

Supplementary Information for Synergistic effect of aluminum diethylphosphinate / sodium stearate modified vermiculite on flame retardant and smoke suppression properties of amino coatings

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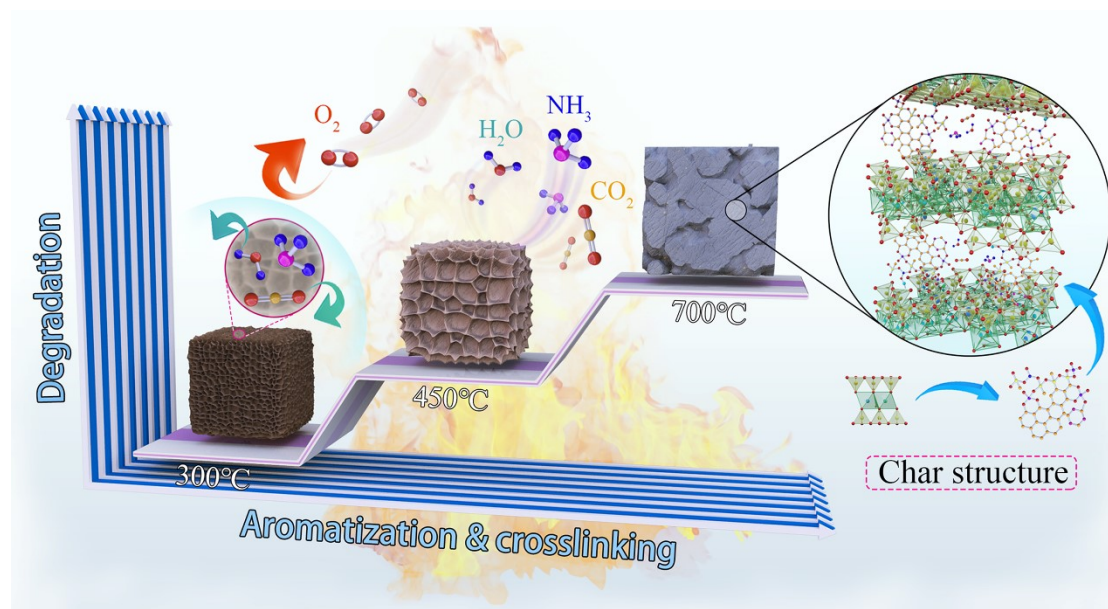
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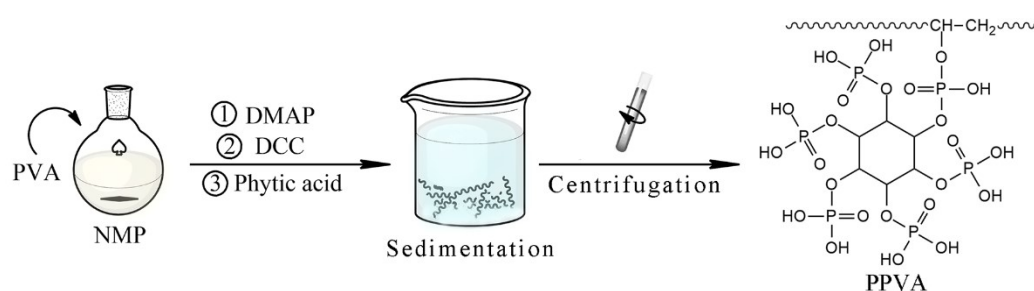
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Preparation of PPVA



Scheme S1. Synthesis route of the PPVA.

Firstly, under continuous stirring, polyvinyl alcohol (PVA, 5.6 g) was fed into 1-Methyl-2-pyrrolidinone (NMP, 120 ml) in a one-necked flask at room temperature. Afterwards, the solution was heated to 90 °C, condensed and refluxed for 60 min to make PVA fully dissolved. Hereafter, 4-Dimethylaminopyridine (DMAP) and N,N'-Dicyclohexylcarbodiimide (DCC) were added into the solution. Simultaneously, phytic acid (PA, 3.6 g) was slowly added dropwise under magnetic stirring at 70 °C for continuous reaction. After 3h of reaction, the solution was poured into ethanol according to the volume ratio of reaction solution to ethanol of 1:3. After storage at room temperature for 8 h, a large number of floccules were precipitated in the solution. The floccules were vacuum filtrated, rinsed with ethanol for three times, and finally dried in an 80 °C oven for 12 h to obtain a white translucent solid product named PPVA, with a yield of 83.7%.

Preparation of film

The coating film is prepared by painting several times. For each painting, the film was placed to a constant weight at room temperature (25 °C) and humidity (60 %). Then, the dry film thickness was measured via digital coating thickness gauge (Qnix 4500, China) at different positions on the surface for several times and take the average value. Afterwards, repeating this step until the final film thickness reaches to 2 ± 0.2 mm.

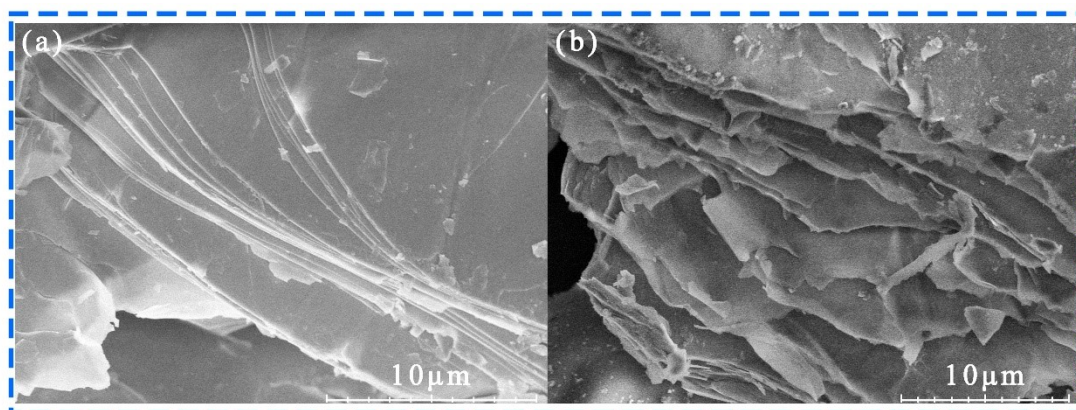


Figure S1. SEM images of EV and MEV.

The mechanism of microwave expansion of vermiculite is that: water molecules in the interlayers of the individual flakes are driven off quickly as steam by microwave treatment that causes the layer separation or exfoliation of the samples.¹ Compared to origin vermiculite, the microwave expanded vermiculite exhibits more obvious separation layers.

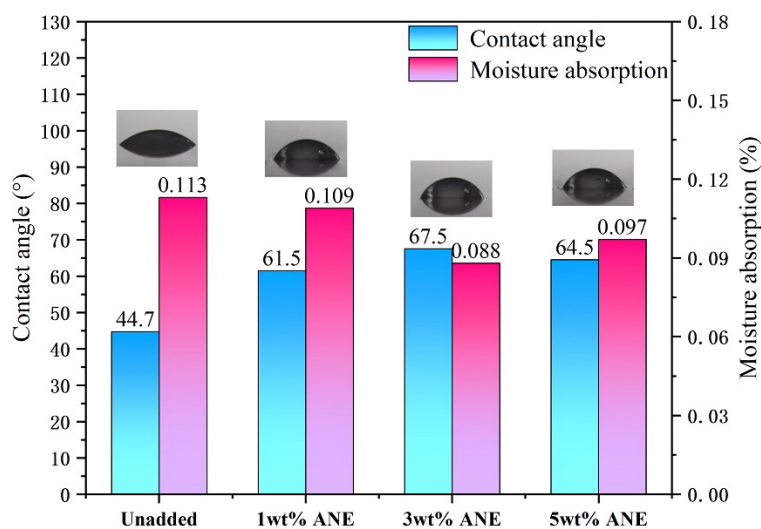


Figure S2. Contact angles and moisture absorption of coatings.

Figure S2 shows the wettability of different coatings. It can be found that coatings filled with ANE can improve the water contact angle and decrease moisture absorption. With the amount of ANE added, the hydrophobicity of coatings is increased. When the addition amount of ANE is 3 wt%, the contact angle of the film is the largest at 67.5° and

moisture absorption is the lowest of 0.088%. However, an excess of 5 wt% ANE will increase the viscosity of the coating system, leading to the coating surface being uneven and reduce its hydrophobicity.

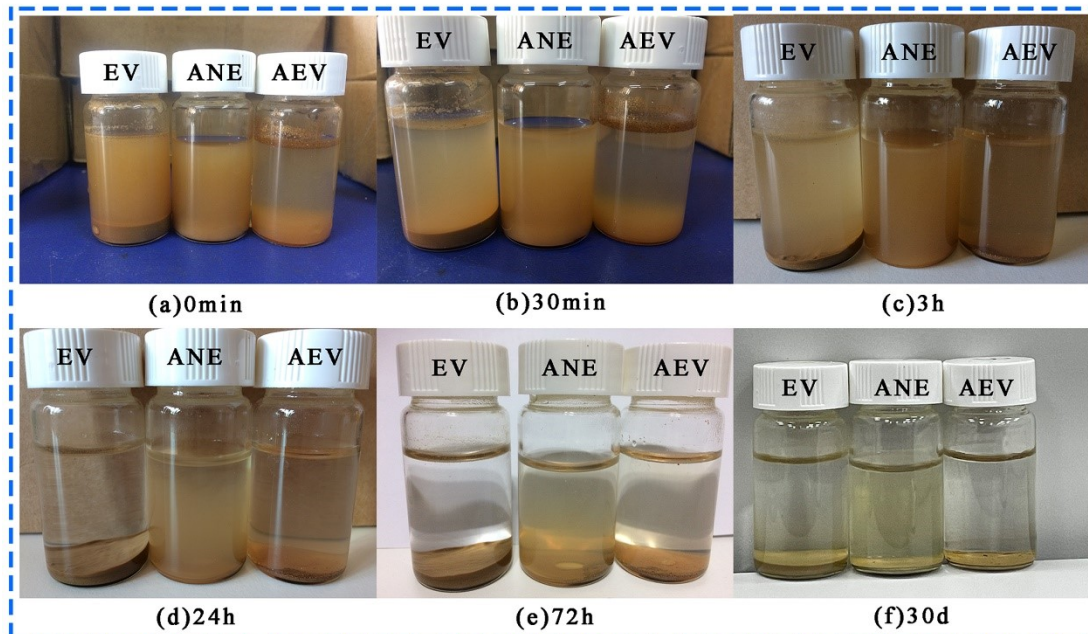


Figure S3. The dispersion test of EV, AEV and ANE.

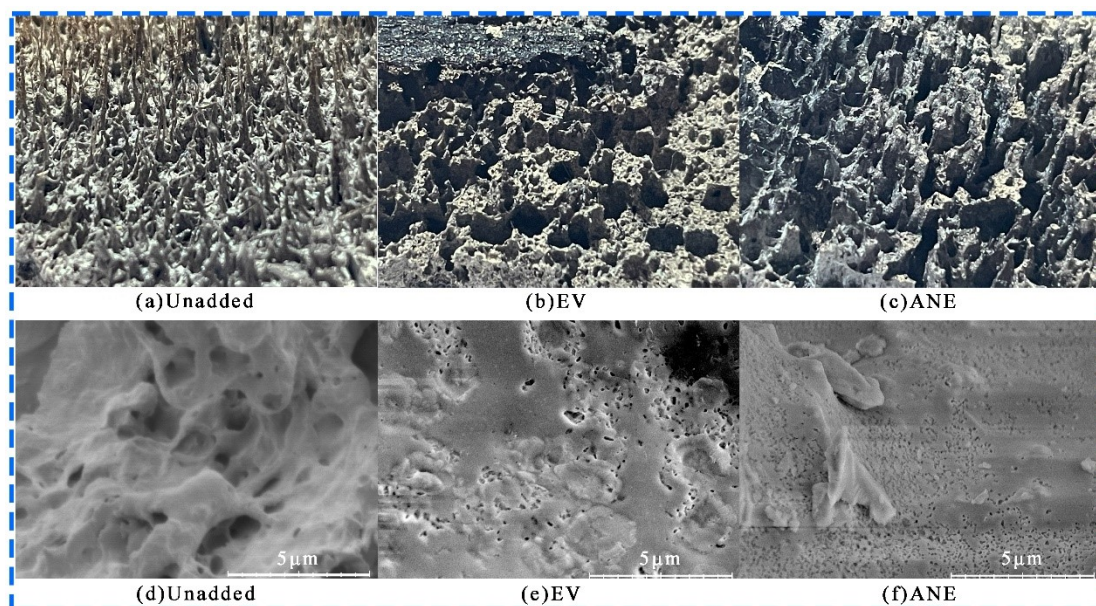


Figure S4. The cross section view of char residues and their SEM images.

In comparison, an obvious carbon skeleton structure can be observed in Figure S4b and Figure S4c. By further comparing their corresponding SEM images, it can be found that the foam structure of EV and ANE samples was significantly improved by

adding vermiculite (which produced a denser and more uniform foam structure) compared to Unadded sample (which was porous with a non-uniform form structure). The char layer of ANE had a uniform and dense foam structure, which could isolate the heat and smoke and provide better fire protection.

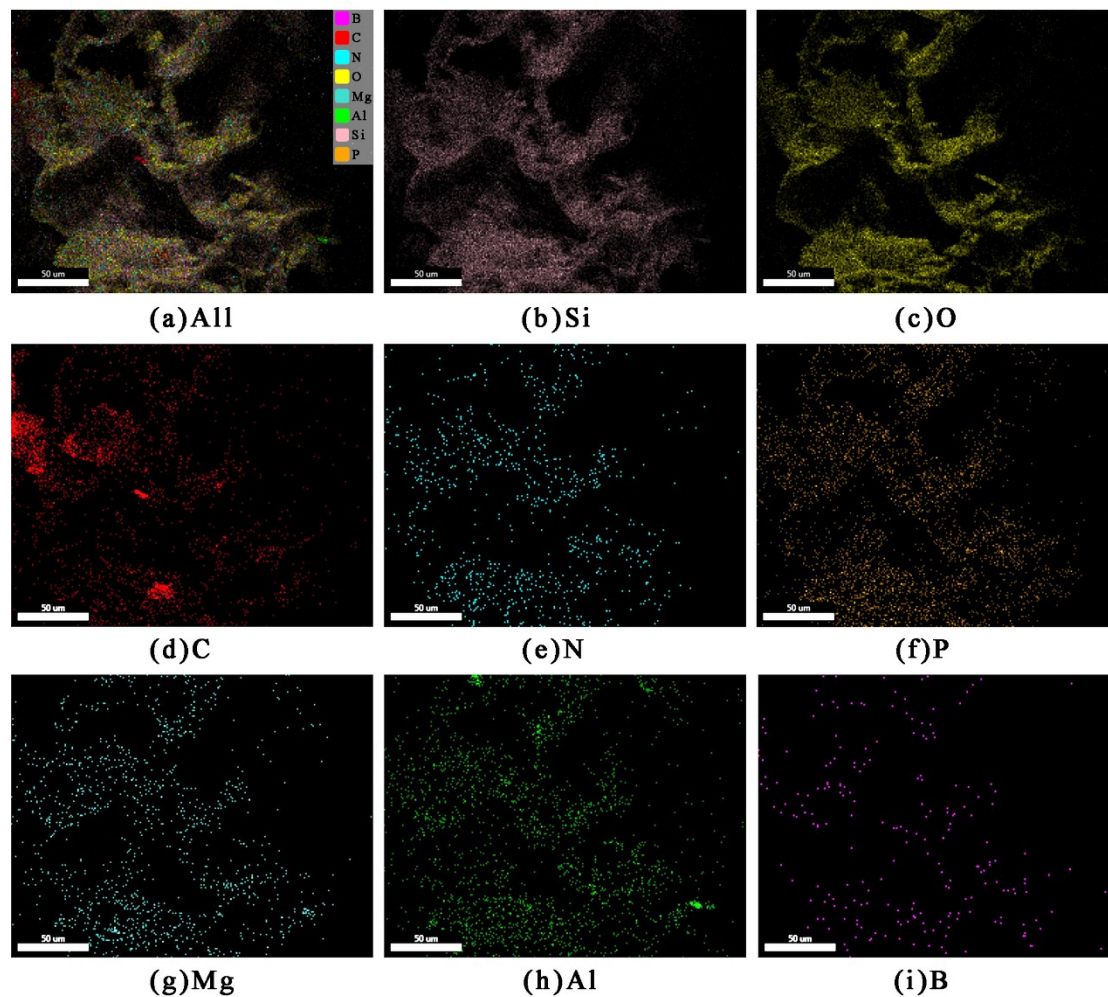


Figure S5. EDS mapping of 3 wt% ANE char residue.

Reference for supporting information

- 1 A. Obut, I. Girgin and A. Yörükođlu, *Clays & Clay Miner.*, 2003, **51**, 452–456.