Supporting Information

Controllable fabrication of a hybrid containing dodecyl dihydrogen phosphate modified magnesium borate whisker/hydrated alumina for enhancing the fire safety and mechanical properties of epoxy resin

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3.1 Characterization of the as-prepared samples

The composition of MBW@HA-DDP was determined by thermogravimetric analysis (TGA). The specific results were shown in Fig. S1 and Table S1. Before 800 °C, MBW was very stable and hardly decomposed. In contrast, HA and MBW@HA present residual weight percentages of 64.61 and 93.64% at 800 °C. Then, it can be calculated that the MBW and HA weight percentages for MBW@HA are 82.03 and 17.97%, respectively. Regarding MBW@HA-DDP, there was a clearly weight loss step range of 200-480 °C in comparison with that of MBW@HA. This was due to the combustion of DDP and it normally burns off after 480 °C. Thus, the weight percentage of MBO, HA, and DDP in the MBW@HA-DDP hybrid was 78.00, 17.09, and 4.91%, respectively.

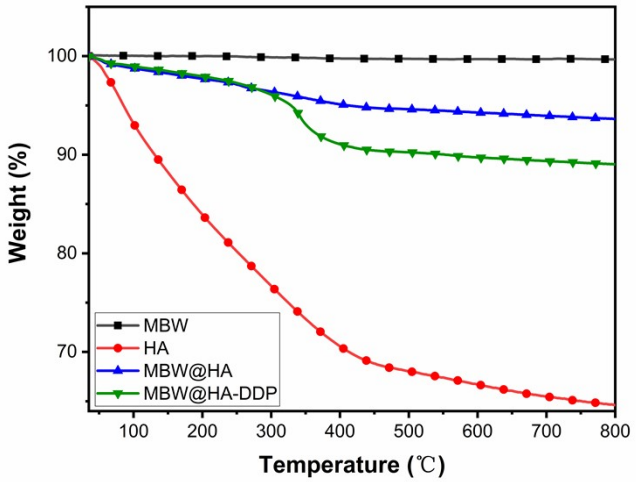

Fig. S1. TGA curves for MBW, HA, MBW@HA, and MBW@HA-DDP.

Table S1. The composition of as-prepared samples

Sample	Weight of TGA (%)	Composition (%)		
	800 °C	MBW	HA	DDP
MBW	99.67			
HA	64.61			
MBW@HA	93.64	82.03	17.97	
MBW@HA-DDP	89.04	78.00	17.09	4.91

3.3 Flame retardancy of EP composites

The flame retardancy effect of MBW@HA-DDP on EP was also compared with those of metal hydroxides such as magnesium hydroxide (MH) and layered double hydroxide (LDH) that are commonly used to meliorate the flame retardant properties of polymers. As shown in Table S2, the PHRR and THR of EP composite with MBW@HA-DDP added were reduced to a greater degree

than with the same amount of MH or LDH added, showing that MBW@HA-DDP has better flame retardancy. In addition, the incorporation of MBW@HA-DDP did not deteriorate the mechanical properties of EP but improved it to some extent.

Table S2. Comparison of performance for different composites with the same amount of fillers added (10 phr)

compostie	Flame retardancy		Mechanical properties	
	PHRR/decreased %	THR/decreased %	tensile/increased %	impact/increased %
EP/MH	16.4	27.1	-23.3	-42.1
EP/LDH	16.1	22.6	-20.2	-27.4
EP/MBW@HA-DDP	32.0	28.1	21.2	10.4

3.4 Smoke suppression achieved using EP composites

The thermal decomposition process of EP and its composites was studied by TGA under N_2 atmospheres. The specific results were showed in Fig. S2 and Table S3. The temperatures at which 5% weight loss and max rate of weight loss occur are defined as the initial degradation temperature ($T_{-5\%}$) and the maximum degradation temperature (T_{max}), respectively. Compared to that of pure EP, the $T_{-5\%}$ and T_{max} of all its composites decreased to a varying extent. This mainly due to the catalytic degradation effect of the products formed during the thermal decomposition of fillers, such as Al_2O_3 and dehydrated phosphorus oxoacids. Besides, two degradation stages could be observed for EP1: the first stage range of about 220 °C to 340 °C, which is due to the early decomposition of HA to protect the matrix during combustion; the second stage after 340 °C is mainly caused by decomposition of EP matrix. However, the char yields of its composites at 800 °C are all increased in comparison with that EP. Among them, the char yield of EP4 is the highest, implying that DDP has a role in promoting the formation of char residue.

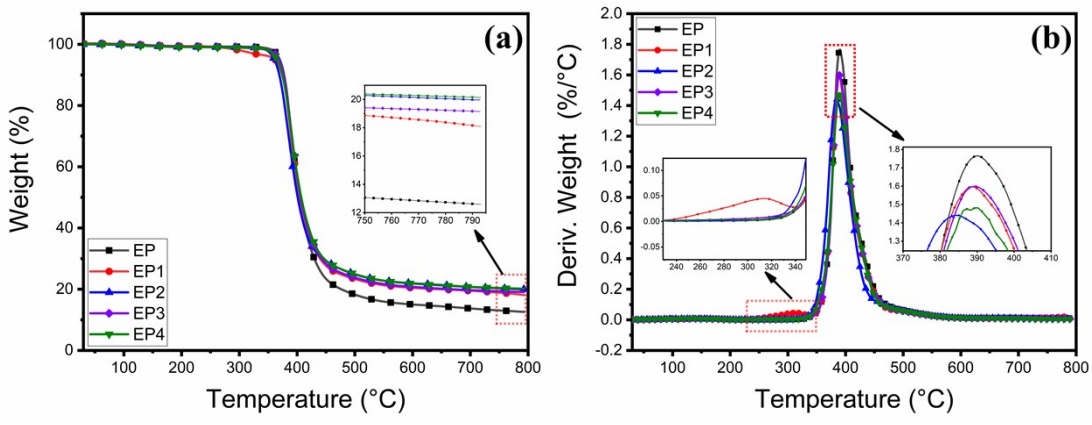

Fig. S2. (a) TGA and (b) DTG curves for EP and its composites.

Table S3. TGA data for EP and its composites

Sample	$T_{-5\%}$ (°C)	T_{max} (°C)	Char yield (%)
EP	370.1	390.3	12.6
EP1	361.9	383.5	18.1
EP2	360.6	383.7	19.9
EP3	368.3	388.7	19.1
EP4	365.3	387.9	20.1

3.5 Analysis of the char residues formed from EP composites

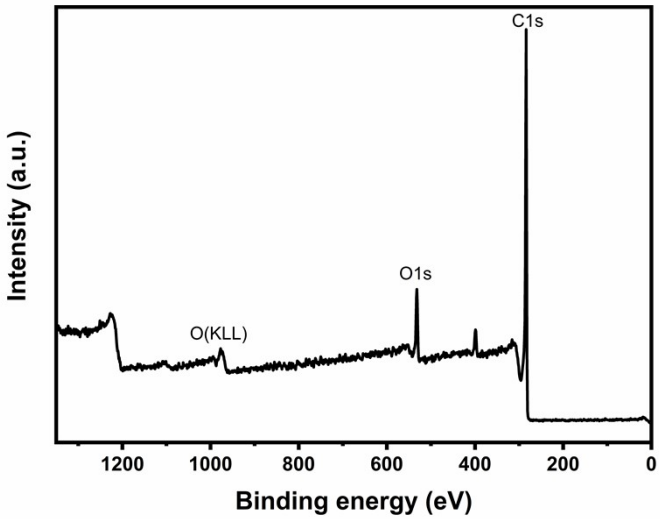

Fig. S3. Full-scan XPS spectral profiles of the char residue obtained from pure EP.

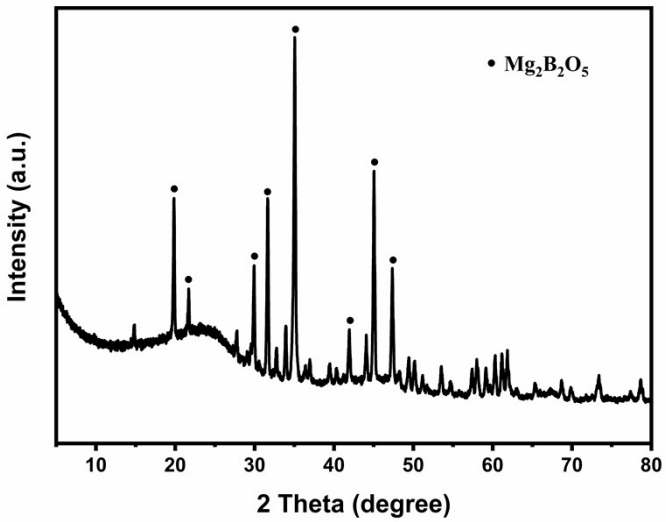

Fig. S4. XRD patterns recorded for the char residue obtained from EP4.

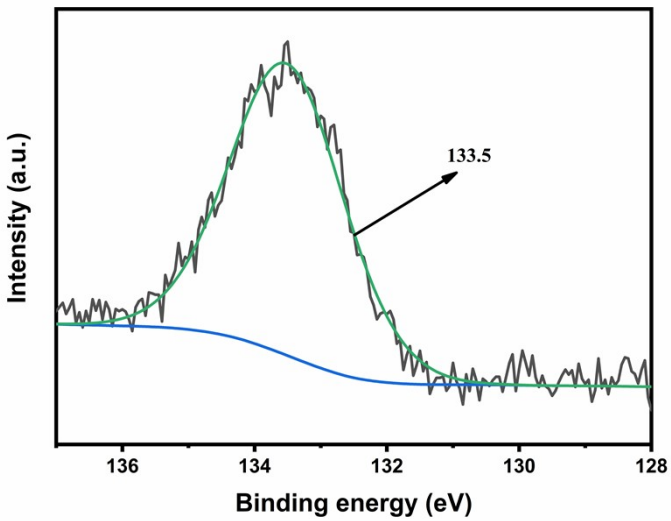

Fig. S5. High-resolution XPS spectral profiles recorded for P2p in MBW@MH-DDP.