

Novel exploration of the flame retardant potential of bimetallic MXene in epoxy composites



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Abstract

Considering the promising fire-proofing performance of 2D $\text{Ti}_3\text{C}_2\text{T}_x$ MXene and synergistic effects between the elements, this work comparatively investigated the flame-retardant effects of mono/bimetallic MXene ($\text{Ti}_3\text{C}_2\text{T}_x$, $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$) in epoxy resin (EP). MXenes demonstrate good structural stability under thermal conditions, contributing to improved thermal and flame retardancy of EP composites. Furthermore, EP composites with 1 wt% $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ MXene achieved improved thermal properties and increased fire safety with significantly reduced heat release rate and smoke release rate compared to pure EP, which was also superb over EP/ $\text{Ti}_3\text{C}_2\text{T}_x$ composites. It can demonstrate that $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ MXene has superior flame retardant properties than $\text{Ti}_3\text{C}_2\text{T}_x$ MXene.

Preparation and characterization

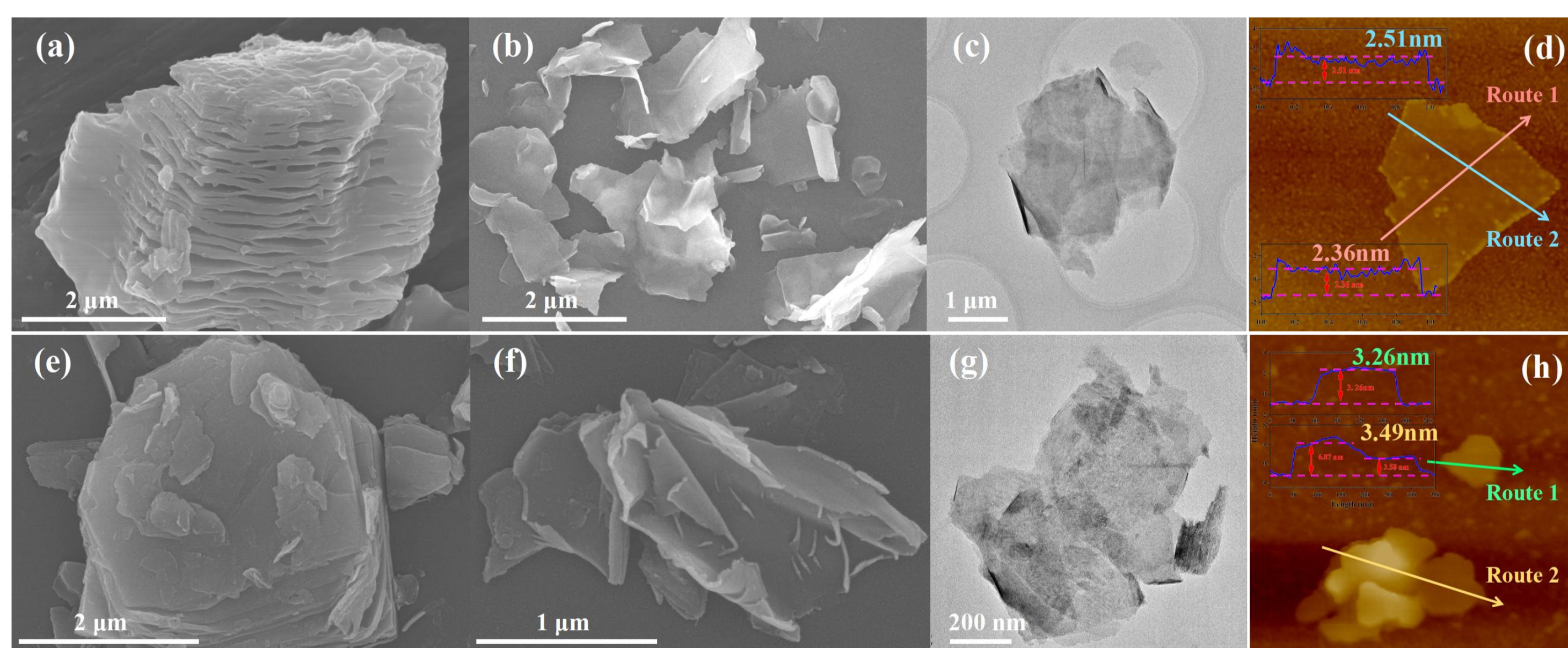
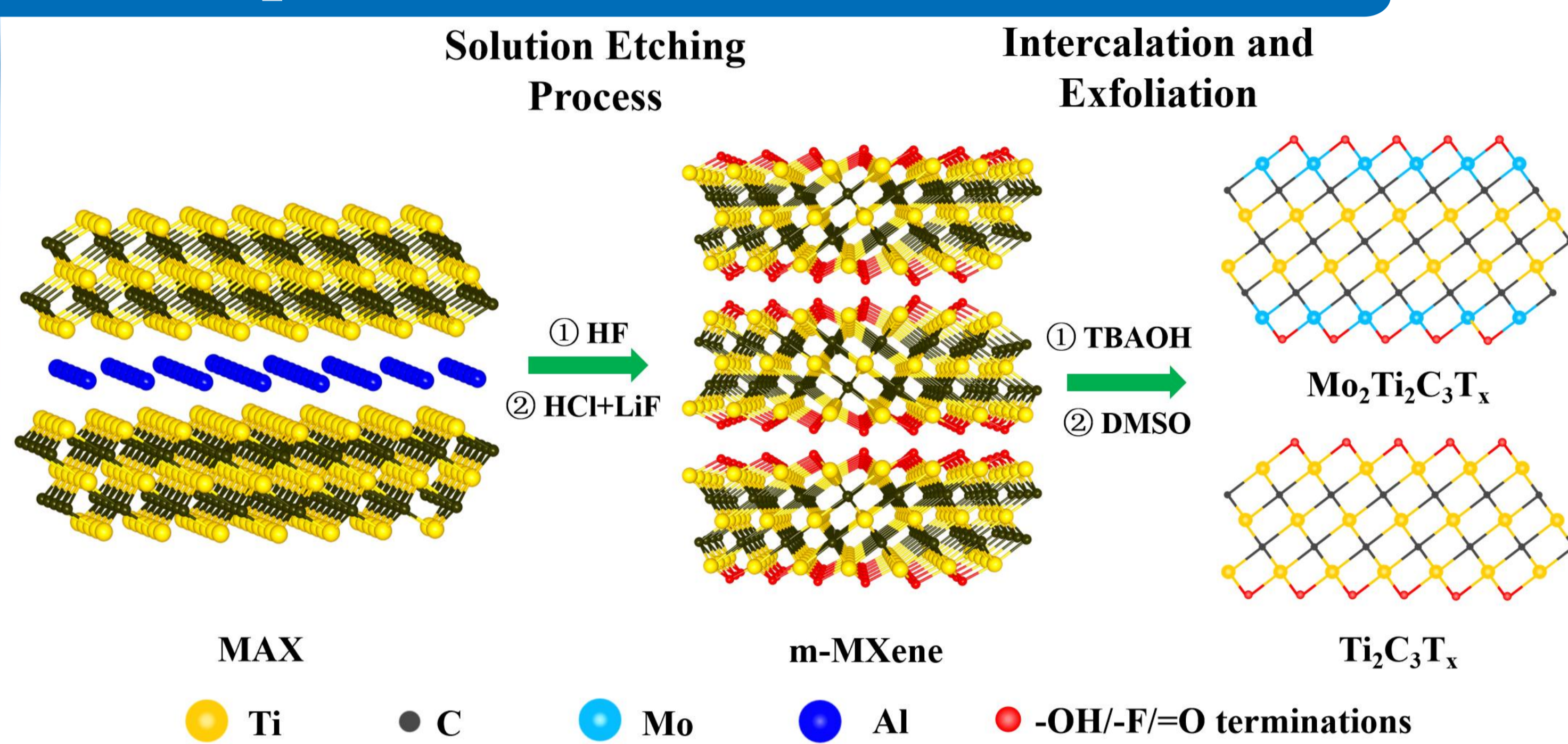


Figure 2 SEM, TEM and AFM images of $\text{Ti}_3\text{C}_2\text{T}_x$ (a-d) and $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ (e-h).

Flame retardancy

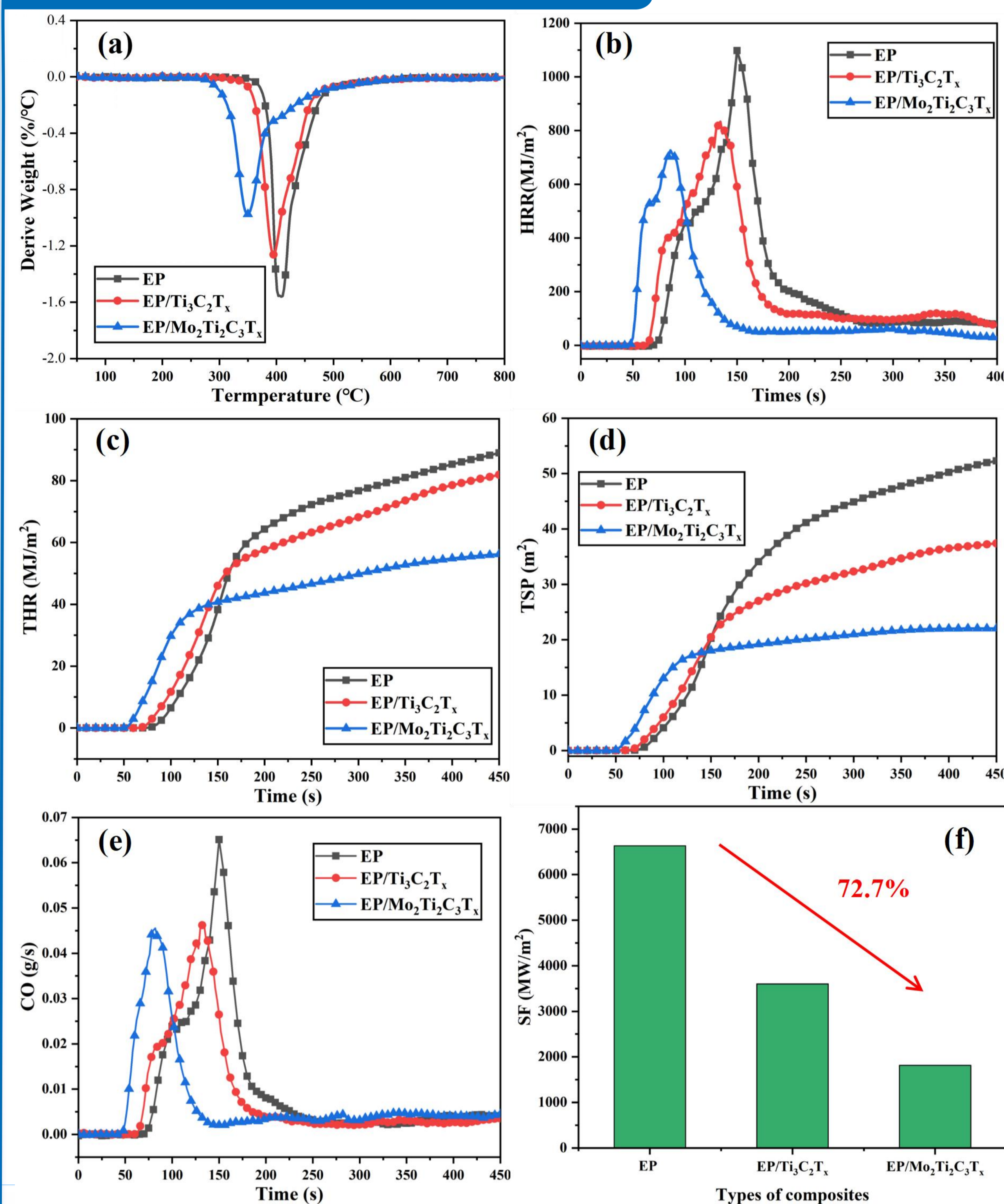
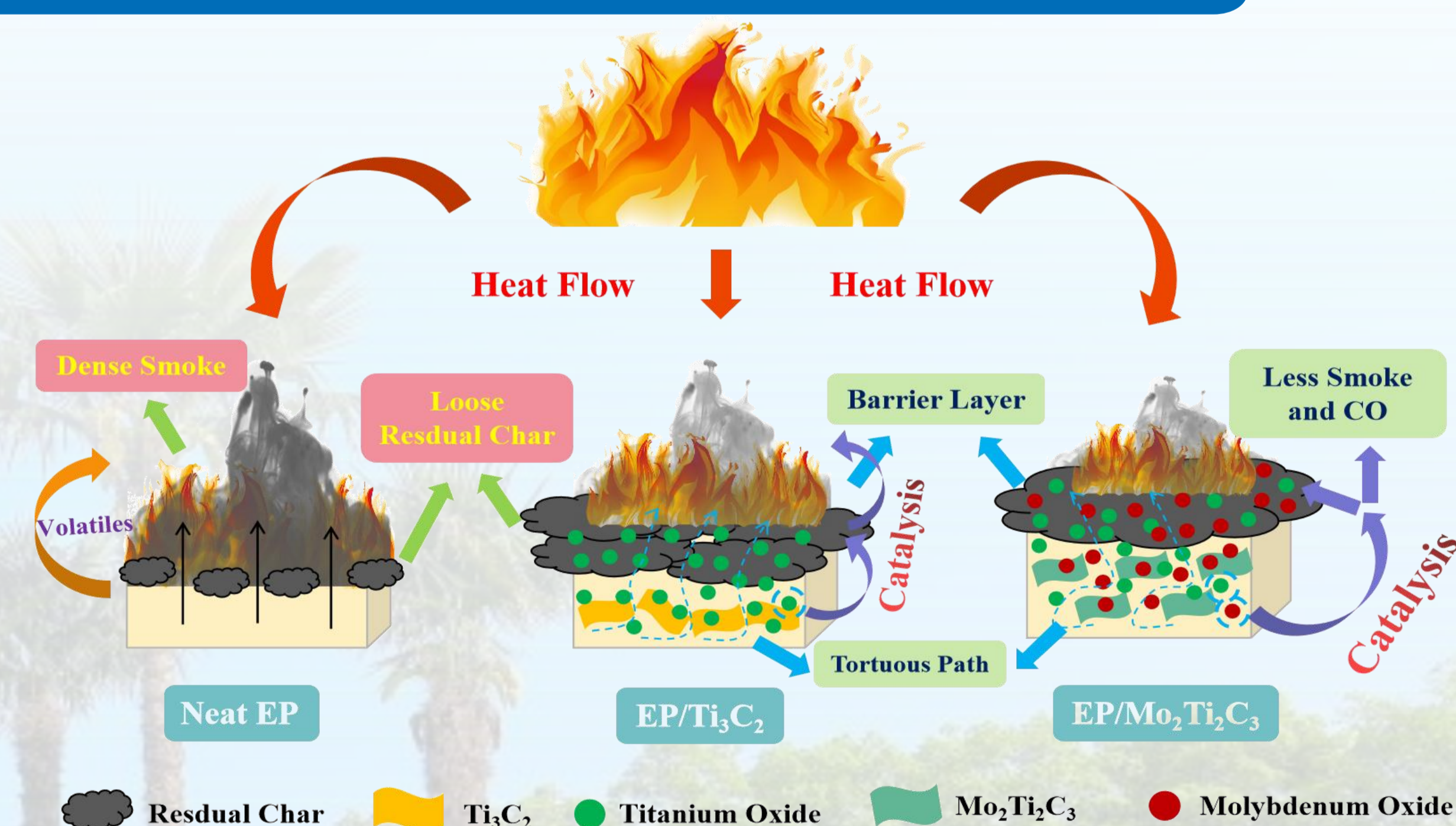


Figure 4 R_{\max} (a), HRR (b), THR (c), TSP (d) and CO (e) curves and SF values (f) of EP composites

Flame retardant mechanism



Structural thermal stability

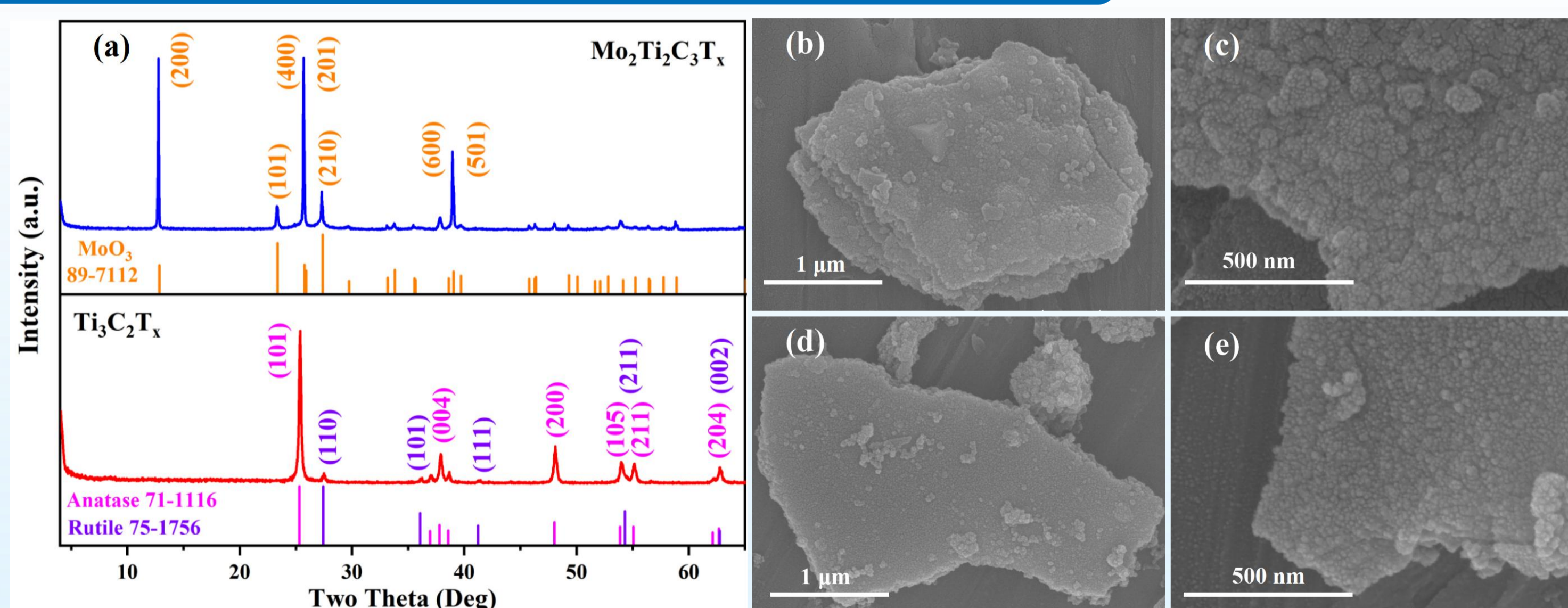


Figure 3 XRD patterns (a) and SEM images of $\text{Ti}_3\text{C}_2\text{T}_x$ (b and c) and $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ (d and e) after calcination at 500 °C.

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Conclusion

- $\text{Ti}_3\text{C}_2\text{T}_x$ and $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ MXenes were successfully prepared by acid etching methods, along with $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ MXene endowing the EP with higher fire safety.
- The improved fire safety of EP/ $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ composites was revealed by decreasing PHRR, THR, PSPR, TSP, PCO and PCO_2 , down by 34.0%, 37.0% 32.7%, 57.7%, 30.8% and 37.7% respectively.
- The superior flame retardancy of bimetallic $\text{Mo}_2\text{Ti}_2\text{C}_3\text{T}_x$ MXene was corresponding to the catalytic charring and attenuation of double metal components (Mo-Ti elements), together with physical shielding effect of nanosheet.