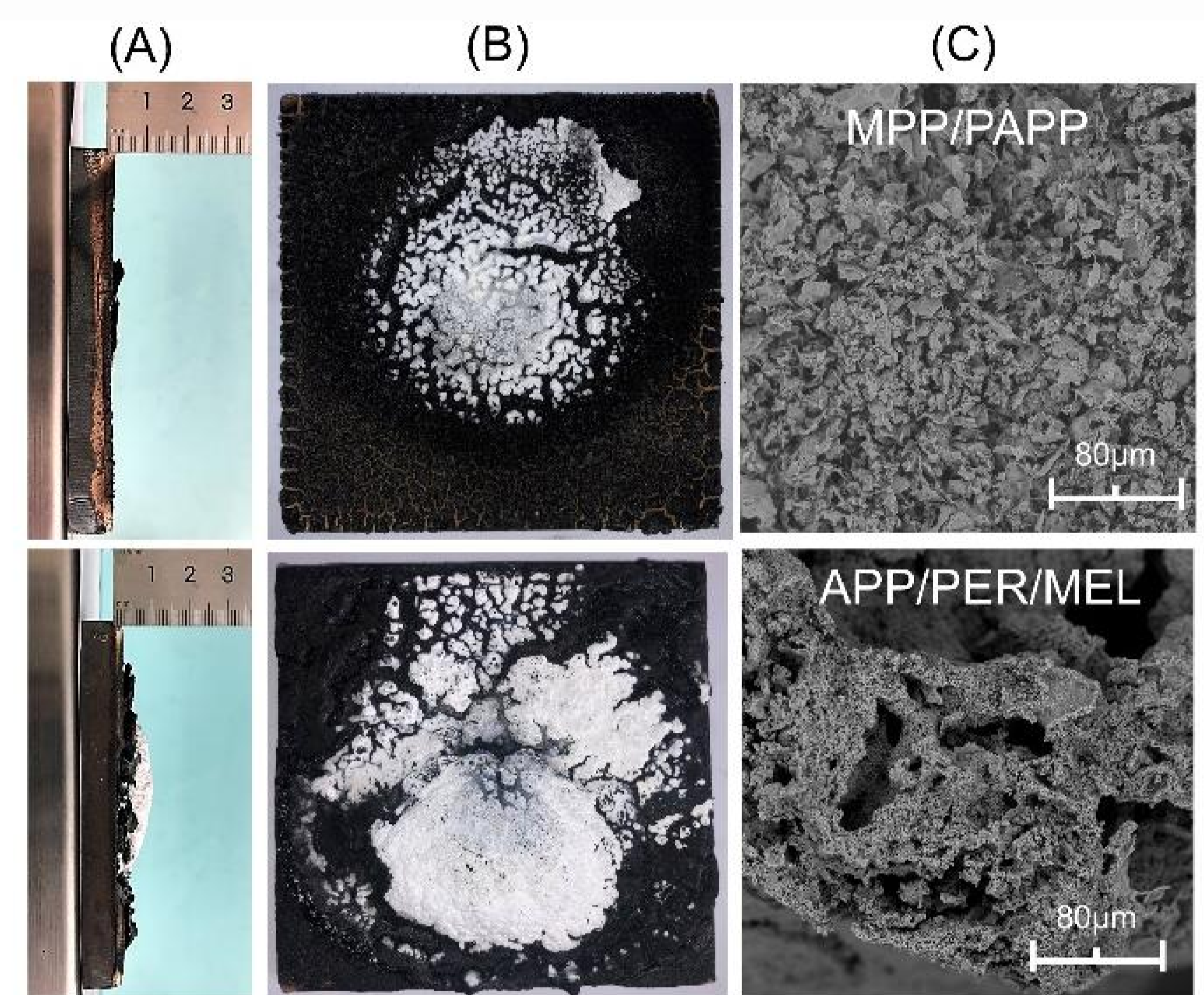


Figure 3 (A) Swelling chars after the torch test. (B) Digital pictures of char layers. (C) SEM images of the cross layer of the chars.

Thermal stability and char formation of MPP/PAPP-IC was better. The dense, complete and consistent char layer (Figure 3(C)) indicated that its mechanical strength was significantly improved.

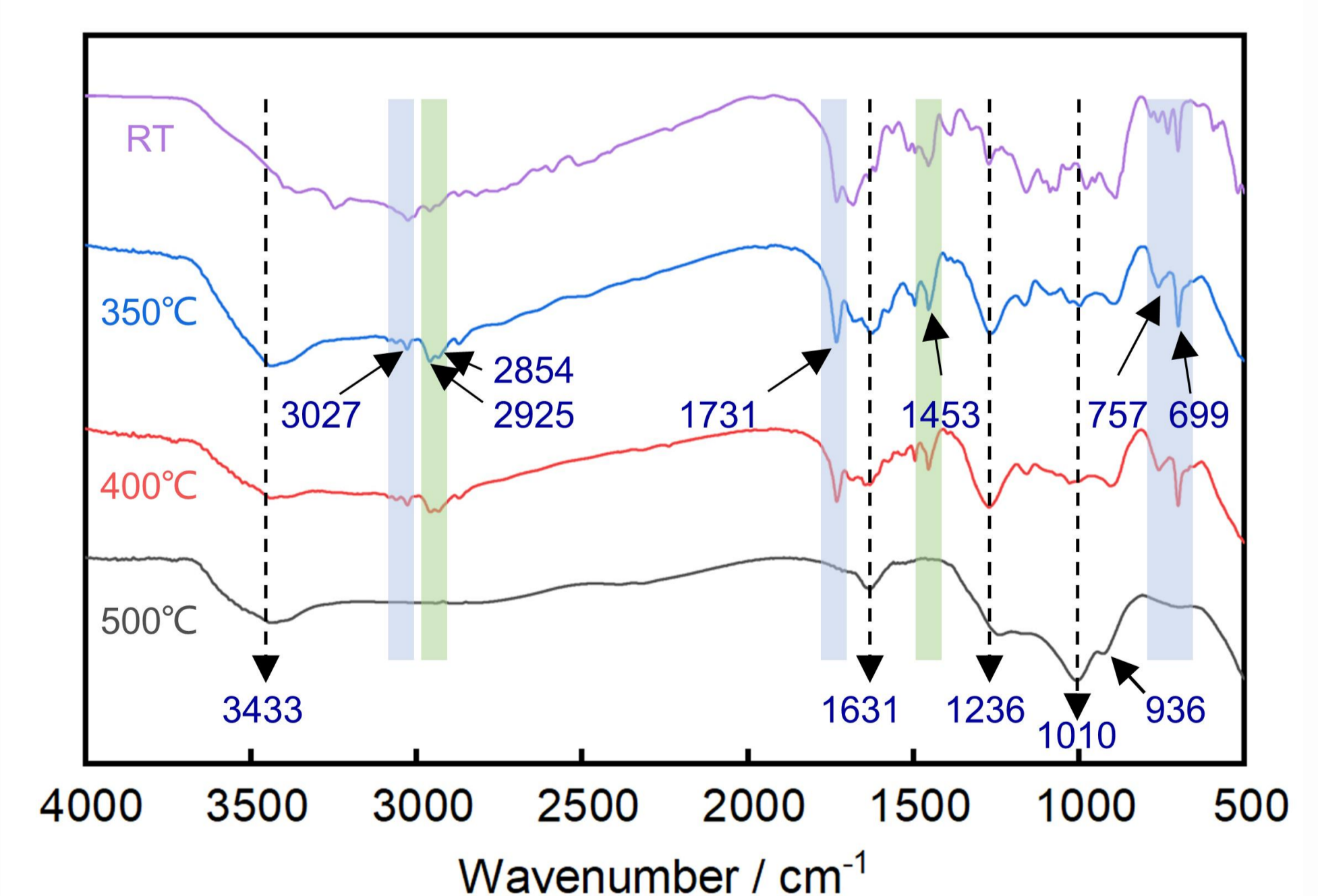


Figure 4 FTIR spectra of MPP/PAPP-IC at different temperat

The synthesis of MPP/PAPP was efficient with intra-molecular synergistic effect between piperazine and phosphoric acid groups.