Supplementary Information

Multi-Gradient Energy-Saving Smart Window with Thermochromism and Multimodal Thermal Energy Storage

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Experimental Section

Preparation of Samples for Indoor and Outdoor Thermal Tests

Preparation of MGES smart window and large smart window samples pour the high-concentration liquid directly into the prepared simple glass box with 1 mm space to form a 1-mm high-concentration liquid sample and then seal it with silica gel. The size of all samples was 20 cm × 20 cm. Similarly, the hydrogel and DI water were poured directly into the prepared glass boxes (20 cm × 20 cm) with 10-mm reserved space to

form a 10-mm water sample and a 10-mm liquid sample, respectively. The glass box was then sealed with silicone gel.

Indoor Thermal Test

Through this test, it provides an accurate assessment of the effectiveness of thermoresponsive hydrogel. The ambient temperature of the indoor lighting test is 25 ℃. The indoor test glass box is made of a glass box, five pieces of polystyrene foam plastic with a thickness of 5 cm and a black inner surface, and different samples. The thermocouple is used to detect the temperature of two different parts in the glass box: the inner surface of the window (temperature sensor A) and the air temperature in the geometric center of the glass box (temperature sensor B). Measure the size of the glass box (20 cm × 20 cm × 30 cm), cut the polystyrene foam, and use it to align the side and back. The solar lamp with a power of 250W used in the experiment was placed 22 cm away from the front of the glass box. The area between the lamp and the glass box is connected with aluminum foil to prevent heat loss.

Outdoor thermal test

The purpose of the outdoor test is to compare the energy-saving performance of normal glass plates, 1-mm MGES smart window, 10-mm deionized water, and 10-mm MGES smart window samples under the real environment of temperature fluctuation. A box with a glass panel (20 cm × 20 cm × 5 mm) on the top (internal size: 20 cm × 20 cm × 30 cm) was set as a control sample with a thermocouple sensor in the geometric center. The top glass plate was replaced with 1mm thick liquid, 10-mm deionized water, and 10-mm liquid respectively. For outdoor demonstration at high

temperatures, the four devices were placed outdoors without any shelter and were exposed to direct sunlight.

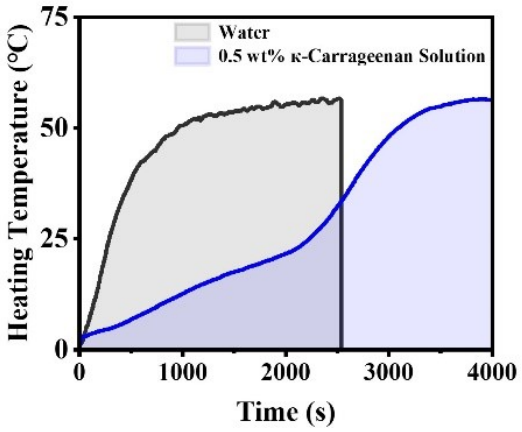

Fig S1. The comparison of heating temperature curves of water and 0.5 wt% κ-Carrageenan solution.

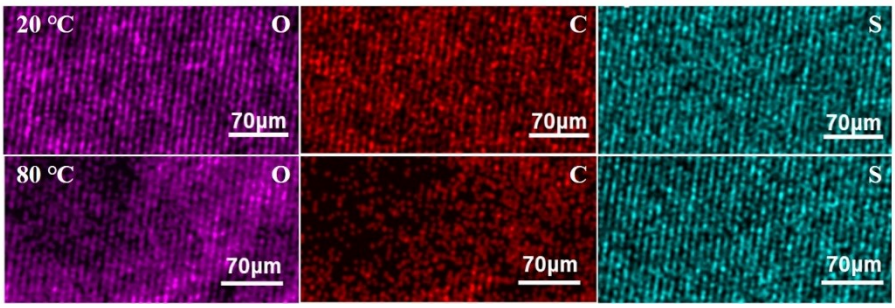

Fig S2. Elemental mapping images of thermoresponsive hydrogel at 20 ℃ and 80 ℃.

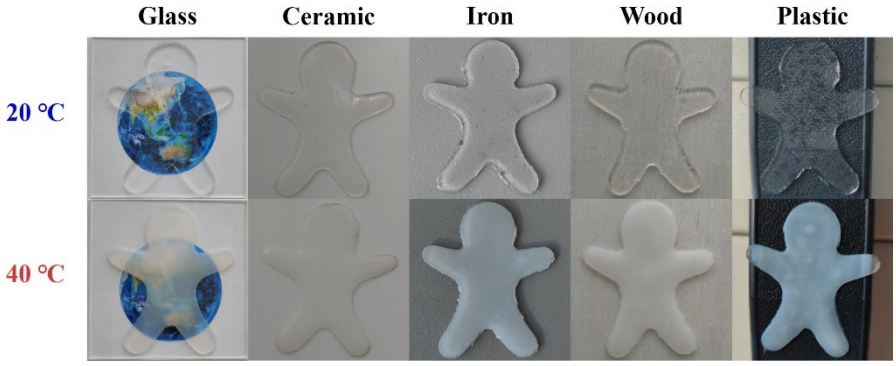

Fig S3. Optical images of thermoresponsive hydrogel patterns on surfaces of different materials at 20 and 40 ℃.

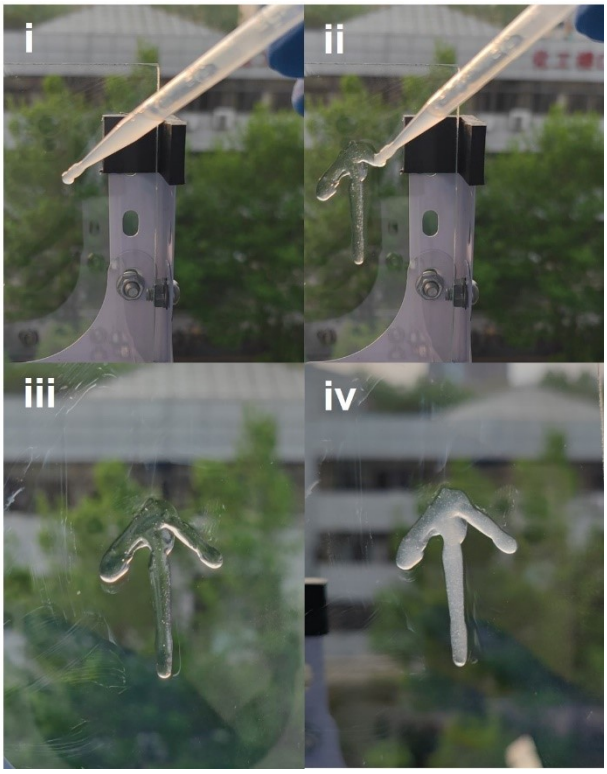

Fig S4. i,ii) Optical images of drawing pattern on glass with a dropper at room temperature. There is liquid thermoresponsive hydrogel at 40 ℃ in the dropper. iii) Thermoresponsive hydrogel arrow pattern. iv) Thermoresponsive hydrogel arrow pattern with long irradiation time.

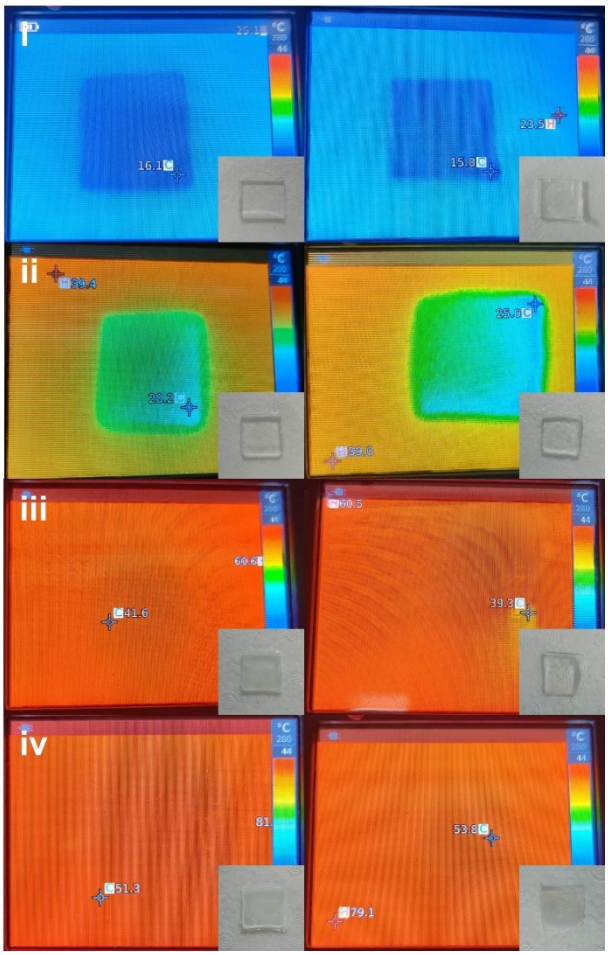

Fig S5. Optical image and infrared thermal image of C2H1N1 (left) and C2H1N3 (right) during heating process.

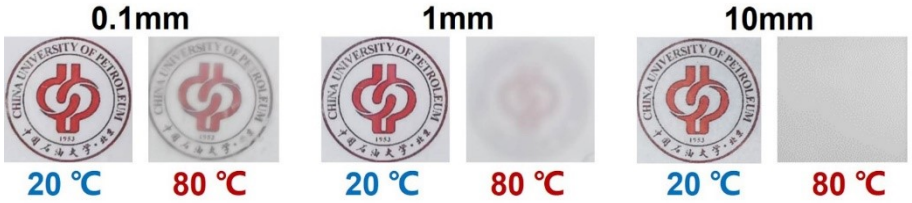

Fig S6. Optical images of thermoresponsive hydrogel with thickness of 0.1mm, 1 mm, 10 mm.

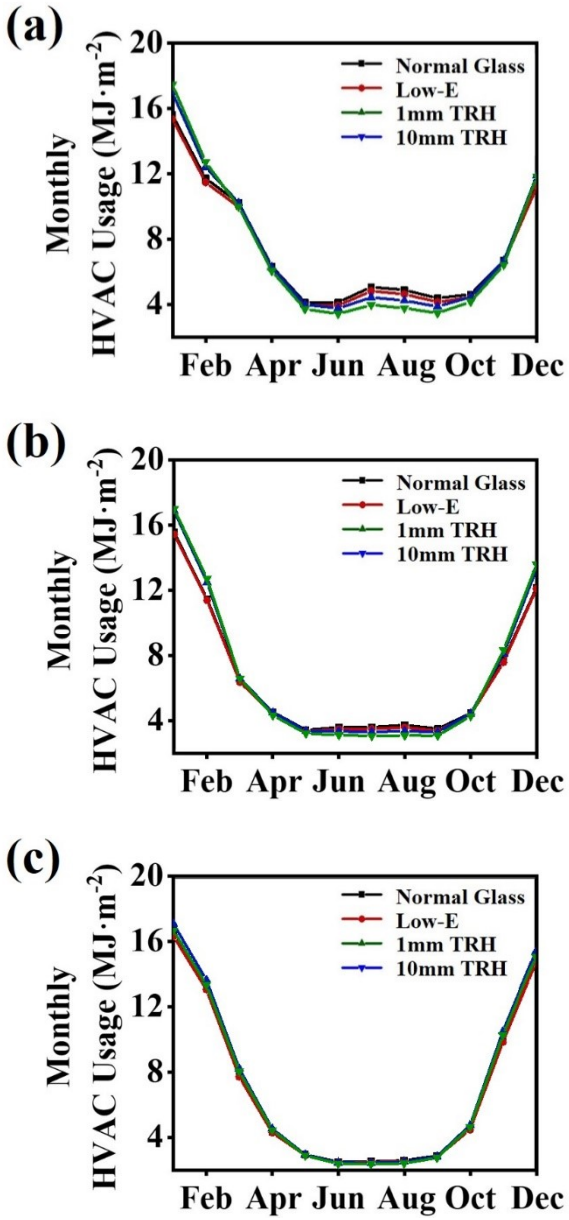

Fig S7. Monthly HVAC energy consumption of four types of windows in Shanghai (a), Beijing (b), and Harbin (c).