The Thermal Insulation Composites for Lithium-ion Batteries

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Background

- The lithium-ion traction battery is the most used power battery for new energy vehicles.
- However, lithium-ion batteries are prone to thermal runaway, and even cause **fires and explosions** in the case of overcharge and high temperature.
- Applying thermal insulation composite to the battery casing is simple and effective protection.
- Here we used hollow SiO_2 microspheres, hollow glass microspheres, hollow phenolic microspheres, and silicone rubber to prepare **thermal insulation composites**.

Experiment Model

- We took three kinds of hollow microspheres as the thermal insulation functional phase and obtained the optimal formulation by orthogonal experiment design.
- The units of the levels of the three factors in Table 1 are mass fractions.

Table 1 Factor Level

Level \ Factor	hollow glass microspheres	hollow SiO_2 microspheres	hollow phenolic microspheres
Symbol	A	B	C
1	6	3	5
2	8	6	10
3	10	9	15

Table 2 Orthogonal-Factor Table

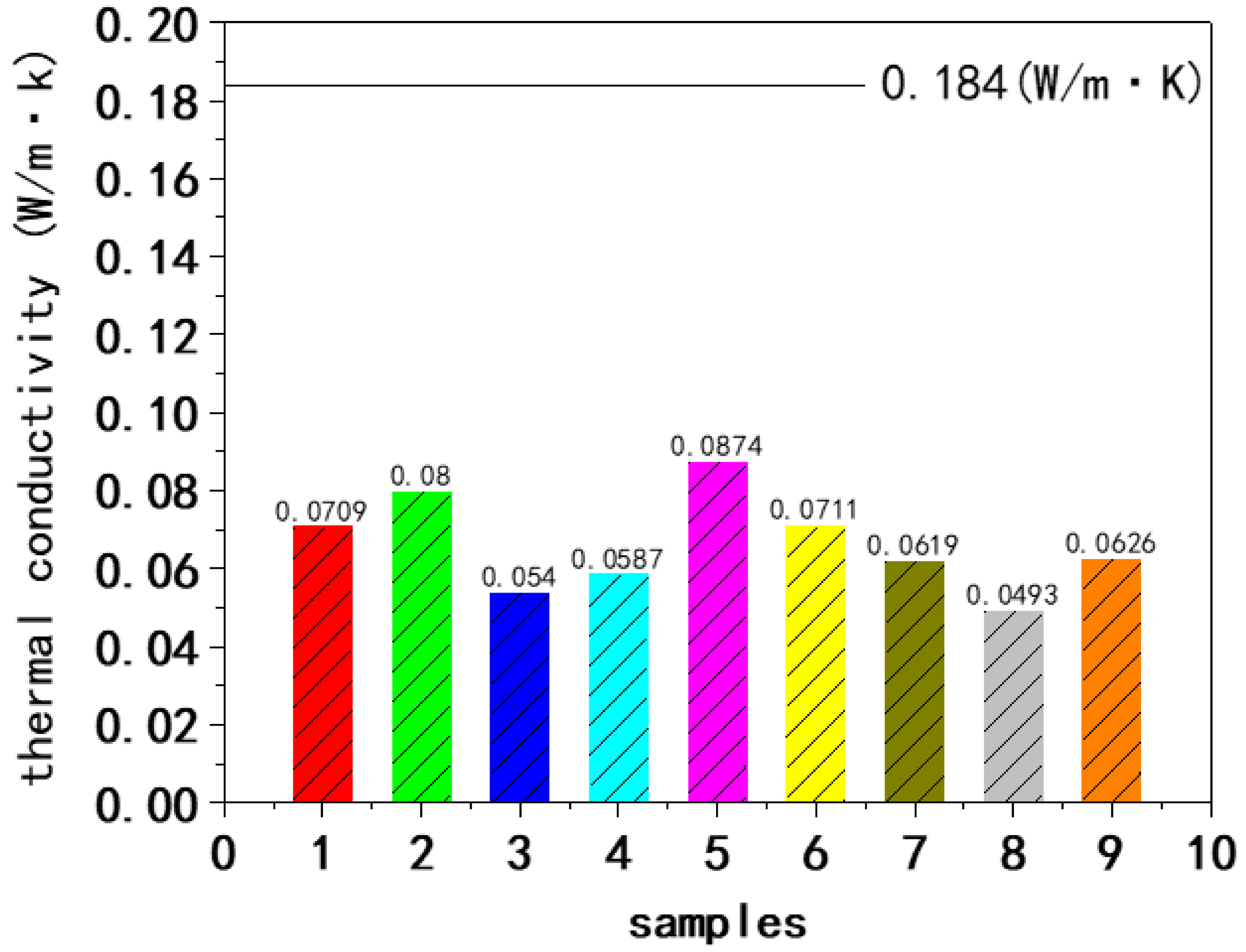
number	A	B	C	Combinations
1	A_1	B_1	C_1	$A_1B_1C_1$
2	A_1	B_2	C_2	$A_1B_2C_2$
3	A_1	B_3	C_3	$A_1B_3C_3$
4	A_2	B_2	C_3	$A_2B_2C_3$
5	A_2	B_3	C_1	$A_2B_3C_1$
6	A_2	B_1	C_2	$A_2B_1C_2$
7	A_3	B_3	C_2	$A_3B_3C_2$
8	A_3	B_1	C_3	$A_3B_1C_3$
9	A_3	B_2	C_1	$A_3B_2C_1$

- The mixing of hollow microspheres with different particle sizes can effectively improve the hollowness of the material.
- And it is difficult for hollow microspheres of dissimilar materials to form thermal conduction channels. All of which helps to reduce the thermal conductivity of the material

Thermal insulation

- The thermal conductivity of samples was determined using the flat heat conduction tester. We plotted and compared the thermal conductivity of samples No.1 to No.9.

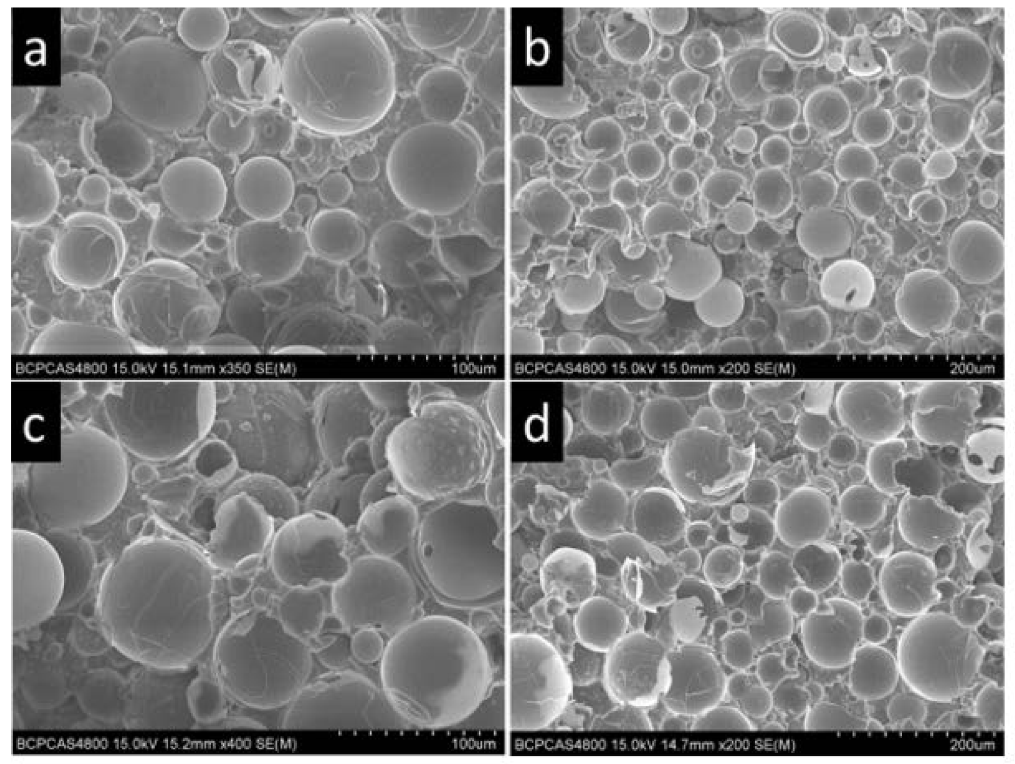
Fig. 1 Thermal conductivity of samples



- The thermal conductivity of sample No.8 is the lowest among all samples, only 0.0493W/m·K. Because the volume fraction of hollow microspheres of sample No. 8 is the largest, the number of hollow microspheres is the largest, and the hollow ratio is the highest among all samples.

Morphological analysis

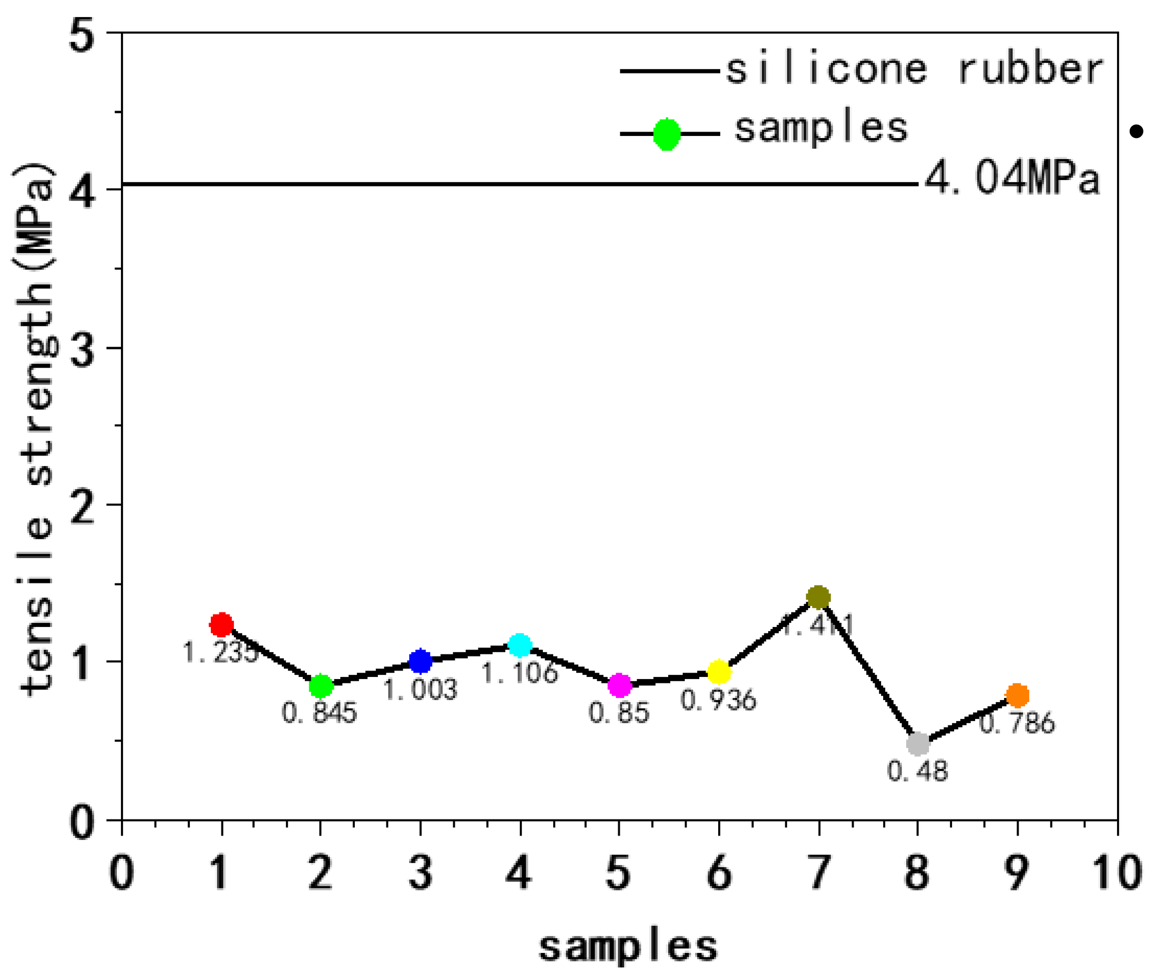
Fig. 2. Scanning electron microscope of thermal insulation composite: (a) and (b) are sample No. 3; (c) and (d) are sample No. 8



- the small-sized hollow microspheres are interspersed between the large-sized hollow microspheres, allowing the silicone rubber between the large-sized hollow microspheres to be drained away, improving the hollowness of the thermal insulation composites.

Mechanical properties

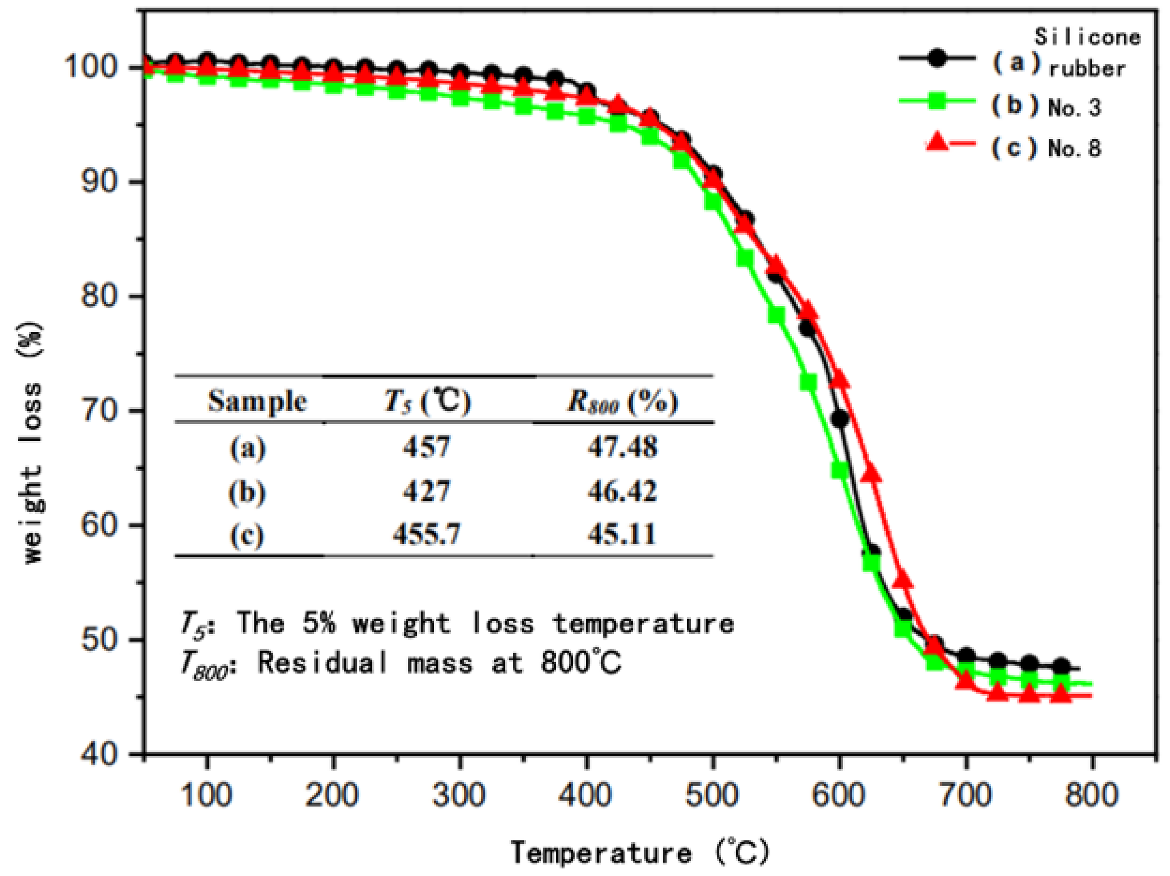
Fig. 3 Tensile strength of samples



- The compatibility between hollow microspheres and silicone rubber is not good, the effect of both bonding modes is weak, and interfacial debonding is easy to occur under the action of tensile force.
- the tensile strength of silicone rubber was 4.04 MPa, and the tensile strength of all orthogonal samples was less than that of silicone rubber.
- Sample No. 8 has the highest content of hollow microspheres, which makes the hollow microspheres pile up tightly, reducing the stress area and increasing the stress concentration zone, resulting in the material being easily pulled off.

Thermal stability

Fig. 4 The TGA curves



- Hollow glass microspheres are more resistant to high temperatures than hollow phenolic microspheres.
- However, the mass of hollow glass microspheres and hollow SiO_2 microspheres of sample No. 8 is 6g smaller in total than that of sample No. 3, and the thermal decomposition temperature of these two microspheres is very high.

Conclusions

(1)the tensile strength of the orthogonal specimens deteriorated with the increase of the hollow microsphere addition, which was due to the poor compatibility of the hollow microspheres with the silicone rubber.

(2)However, the different types of hollow microspheres are not conducive to the formation of thermally conductive pathways even in close contact, which facilitates the reduction of the material thermal conductivity.

(2) we choose sample formulation No. 3 as the best formulation, The thermal conductivity of this formulation is 0.054 W/m·K, a tensile strength of only 1.003 MPa, and a thermal decomposition temperature of 427 ℃.