# Supporting Information

## A Bioinspired Antibacterial and Photothermal Membrane for Stable and Durable Clean Water Remediation

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### Experimental Section

*Materials*: Dopamine hydrochloride (98%) was acquired from J & K Scientific Ltd. (Beijing, China). Tobramycin (95%) was purchased from Dalian Meilun Biotech. Ltd. (Dalian, China). Both ammonia solution (28−30%) and ethanol were obtained from Kelon Chemical Reagent Factory (Chengdu, China). The cellulose acetate (CA) membrane was supplied by Titan Technology Co. Ltd. (Shanghai, China). *E. coli* and *S. aureus* came from American type culture collection. All chemicals were directly used without further purification steps. Deionized water was used throughout the study.

*Preparation of PDA-i (i=0-3)*: 45 mL of deionized water was used to dissolve 200 mg of dopamine hydrochloride, which was followed by the addition of 15 mL of ethanol and 0.25 mL of ammonia solution ($NH_4OH$, 28-30%) into the reaction solution. After 12 h of reaction under magnetic stirring, the PDA-0 sample was obtained by centrifuging the reaction solution and using deionized water to wash it three times. For the preparation of TOB-doped PDA NPs, different amounts of TOB were added to the dopamine hydrochloride aqueous solution, according to the recipes in Figure S1. Afterwards, the ethanol solution and ammonia solution were added, and the reaction was carried out for 12 h to obtain PDA-i (i=1-3) samples.

*Preparation of PDA-0@CA and PDA-1@CA membrane*: The as-prepared PDA-0 and PDA-1 NPs were employed to prepare the corresponding aqueous solutions (5 mg $mL^{-1}$, 4 mL), which were further deposited onto the CA membrane by suction filtration to render them hydrophilicity and light absorption performance.

*Characterization*: SEM of FEI Quanta 250 was used to observe the morphologies of the NPs and coatings. The XPS of PDA-i (i=0-3) samples were obtained from a VG ESCALAB MKII spectrometer with Al Kα radiation. The ESI-MS spectrum was analysed by an Agilent QTOF6550 using positive ion mode electrospray ionization. Cyclic Voltammetry (CV) measurements were collected on a CHI760E electrochemical workstation in acetonitrile solution with 0.1 M tetrabutylammonium hexafluorophosphate ($Bu_4NPF_6$). The working electrode was indium tin oxide coated with NPs, the counter electrode was a Pt wire, and the reference electrode was Ag/AgCl. Water contact angles with 4 μL of the water drop were obtained by a Data-Physics OCA 25. An IR camera (FLIR, T460) was used to collect all IR photographs. An inductively coupled plasma optical emission spectrometer (ICP-OES, IRIS Adv) was used to evaluate the contents of different metal ions in water.

*Calculation of TOB doping ratio*: The TOB doping ratio in different samples could be determined by C/O ratio. Here is how to calculate this value (Eq. 1):

$$N_{DA} \times (1 - x) + N_{TOB} \times x = N_m \quad (1)$$

where $x$ is the content of TOB, $N_{PDA}$ is C/O ratio of DA ($C_8HNO_2$), and its value is 4, $N_{TOB}$ is C/O ratio of TOB ($C_{18}H_{37}N_5O_9$), and its value is 2. $N_m$ is the C/O ratio from measurement.

*Theoretical Calculation*: The energy levels of the molecular orbits could be obtained by Gaussian09 package.[60]

*Evaluation of photothermal performance*: PDA-i (i=1-3), 1 mL of 100 μg/mL NPs aqueous solution was irradiated under an 808 nm laser for 10 min (1.5 W $cm^{-2}$), and then cooled naturally. During the whole process, the temperature at 10 s intervals was recorded using a digital thermometer.

*Calculation of photothermal efficiency*: The photothermal conversion efficiency ($\eta$) of PDA-i (i=0-3) NPs was able to be calculated with Eq. 2:

$$\eta = \frac{hA\Delta T_{max} - Q_s}{I(1 - 10^{-A_\lambda})} \quad (2)$$

where $\Delta T_{max}$ is the maximum temperature of the solution, $Q_s$ is the heat associated with water (could be ignored), $I$ is the intensity, and $A_\lambda$ is the absorbance of the solution at 808 nm. $hA$ could be acquired by the following Eq. 3：

$$\tau_s = \frac{m_D c_D}{hA} \quad (3)$$

where $\tau_s$ is the time constant, $m_D$ is the quality of the solution, and $c_D$ is the heat capacity of the aqueous solution. The total photothermal conversion efficiency could be obtained from Eq. 3 and Eq. 4:

$$\eta^* = \eta\,(1 - 10^{-A_\lambda}) \quad (4)$$

*In vitro release of TOB*: 80 mL of PBS buffer with various pH was added into the glass bottle containing the PDA-i (i=1-3) aqueous solution. The glass bottle was

incubated at 37 °C, and then 1 mL of the samples were acquired every 1 h. To calculate the cumulative drug release ratio, the PDA-i sample treated with buffer (pH=2) was considered as 100% cumulative drug release. By using the same steps, the drug release at 45 °C was investigated. The release of TOB could be studied by a ninhydrin derivatization instrument. Before measurement, the derivatization reagent was obtained real-timely by adding 340 mg of ninhydrin and 60 mg of reduced ninhydrin to 40 mL of ethylene glycol methyl ether. The 500 μL of sample solution was mixed well with 500 μL of acetic acid-sodium acetate buffer (pH=5.4) and 500 μL of prepared derivatization reagent. The mixed solution was heated to 100 °C for 10-15 min. With the release of TOB, the colour of the solution transformed from transparent and colourless to blue-purple. Then recording the absorbance of different samples at 570 nm to analyse the release amount of TOB. Each sample was measured three 3 times.

*Zone of Inhibition (ZOI) Assessment*: 100 μL of the bacteria solution ($10^5$ CFU/mL) was added onto the agar medium and spread evenly. The membranes with a diameter of 1 cm were placed on the medium. After incubating at 37 °C for 12 h, the antibacterial activity of different sample membranes was assessed by noticing the clear area around the membrane on the agar surface.

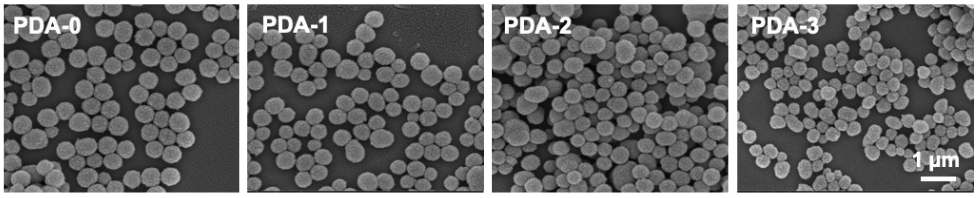
*Water Evaporation Experiments*: A hydrophilic light absorber was formed by depositing PDA-1 aqueous solution (5 mg $mL^{-1}$, 4 mL) on the CA membrane. To reduce the loss of heat transfer, a polystyrene (PS) foam was selected as heat insulation to help confine the heat at the interface. By gathering the condensed

water when illuminated, clean water could be collected. A FLIR T460 infrared camera was used to collect the infrared photographs. An OHAUS, CP313 electrical balance was utilized to measure the weight loss, and the corresponding evaporation rate and efficiency could be obtained.

**(a)**

| Samples | PDA (mg) | TOB (mg) | $C_2H_5OH$ (mL) | $H_2O$ (mL) | $NH_3 \cdot H_2O$ (mL) |
|---|---|---|---|---|---|
| PDA-0 | 200 | 0 | 45 | 15 | 0.25 |
| PDA-1 | 140 | 60 | 45 | 15 | 0.25 |
| PDA-2 | 100 | 100 | 45 | 15 | 0.25 |
| PDA-3 | 60 | 140 | 45 | 15 | 0.25 |

**(b)**




**(c)**

| Samples | Size $_{SEM}$ (nm) | Size $_{DLS}$ (nm) | PDI | Zeta (mV) | Yield (%) |
|---|---|---|---|---|---|
| PDA-0 | 539±18 | 571 | 0.168 | -28.2 | 22.4 |
| PDA-1 | 461±21 | 507 | 0.182 | -32.7 | 28.8 |
| PDA-2 | 374±24 | 426 | 0.250 | -32.8 | 19.2 |
| PDA-3 | 325±16 | 378 | 0.360 | -36.1 | 11.5 |

**(d)**

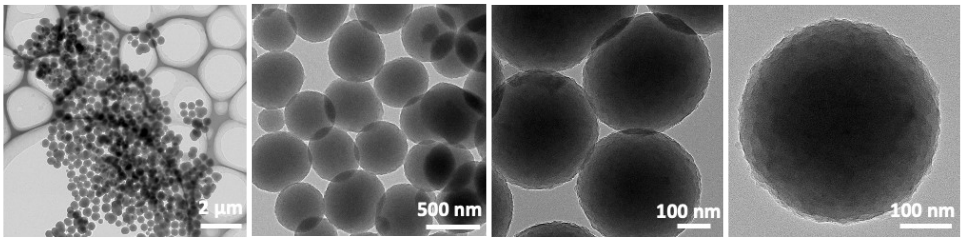



**Figure S1.** (a) Experimental recipes of PDA-i (i= 0-3) fabrication. (b) Representative SEM images of PDA-i (i = 0-3) samples. (c) Summary of physical parameters of PDA-i (i= 0-3). (d) Representative TEM images of PDA-1 NPs.

(a)

| Samples | Atomic Percentages | | | O/C | N/C |
|---|---|---|---|---|---|
| | C 1s (%) | N 1s (%) | O 1s (%) | | |
| PDA-0 | 74.14 | 8.76 | 17.1 | 0.25 | 0.125 |
| PDA-1 | 71.19 | 9.82 | 18.99 | 0.267 | 0.138 |
| PDA-2 | 68.74 | 10.33 | 21.2 | 0.308 | 0.150 |
| PDA-3 | 67.22 | 10.5 | 22.28 | 0.331 | 0.156 |

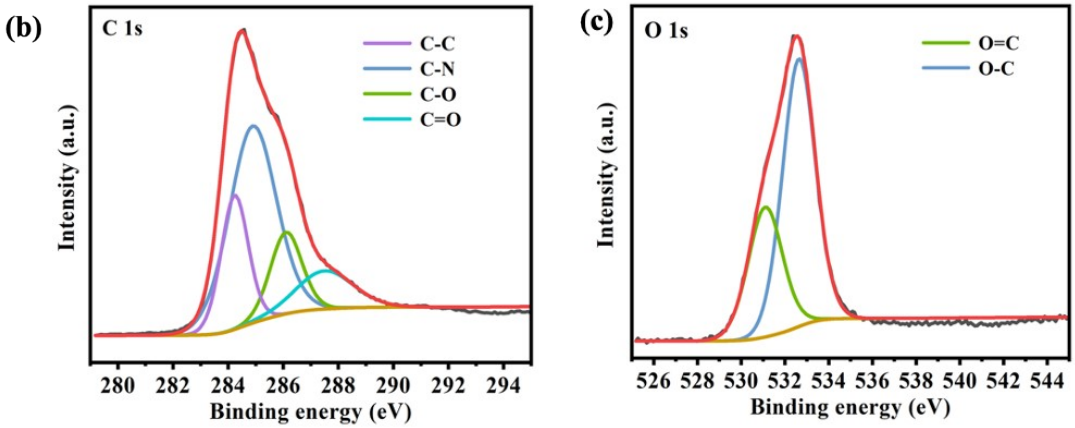



**Figure S2.** (a) Elemental composition of PDA-i (i=0-3) NPs. High-resolution XPS spectrum of (b) C 1s and (c) O 1s regions for PDA-1 NPs. The red line was the global envelope used to fit the spectra.

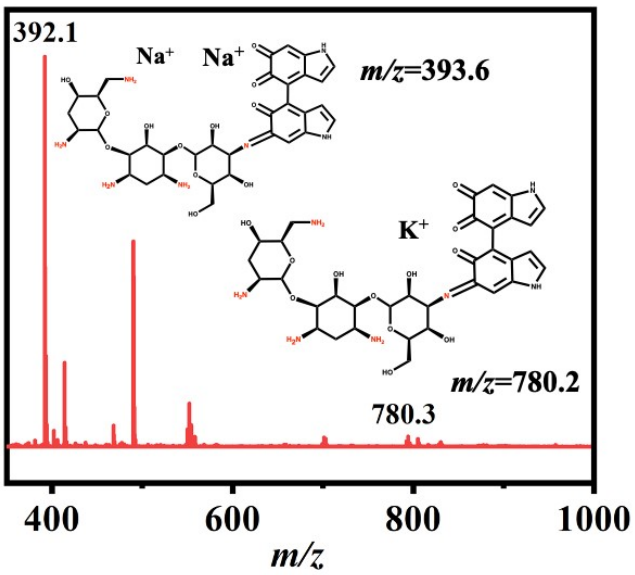



**Figure S3.** ESI-MS spectrum of crude solution and possible oligomeric structures assigned to main peak.

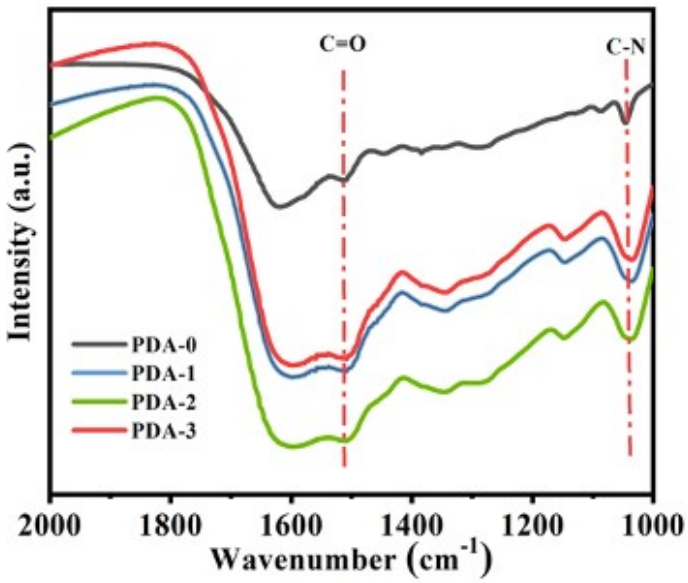



**Figure S4.** FTIR spectra of PDA-i (i=0-3).

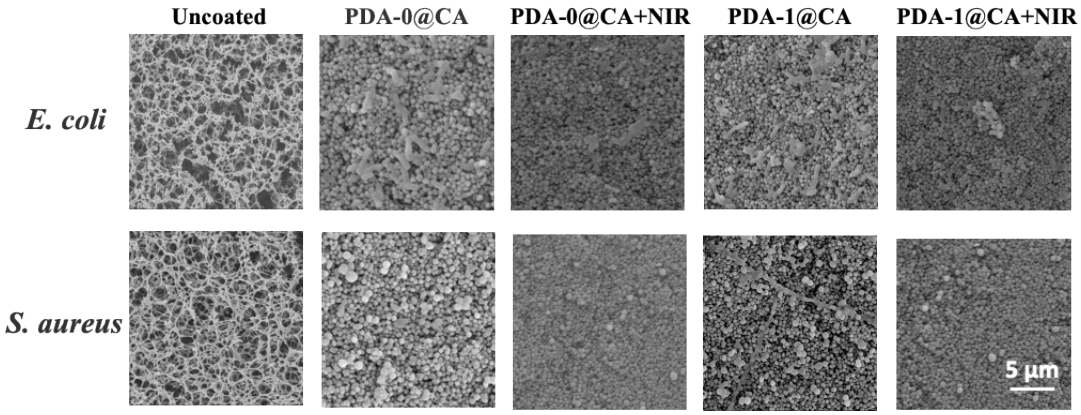



**Figure S5.** SEM images of *E. coli* and *S. aureus* treated with uncoated/coated CA membrane.

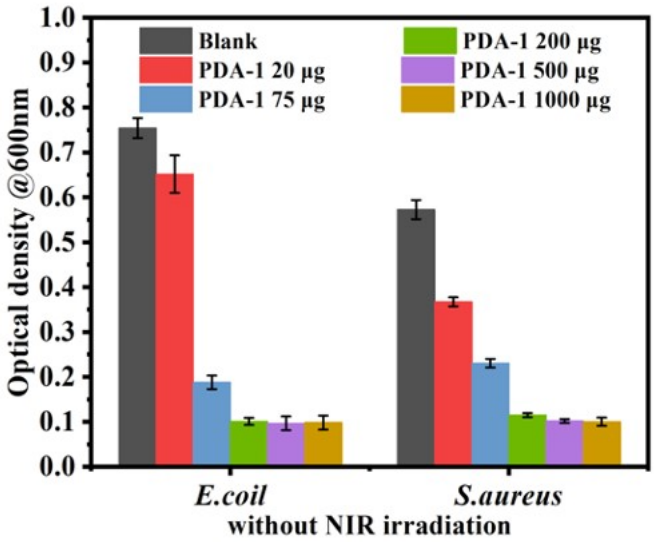



**Figure S6.** Antibacterial activity of PDA-1 NPs of different amount without NIR irradiation against *E. coli* and *S. aureus*.

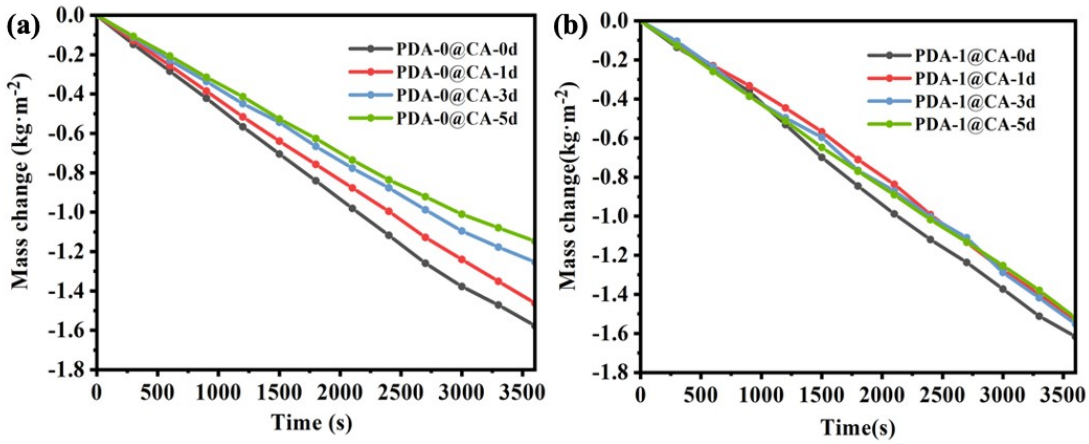



**Figure S7.** Water evaporation performances of (a) PDA-0@CA- and (b) PDA-1@CA (after being soaked in bacterial solution for different days)-based device flotation on the water under 1 sun irradiation.

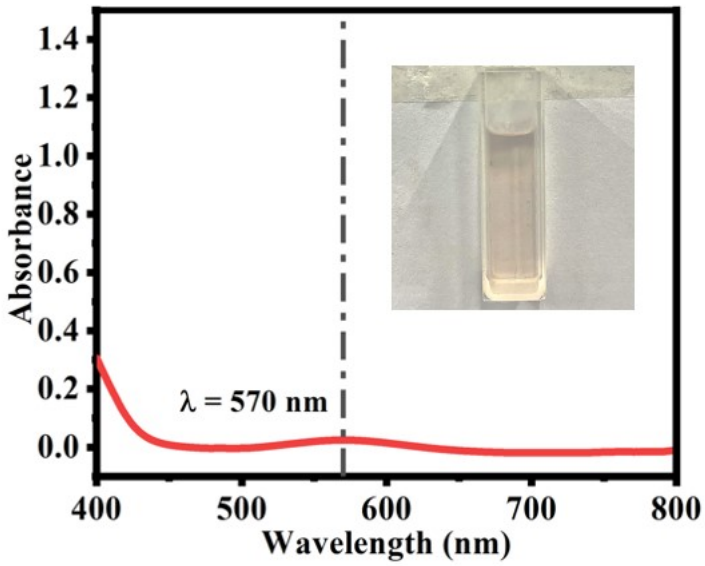



**Figure S8.** The UV-vis absorbance spectrum of purified water treated by the ninhydrin derivatization method. The inset showed the photograph of tested solution sample after ninhydrin treatment.