ZnO functionalized paraffin/diatomite phase change material and its thermal management mechanism in PDMS coatings

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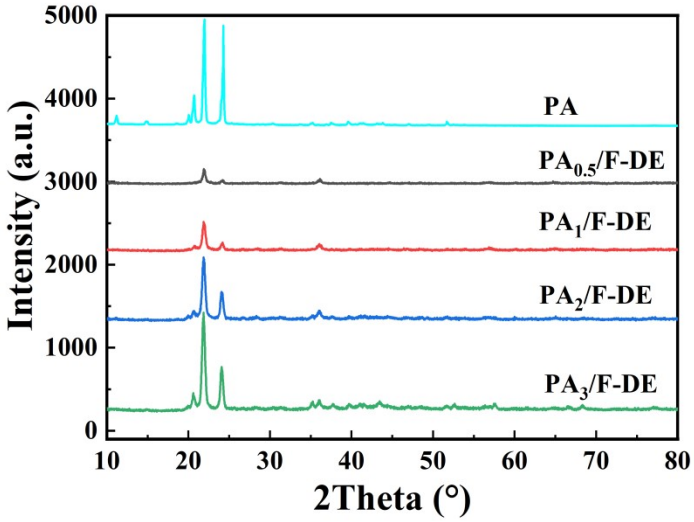

Figure S1 XRD of PA and PA/F-DE

Different contents of PA were melted blending with F-DE to obtain PA/F-DE composite phase change materials (PCMs). The XRD of PA and PA/F-DE were shown in Figure S1. Two sharp diffraction peaks at 21.4° and 24.0° of PA can be observed in PA/F-DE composite PCMs, and the diffraction peak intensity of PA/F-DE increased with increasing PA content.

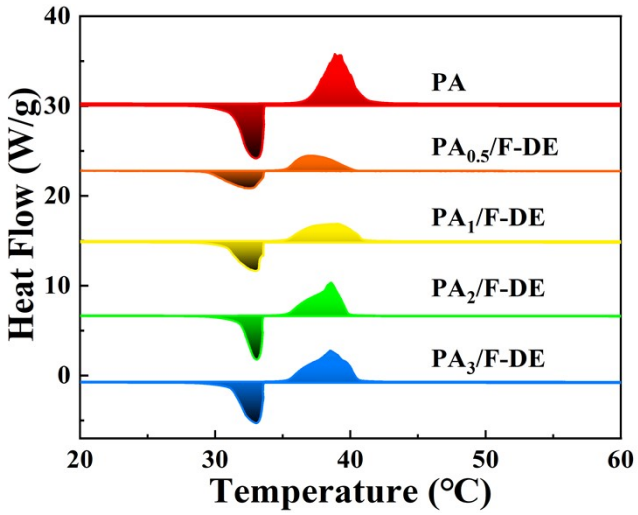

Figure S2 DSC of PA and PA/F-DE

Figure S2 provides the DSC curves of PA and PA/F-DE during endothermic and exothermic processes. PA had strong endothermic and exothermic peaks, and the peaks of PA/F-DE were similar to PA. This indicated that the thermal behavior of PA/F-DE was similar to that of PA. With an increase in PA content, the ΔHm and ΔHc of PA/F-DE increased. The ΔHm and ΔHc of PA_3/F-DE were highest, reaching to 146.8J /kg and 142.7J /kg, respectively, which were approximately 74% of PA (197.7J /kg ΔHm

and 186.1J /kg ΔHc).

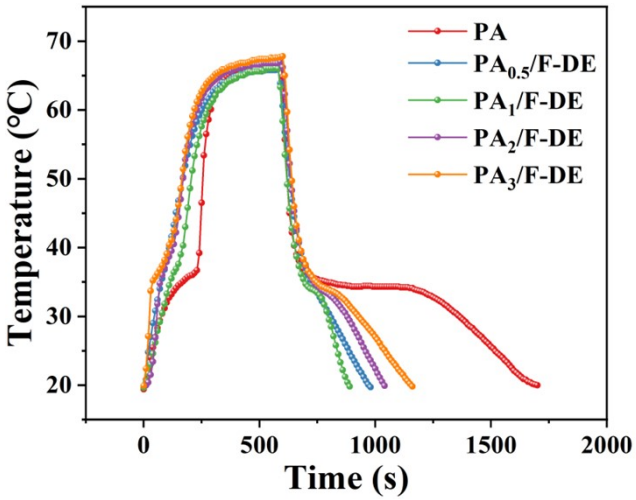

Figure S3 Step cooling curves of PA and PA/F-DE

The step cooling curves of PA and PA/F-DE were shown in Figure S3. PA and PA/F-DE had a temperature constant platform at about 35 °C during heating and cooling process. This is because PA undergoes a phase transition of melting or solidification through endothermic and exothermic PA/F-DE maintains the platform for a longer time as increasing the PA content.

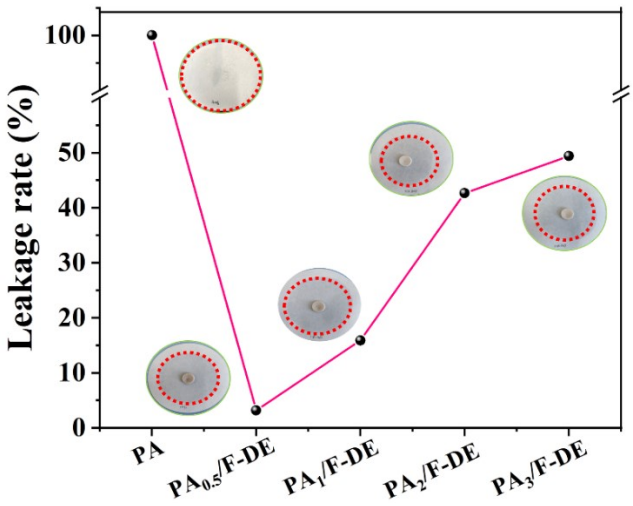

Figure S4 Leakage rate of PA and PA/F-DE

Figure S4 shows the leakage rate of PA and PA/F-DE. Compared with PA, the leakage rate of PA/F-DE decreased significantly because the porous structure of F-DE limited the fluidity of PA adsorbed in porous F-DE. However, the leakage rate of PA/F-DE increased with the content of PA because there was only physical interaction between PA and F-DE.

Table S1 Comparison of properties between PA_1/F-DE/ZnO_{10} and similar materials in literature

PCMs	ΔHm (J/g)	ΔHc (J/g)	Encapsulation ratios (%)	Thermal conductivity (W/m • K)	UV absorption	Refs.
PA/DE	53.10	58.83	31.6	/*	no	[1]
PA/DE	74.95	76.23	55.49	/	no	[2]
PA/F-DE	98.2	95.4	50.4	0.1124	no	Present work
PA/ F-DE/ZnO_1	91.7	89.0	46.4	0.1159	yes	
PA/ F-DE/ZnO_5	90.8	89.0	45.9	0.1183	yes	
PA/ F-DE/ZnO_{10}	76.3	75.73	38.6	0.1227	yes	

* "/" represents not mentioned in the study.

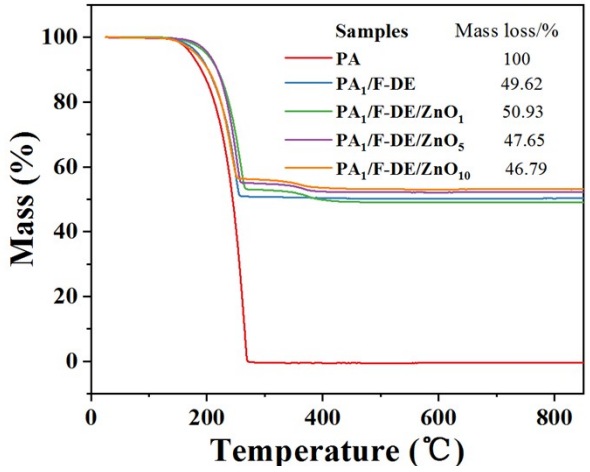

Figure S5 TG curves of different materials.

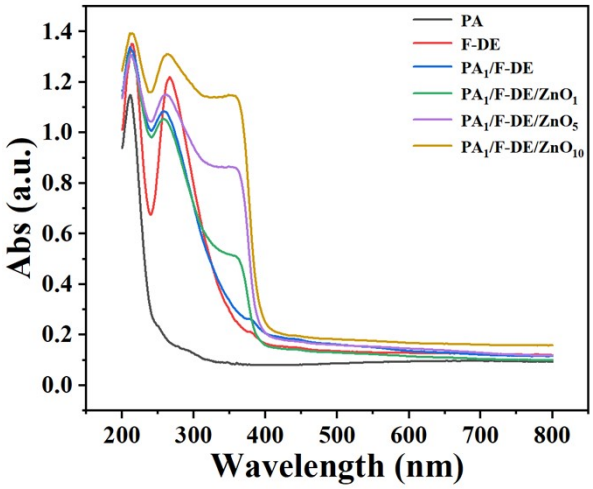

Figure S6 UV-visible absorption spectra of different materials.

Another purpose of ZnO as a functional enhancement of PA_1/F-DE PCMs is its contribution to the UV absorption properties. Figure S6 shows that ZnO had UV absorption in the wavelength range of UVA (320~420 nm), UVB (275~320 nm) and UVC (100~280 nm).[3] The UV absorption intensity was mainly concentrated in the wavelength range of UVA and the enhancement of UV absorbance at UVA was

remarkable for PA_1/F-DE/ZnO. The absorbance at 358 nm (3.29 eV) corresponds to the exciton state of ZnO, and increases with increasing the ZnO content.[4] The UV absorbance of PA_1/F-DE/ZnO at 200~250 nm showed a weak enhancement because of the weak UVC absorption of ZnO. Thus, the introduction of Nano-ZnO endowed the PA/F-DE/ZnO PCMs with good visible light transmission and wide frequency band ultraviolet absorption characteristics. Furthermore, UV light below ~381 nm can be effectively absorbed, and the composite structure can be potentially applied in UV shielding materials and optical materials.[5]

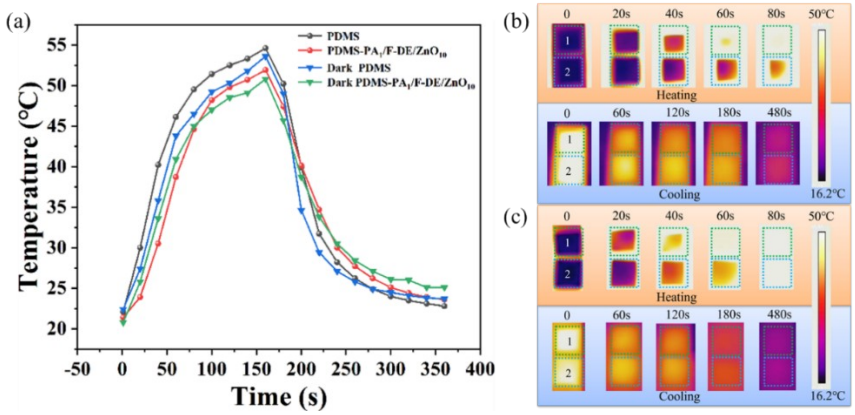

Figure S7 The temperature changes of PDMS-PA_1/F-DE/ZnO_{10} film and PDMS film surface during heating and cooling with time (a) and thermal infrared images in the light (b) and dark (c).

To compare the influence of light on the temperature of PDMS-PA_1/F-DE/ZnO_{10}, the temperature of films under dark condition was also tested (Figure S7). The results demonstrated that light has little effect on the surface temperature of the PDMS-PA_1/F-DE/ZnO_{10}. The temperature change of PDMS-PA_1/F-DE/ZnO_{10} film mainly depends on the properties of PA_1/F-DE/ZnO_{10}.

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