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Supplementary Information

Orderly hybrid aerogel-based hydrate salt for wide-temperature range thermal regulation and flame retardant of Li-ion battery

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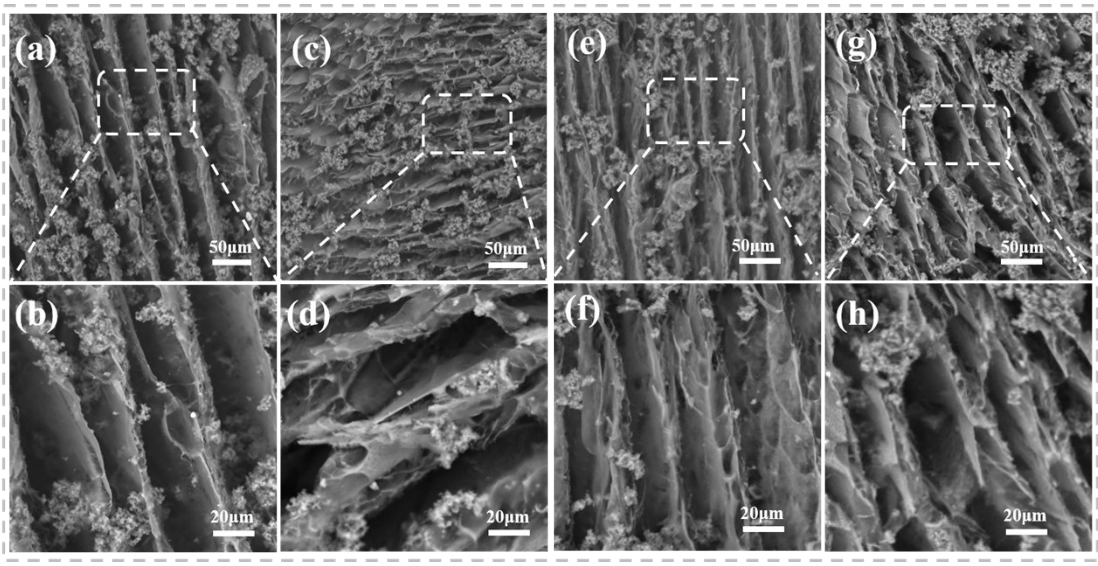
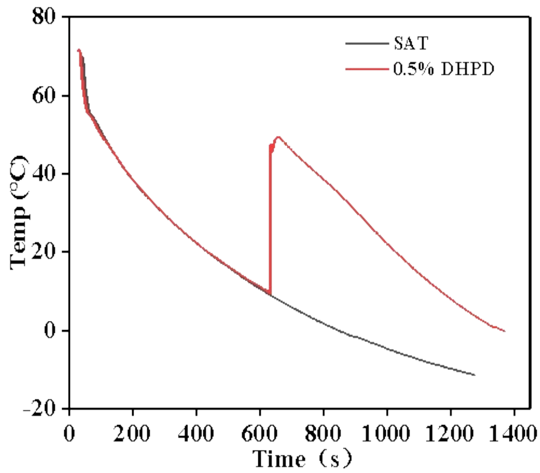


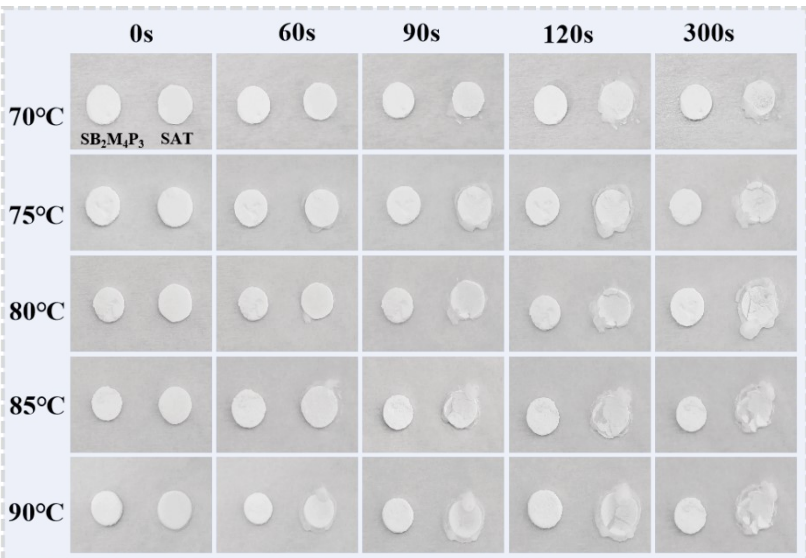
Figure S1. SEM images of surface and cross-section of $SB_2M_3P_3$ and $SB_2M_5P_3$



composites

Figure S2. Step cooling curves of SAT and that with 0.5% DHPD

Figure S3. Leakage-proof test of $SB_2M_4P_3$ and SAT under various temperatures and time



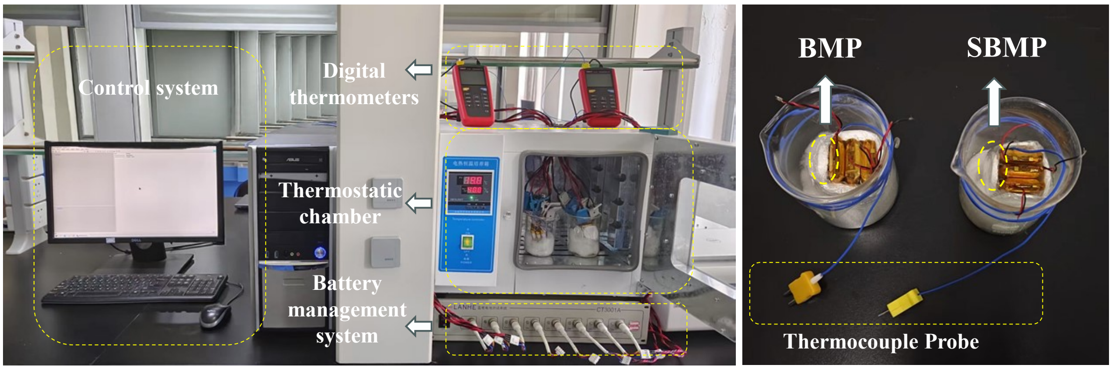


Figure S4. Optical images of high temperature thermal management experiment set-up

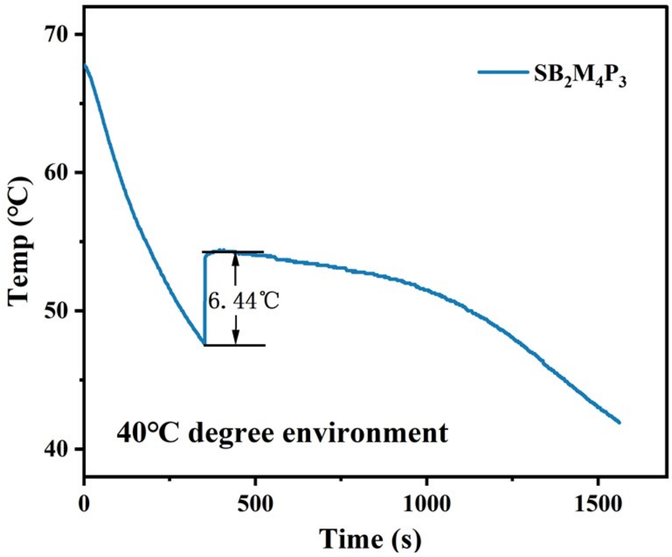


Figure S5. Step cooling curves of $B_2M_4P_3$

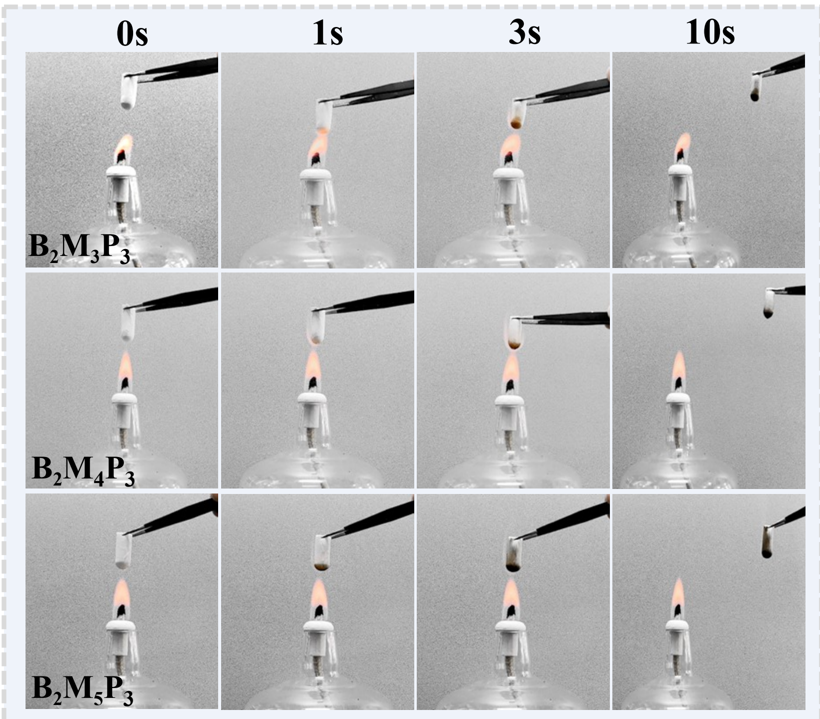


Figure S6. Optical images of $B_2M_3P_3$, $B_2M_4P_3$ and $B_2M_5P_3$

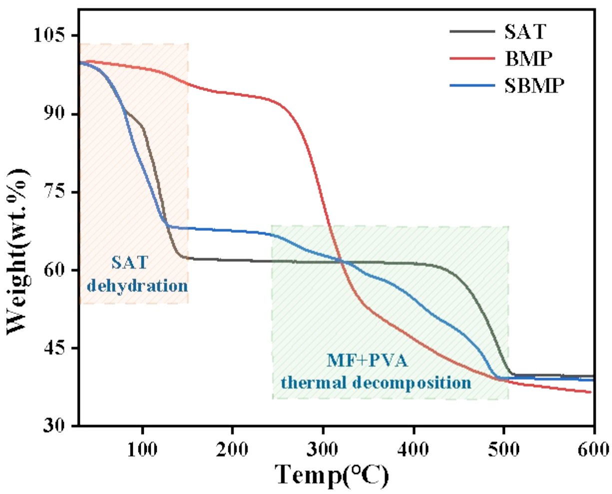


Figure S7. TGA curves of SAT, BMP and SBMP

Thermal management calculation for battery systems

Generally speaking, there are four heat related processes during the thermal management, which are explained as following:

(1) Heat exchange between the battery surface and the environment by convective heat transfer can be calculated as follows:

$$Q_1 = hA(T_B - T_0)t$$

Where h is the heat transfer coefficient, A is the surface area of the battery, T_B is the surface temperature of the cell, T_0 is the ambient temperature, and t is the time.

(2) Heat absorbed or released by the battery can be expressed as:

$$Q_2 = c_p m(T_2 - T_1)$$

Where c_p is the specific heat capacity of the battery, m is battery mass, T_2 is the final temperature of the battery, and T_1 is the initial temperature of the battery.

(3) Heat absorbed or released during the phase change:

$$Q_3 = m_s \Delta H$$

Where m_s is the mass of the phase change material, and ΔH is the melting enthalpy or solidification enthalpy of the phase change material.

(4) Heat generated during battery operation:

$$Q_4 = Pt$$

Where P is the power of the battery and t is for the battery working time.

Note S1: Cooling performance under 40℃ environment:

When battery temperature raised as discharging, the heat generated by battery (Q_4) was absorbed by PCM melting (Q_3), exchanged with the environment (Q_1) and used for battery temperature increase (Q_2). When battery charged and soaked, solidification of PCM released heat (Q_3) to compensate heat exchange with environment (Q_1) and battery temperature dropping (Q_2). On the contrary, there was not phase change process in the referenced system.

Note S2: Warming performance under -30℃ environment:

When battery suspended in chilling environment, solidified PCM released heat (Q_3) to offset heat dissipation (Q_1) and battery temperature decline (Q_2). During restart process, heat generated (Q_4) was used for heat dissipation (Q_1) and battery temperature increase (Q_2). Similarly, there was no phase change stage in the referenced system. The related parameters used for calculation were all measured by experiment and exhibited in Table S1. Heat balance analysis for all these processes were shown in Figure S8 and the calculation results were in Figure 4c and 5a.

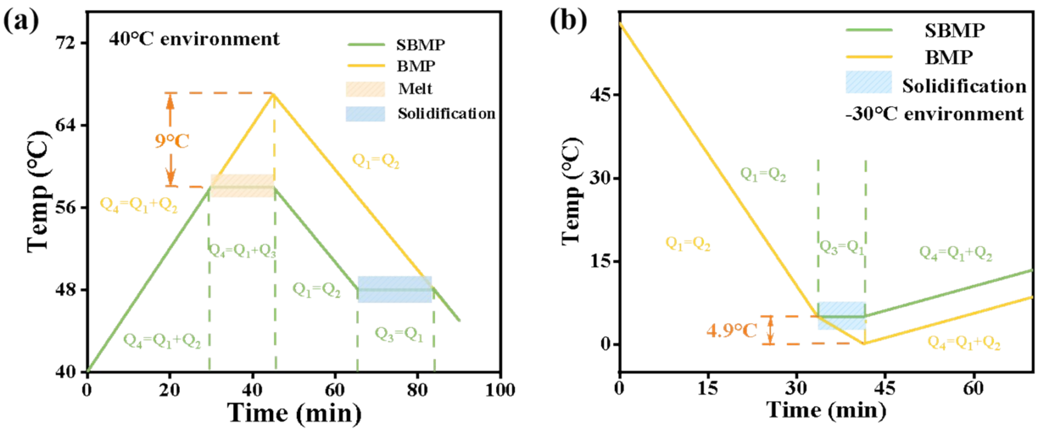


Figure S8 Calculated temperature-time curves for the SBMP and BMP encapsulated battery packs.

Table S1 Battery and phase change material parameters

C_p ($J \cdot g^{-1} k^{-1}$)	m (g)	P (W)	A (m^2)	m_s (g)	ΔH_m (J/g)	ΔH_f (J/g)	h $W/(m^2 \cdot K)$
1	60	0.924	$6*10^{-3}$	1.52	191.85	193.36	3