Robust Janus fibrous membrane with switchable infrared radiation properties for potential building thermal management application

Xuejie Yue [a], Tao Zhang [a*], Dongya Yang [a], Fengxian Qiu [a*], Gengyao Wei [a], Yuanfei Lv[b]

[a] School of Chemistry and Chemical Engineering, Jiangsu University, Zhenjiang 212013, Jiangsu Province, China.

[b] School of Environmental and Chemical Engineering, Hebei Key Laboratory of Applied Chemistry, Yanshan University, Qinhuangdao 066000, Hebei Province, China

*Corresponding authors:

Tel./fax: +86 511 88791800.

E-mail: zhangtaochem@163.com (T. zhang);

fxqiu@ujs.edu.cn (F. Qiu)

Experimental Section

Preparation of ZnO/cellulose membrane

Large scale syntheses of ZnO/cellulose membrane was prepared according to the previous study.[1] Typically, 10 mmol of zinc acetate dihydrate solution was prepared by dissolving into 100 mL of isopropyl alcohol at 80 ^{o}C for 15 min. After this time, 0.14 mL of triethylamine was slowly added to the stirred solution at 85 ^{o}C for 10 min, and the ZnO seed solution was obtained. Then, the filter paper was immersed in the ZnO seed solution for 3 min, followed by drying in an oven at 80 ^{o}C for 10 min. Then obtained ZnO-seed fiber paper was immersed in 70 mL of the growth solution, which is the mixture solution of zinc acetate (5.0 mM) and triethylamine (5.0 mM), cured at 90 °C for 9 h in an oven. The ZnO nanorods array-coated cellulose membrane was rinsed by the water and dried at 60 ^{o}C for 5 h.

Preparation of ultralong MnO_2 nanowires

The ultralong MnO_2 nanowires were obtained by a hydrothermal route. Typically, 6.65 g of K_2SO_4, 20.5 g of $K_2S_2O_8$, and 6.5 g of $MnSO_4 \cdot H_2O$ were dissolved in 160 mL of water. The mixture solution was transferred into a Teflon-lined stainless-steel autoclave. The autoclave was then kept at 250 °C for 60 h in an oven and then cooled to room temperature. The obtained ultralong MnO_2 nanowires was thoroughly washed using the deionized water to remove the residual salt. 1 g of the obtained samples was then dispersed in 500 mL of water under stirring for 18 h, and the ultralong MnO_2 nanowires suspension was obtained.

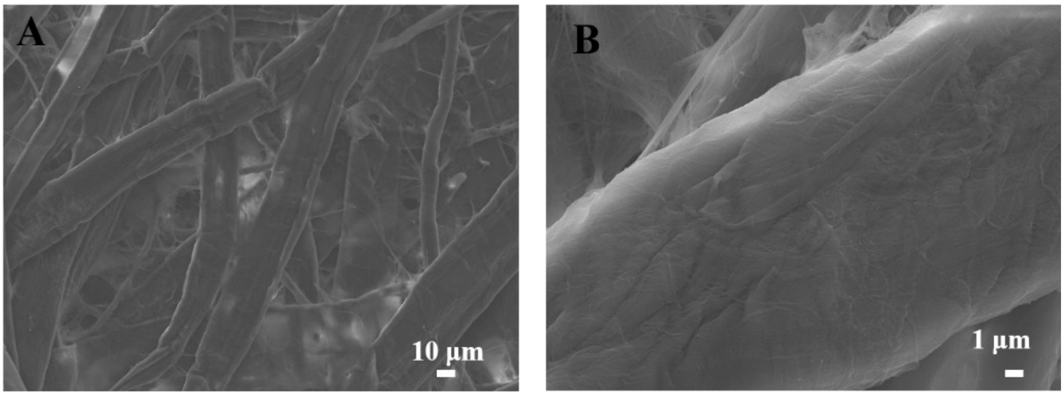

Figure S1. SEM images of cellulose fiber membrane with different magnification.

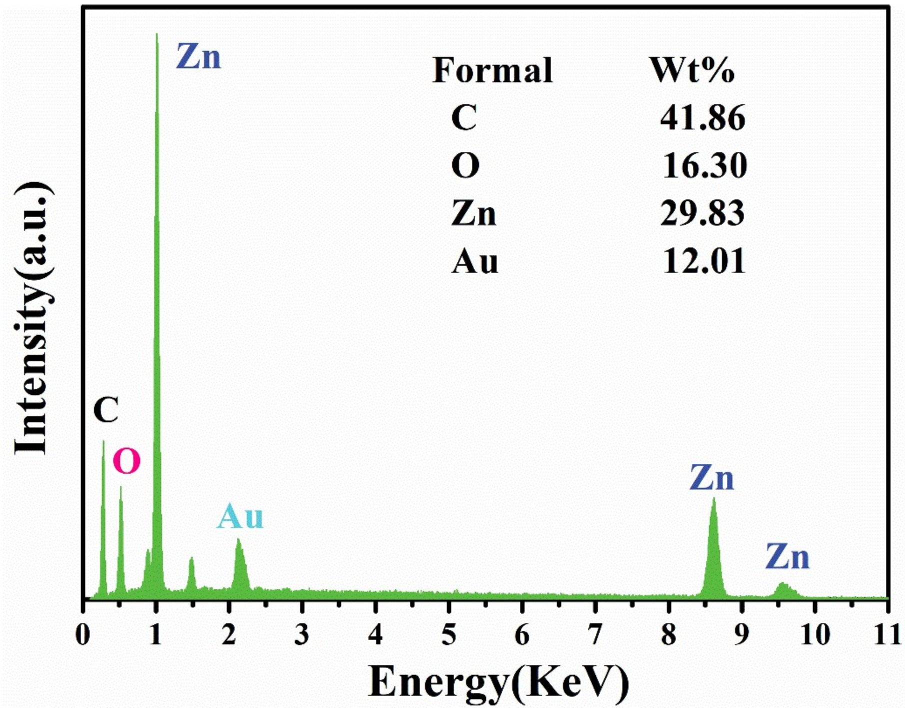

Figure S2. EDS spectrum of the ZnO-NRs@cellulose fiber layer.

In order to evaluate the interfacial compatibility between ZnO@cellulose fibers and MnO_2-NWs, the formation mechanism of MnO_2-NWs layer on ZnO@cellulose fibers layer with depositing time was investigated by tuning MnO_2-NWs loading. With a low MnO_2-NWs loading, several nanowires were closely attached to the ZnO@cellulose fibers surface (Figure S3A). When more MnO_2-NWs loads on the ZnO@cellulose fibers layer surface, more MnO_2-NWs are entangled with ZnO@cellulose fibers and the MnO_2-NWs tend to entangle with each other (Figure S3B and C). With the continuing increase of MnO_2-NWs loading, MnO_2-NWs self-assemble into an interpenetrating network structure, covering with the ZnO@cellulose fibers layer (Figure S3D).

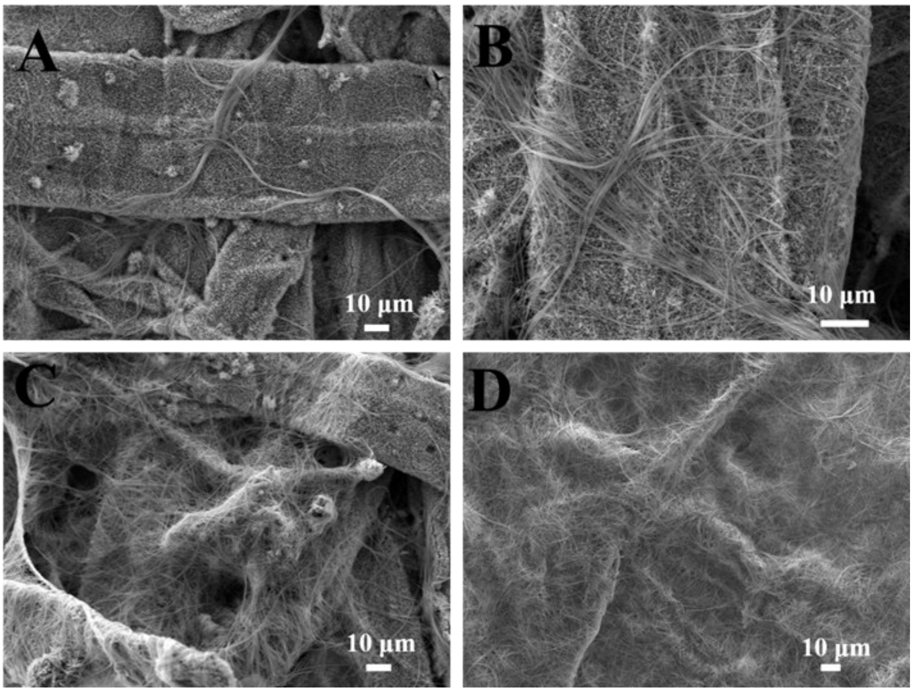

Figure S3. The SEM images for evaluating the compatibility mechanism between ZnO-NRs@cellulose fibers and the MnO_2 nanowires layer with different loading.

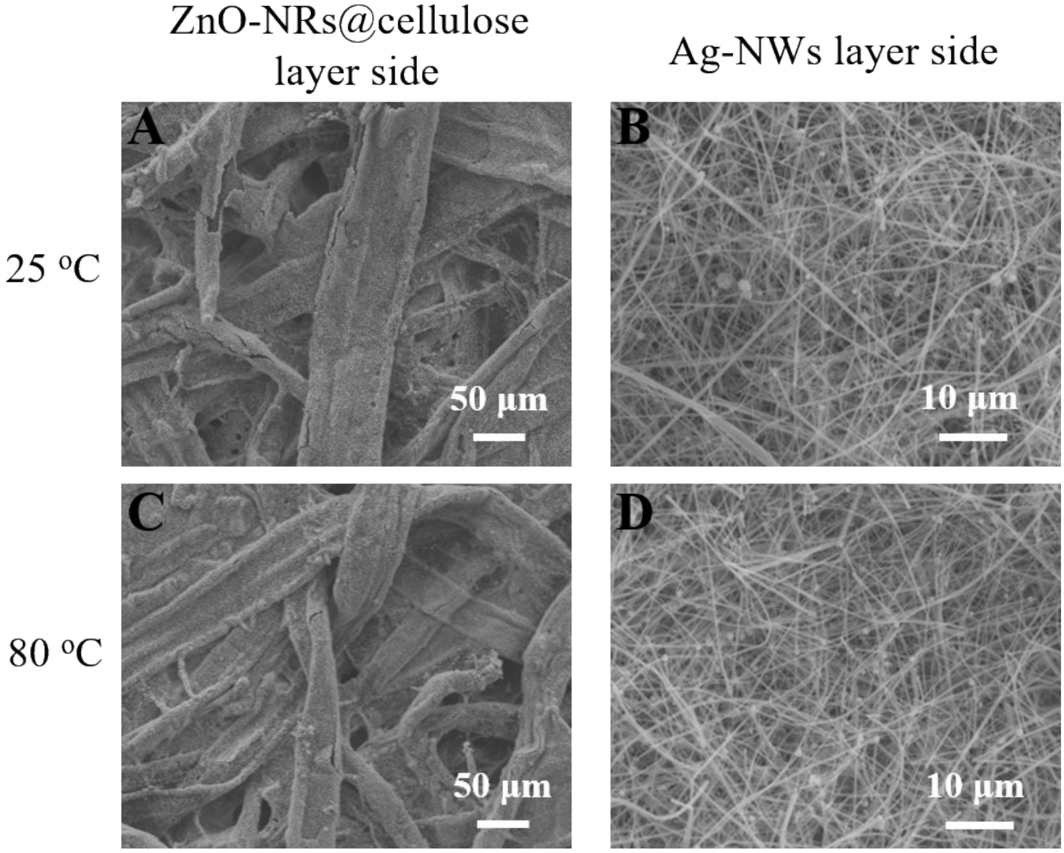

Figure S4. The SEM images of the Janus membrane after soaking in water with different temperatures.

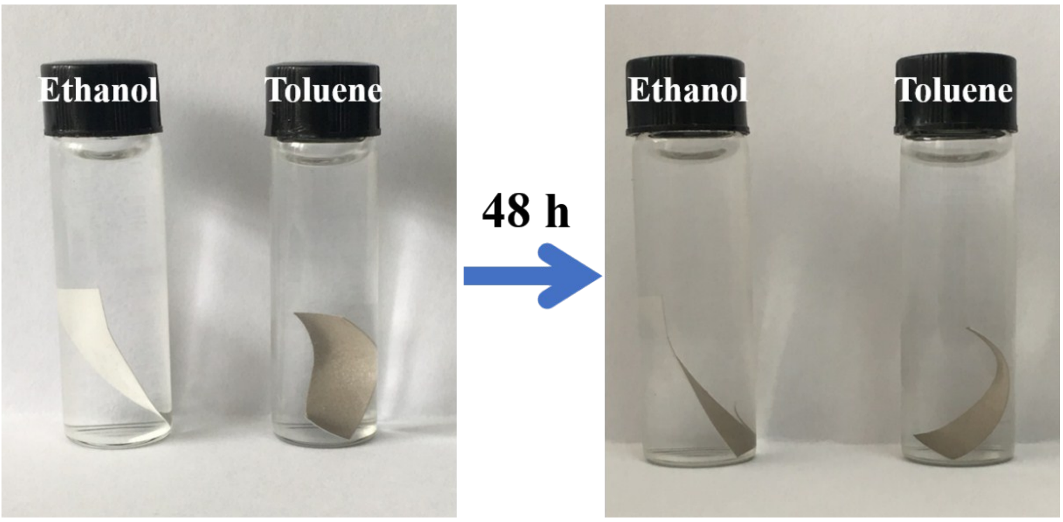

Figure S5. Optical photos of the Janus ZNCMA membrane before and after soaking in ethanol and toluene, respectively.

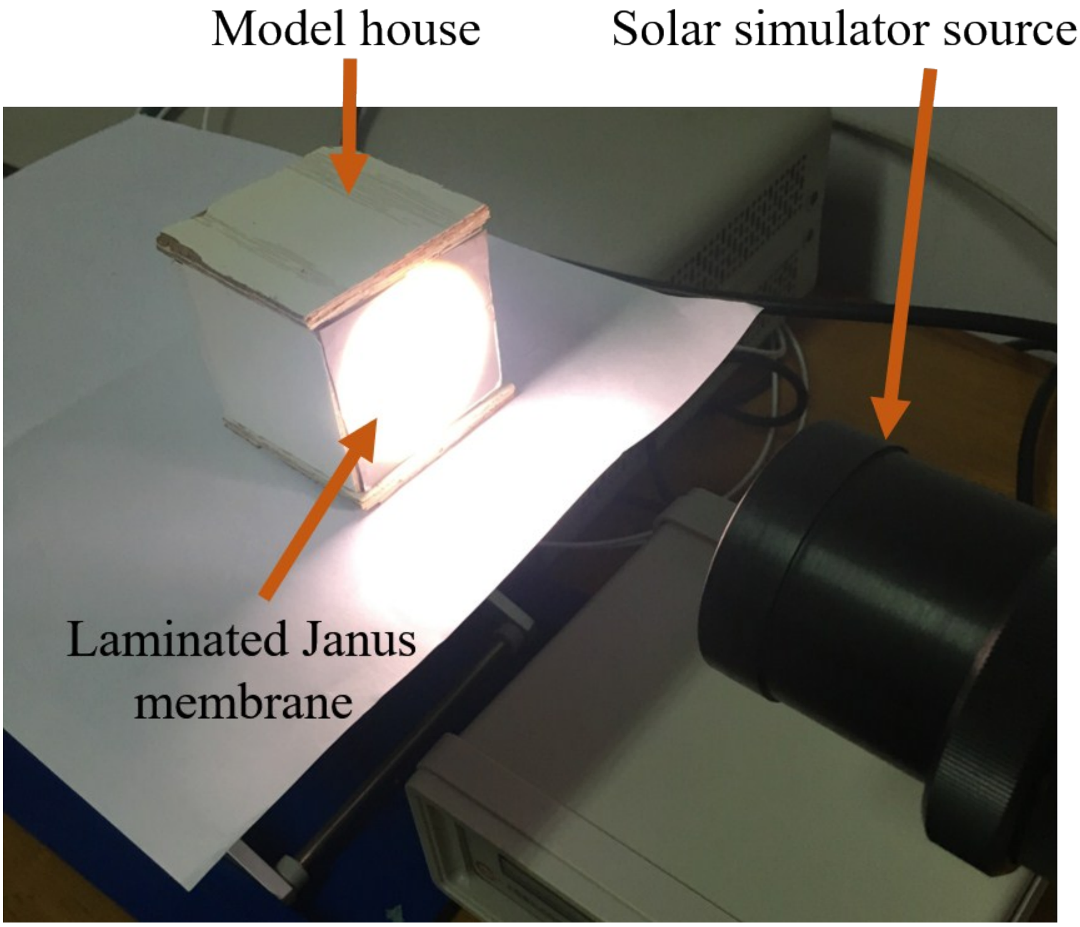

Figure S6. Photo of the thermal measurement setup.

Reference

1. X. Yue, T. Zhang, D. Yang, F. Qiu and Z. Li, *Cellul.*, 2018, **25**, 5951-5965.