A novel energetic composite with a special sandwich microstructure: RDX/expanded graphite intercalation composite

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Introduction

- A variety of carbon materials have been developed as carriers of EMs for higher performance.
- Considering that expanded graphite (EG) possesses such many outstanding properties, we employed the solvent/anti-solvent process to recrystallize RDX crystal into holes of EG.
- The advanced sandwich microstructure possessed two effects: (i) high heat conduction and (ii) hot spots isolation of the carbon microstructure, which were the key to improve thermal stability and decreasing sensitivity.

Preparation of RDX/EG intercalation composite

1) Preparing RDX solution with different concentrations;
2) Adding EG into the solution and soaking to fully wetted;
3) Filtering out the EG absorbing the RDX solution fully from the suspension and pouring the filter residue into deionized water rapidly following the agitation for 5 min;
4) Filtering out the production and washing the sample with deionized water to remove the remaining RDX outside EG;
5) Drying samples at 60℃ to the constant weight.

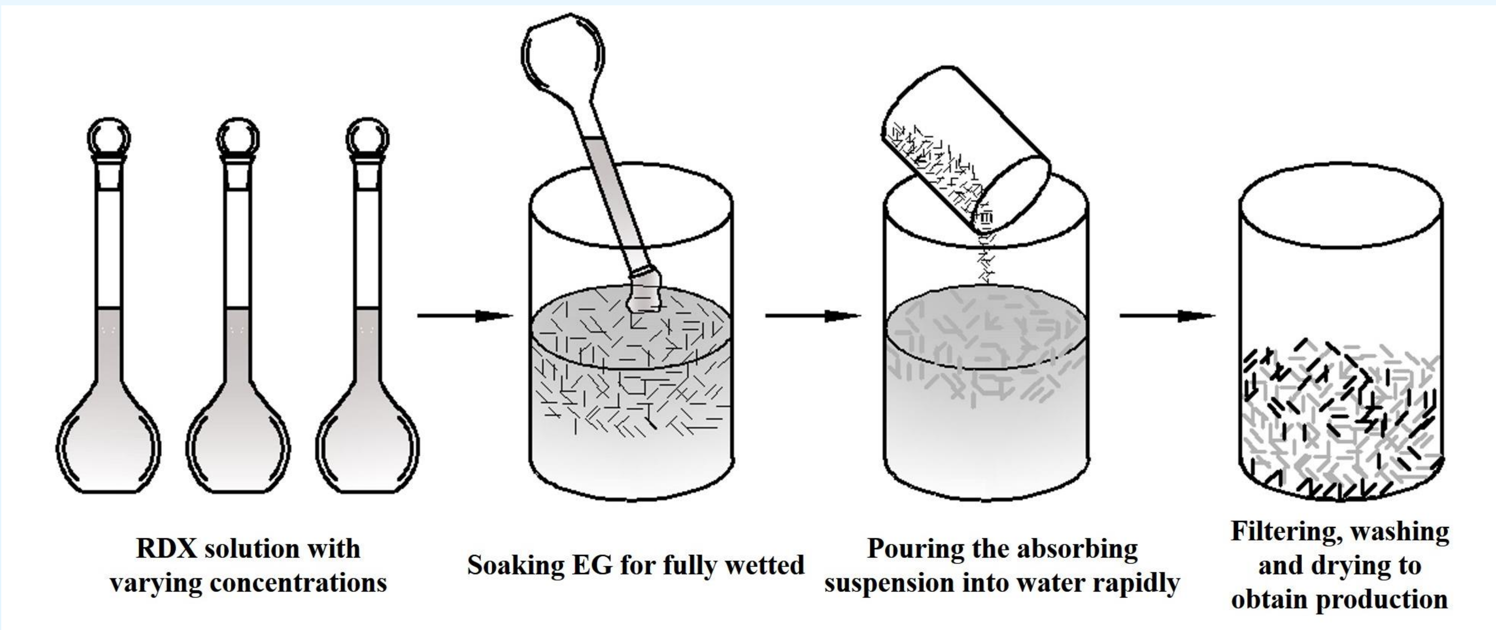

Figure 1. Procedures for the formation of RDX/EG intercalation composites

Sandwich microstructure

- Effect of volume ratio of solvent to anti-solvent on intercalation

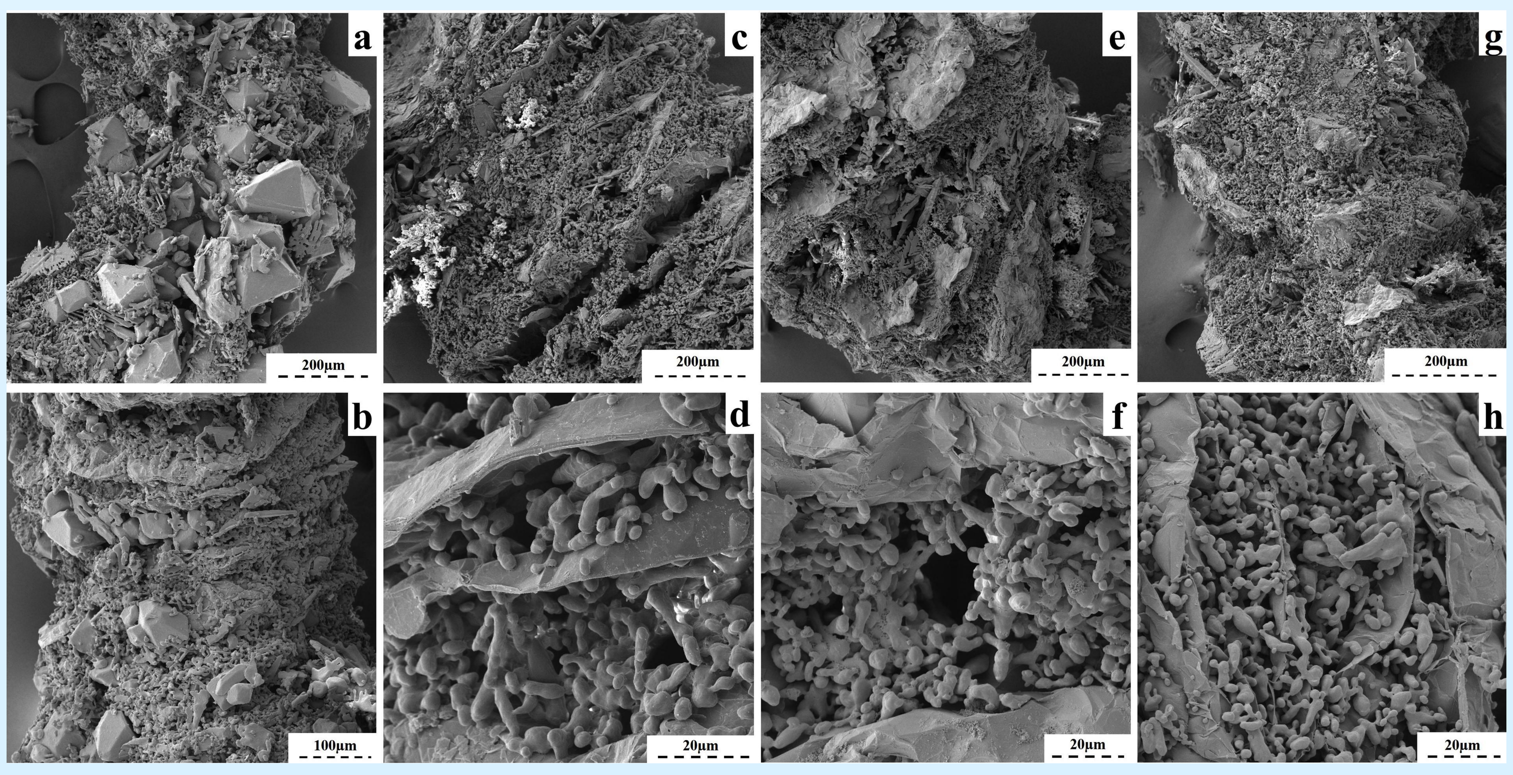

Figure 2. SEM images of RDX/EG intercalation composites prepared under different volume ratio of solvent to anti-solvent conditions: (a, b) 1:2; (c, d) 1:6; (e, f) 1:10; (g, h) 1:20

- Effect of concentration of RDX solution on intercalation

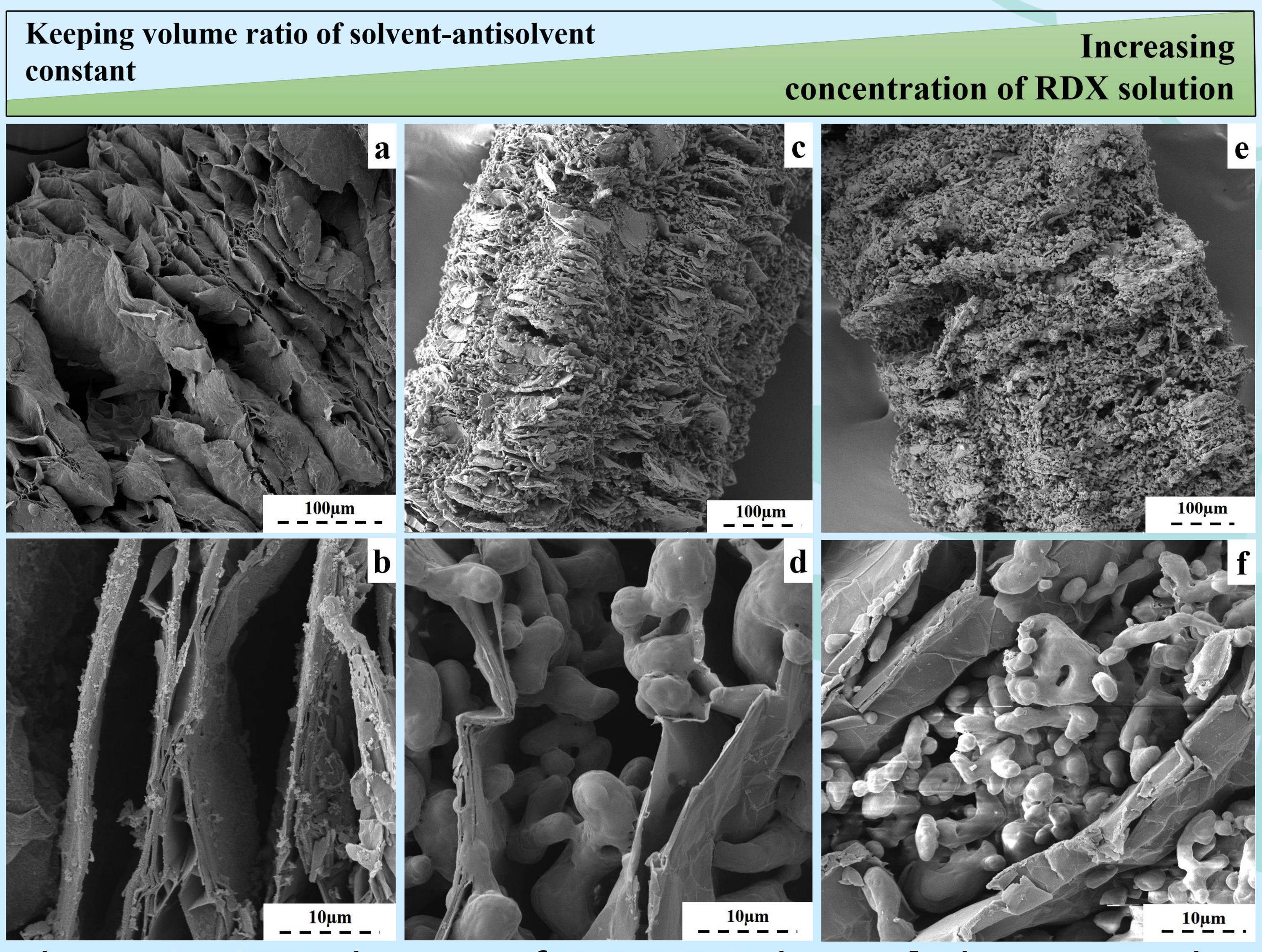

Figure 3. SEM images of RDX/EG intercalation composites prepared under different RDX solution concentration conditions: (a, b) 0.10 mol·L^{-1}; (c, d) 0.90 mol·L^{-1}; (e, f) saturation.

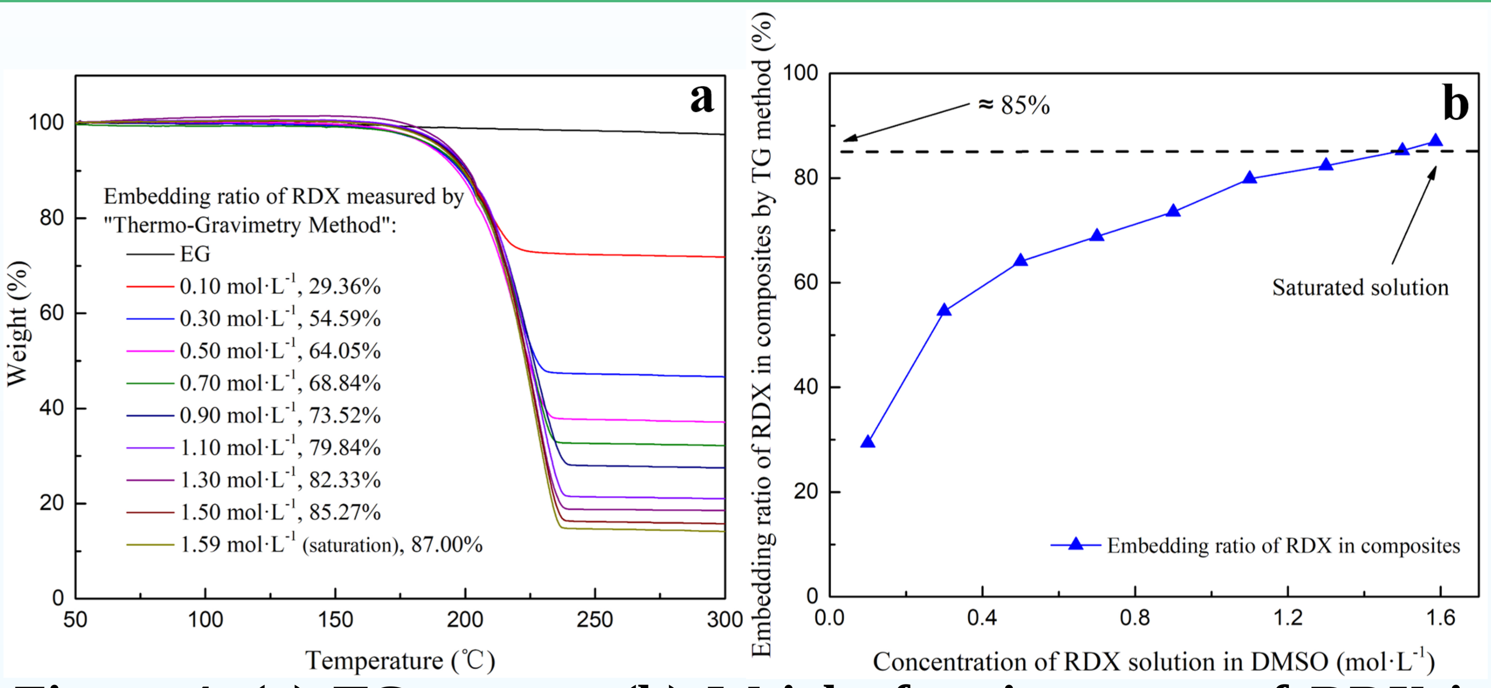

Figure 4. (a) TG curves; (b) Weight fraction curve of RDX in composites against concentration

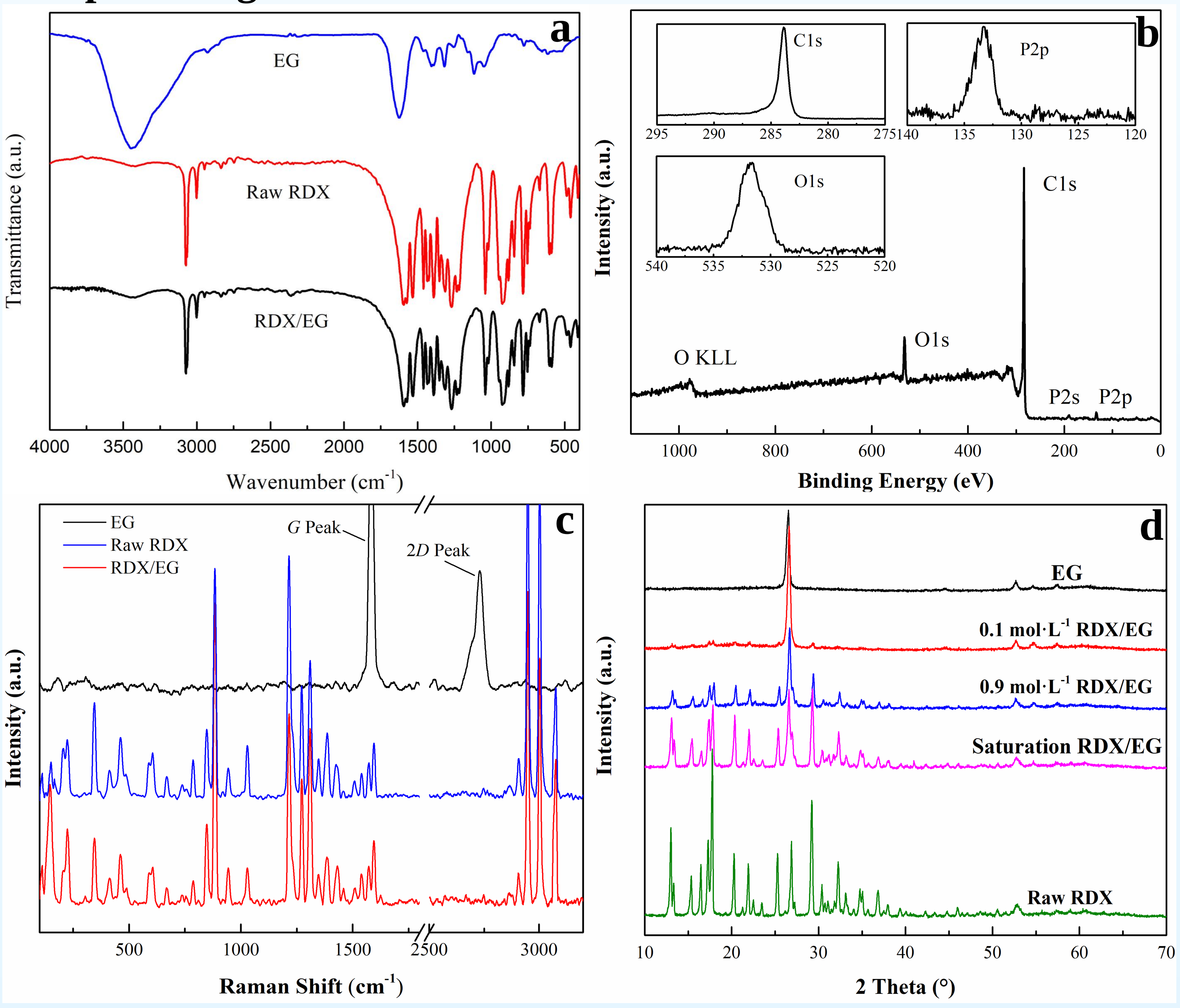

Figure 5. (a) IR spectroscopies; (b) The XPS general spectroscopy and the C1s, O1s, P2p spectroscopies (in the inserts) of EG; (c) Normalized Raman spectroscopies; (d) XRD patterns

Explosive properties

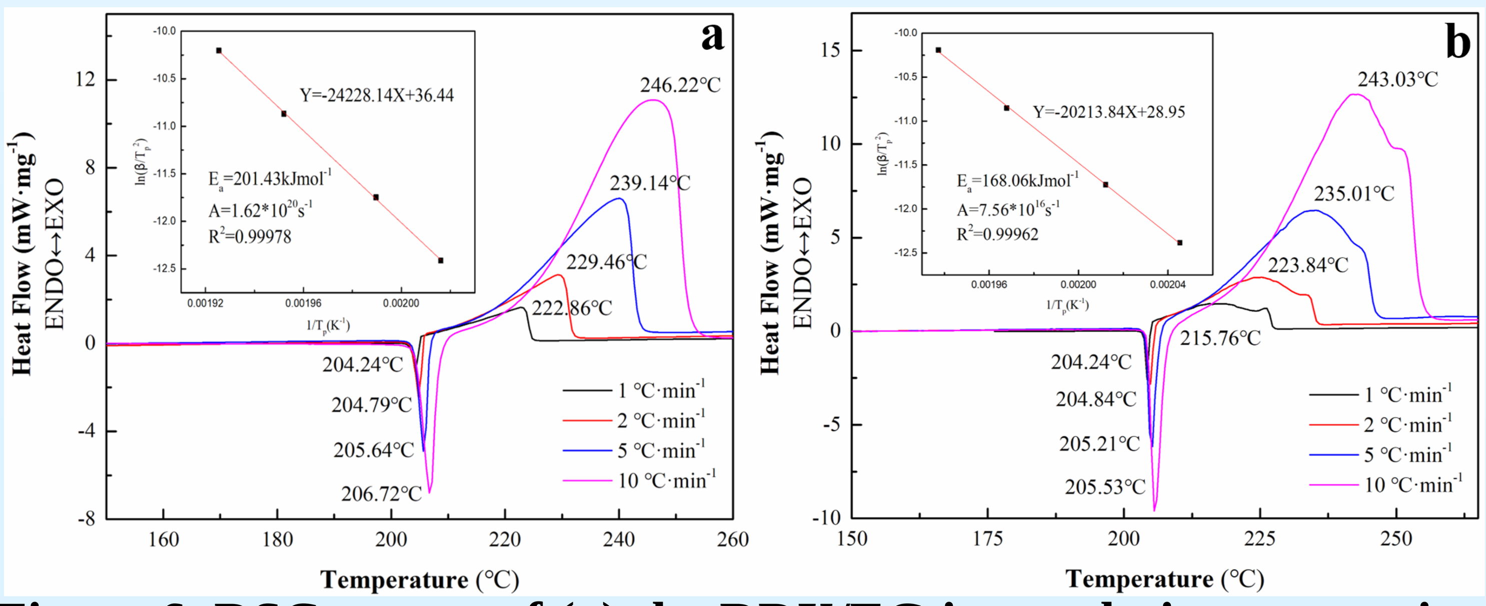

Figure 6. DSC curves of (a) the RDX/EG intercalation composite and (b) raw RDX at different heating rates. Kissinger plots of ln(β/T_P^2) versus 1/T_P were shown in the inserts

Table 1. Kinetics, thermodynamics and thermal stabilities parameters of raw RDX and the maximum intercalated RDX/EG composite (run 9) derived from their DSC curves

Samples	β (K·min^{-1})	T_P (℃)	Kinetics: E_K (kJ·mol^{-1})	Kinetics: lgA_K (s^{-1})	Kinetics: k (s^{-1})	Thermodynamics: $\Delta H^{\neq}$ (kJ·mol^{-1})	Thermodynamics: $\Delta G^{\neq}$ (kJ·mol^{-1})	Thermodynamics: $\Delta S^{\neq}$ (J·mol^{-1}·K^{-1})	Thermal stabilities: T_b (℃)
Run 9	1	222.86	201.43	20.21	0.10	197.21	131.61	129.24	224.09
	2	229.46			0.19				
	5	239.14			0.47				
	10	246.22			0.89				
Raw RDX	1	215.76	168.06	16.88	0.08	163.88	130.94	65.56	216.44
	2	223.84			0.16				
	5	235.01			0.40				
	10	243.03			0.74				

Table 2. Impact and friction sensitivities of raw RDX and RDX/EG intercalation composites

Run	Concentration of RDX solution (mol·L^{-1})	Volume ratio of solvent to anti-solvent	Weight fraction of RDX in composites (%, Sample-Weight Method)	Impact sensitivities H_{50} (cm)	Friction sensitivities P (%)
Raw RDX	-	-	-	10.80	72
5	0.9	1:6	74.92	28.40	20
9	1.59 (saturation)	1:6	84.26	27.10	24

Conclusions

The advanced half-coated parallel multi-sandwiches microstructure possessed two effects: (i) heat conduction and (ii) hot spots isolation, which were the key to higher performance.

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