

## Supplementary information

The abrasion resistance experiment:

Firstly, we cut the PP-PPy film and PP-PPy-pHR film to  $1.5 * 3.0 \text{ cm}^2$ , weigh them, and record the initial mass  $m_0$ . Next, we will fix the white substrate on the table. Place the fixed size film on the surface of the white substrate. Then, place a 100 g ( $\approx 1\text{N}$ ) weight on the surface of the membrane.

At last, we clamp the end of the membrane with tweezers and pull, with a length of 6.5 centimeters. Repeat the above operation, and the membrane will be rubbed 20 times. Repeat the above procedure for 20 times, weigh and record the mass loss.

Table S1. Comparison of PP-PPy<sub>2</sub> and PP-PPy<sub>1</sub>-pHR, PP-PPy<sub>2</sub>-pHR, and PP-PPy<sub>3</sub>-pHR on water evaporation rate

Membrane	PP-PPy <sub>2</sub>	PP-PPy <sub>1</sub> -pHR	PP-PPy <sub>2</sub> -pHR	PP-PPy <sub>3</sub> -pHR
Evaporation Rate ( $\text{kg}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ )	1.61	0.72	1.58	1.05



Figure S1: Pictures of ambient temperature and humidity of water evaporation experiments in March 2024

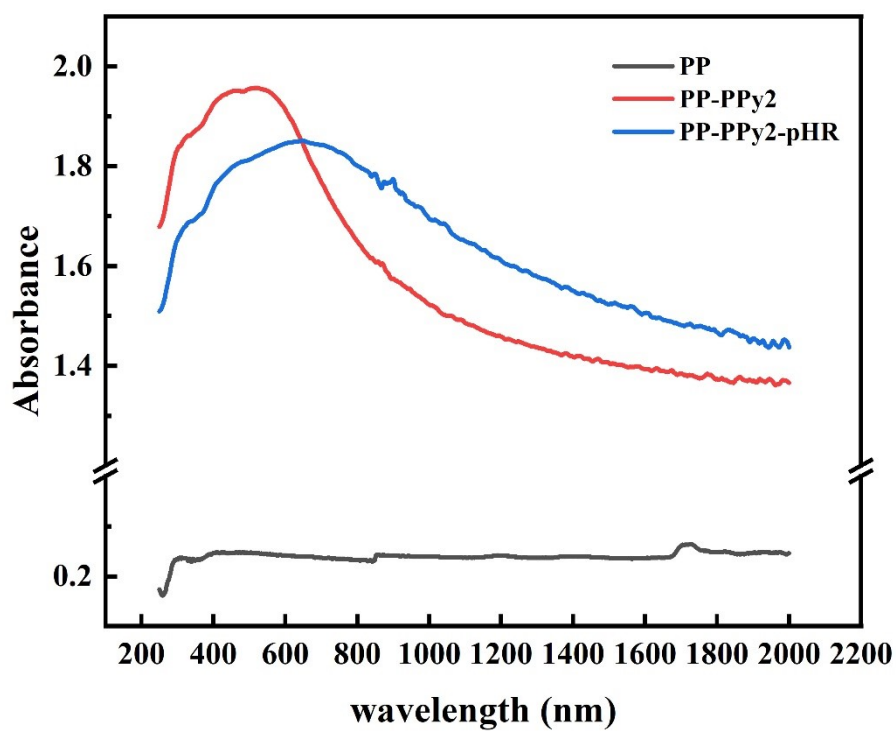


Figure S2: Absorbance test of PP, PP-PPy2, PP-PPy2-pHR