# Electronic Supplementary Material

## Enhanced permeability and biofouling mitigation of forward osmosis membranes via grafting graphene quantum dots

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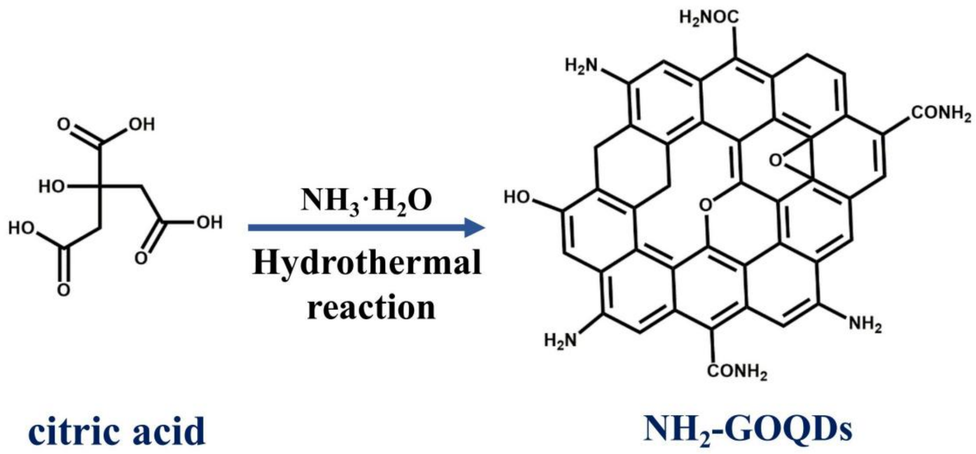


**Fig. S1.** Schematic diagram for synthesis of $NH_2$-GOQDs.

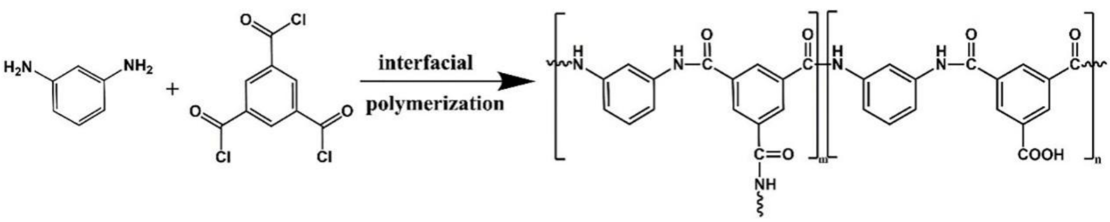


**Fig. S2.** Schematic diagram of the formation of the active layer of membrane by IP reaction between MPD and TMC.

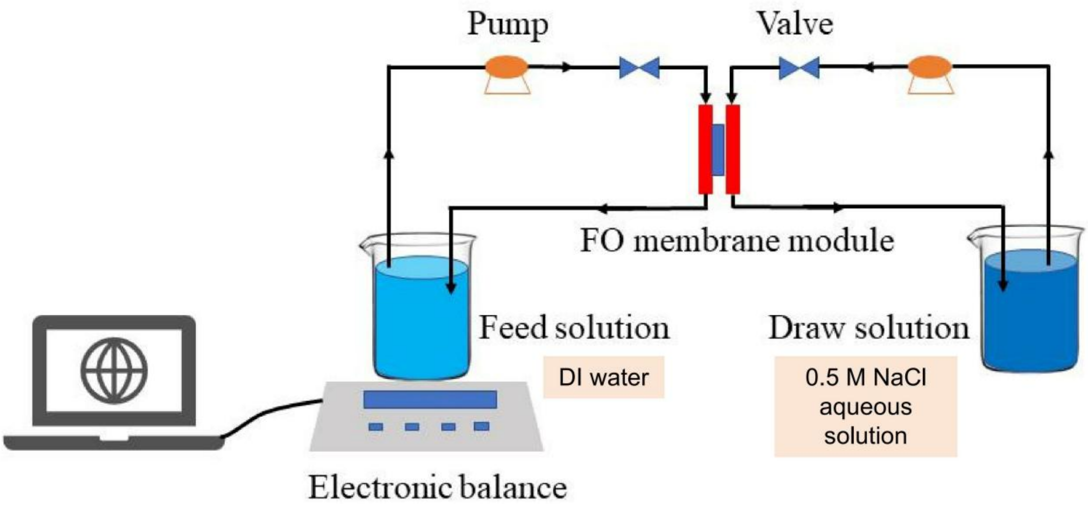


**Fig. S3.** Schematic diagram of the FO membrane operation device.

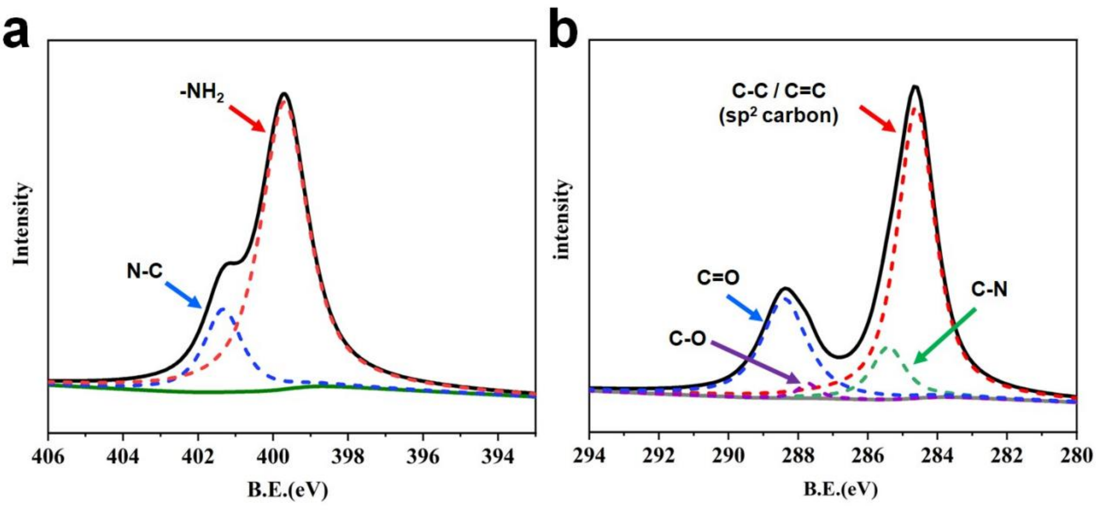


**Fig. S4.** High -resolution XPS spectra of (a) N 1s and (b) C 1s of $NH_2$-GOQDs.

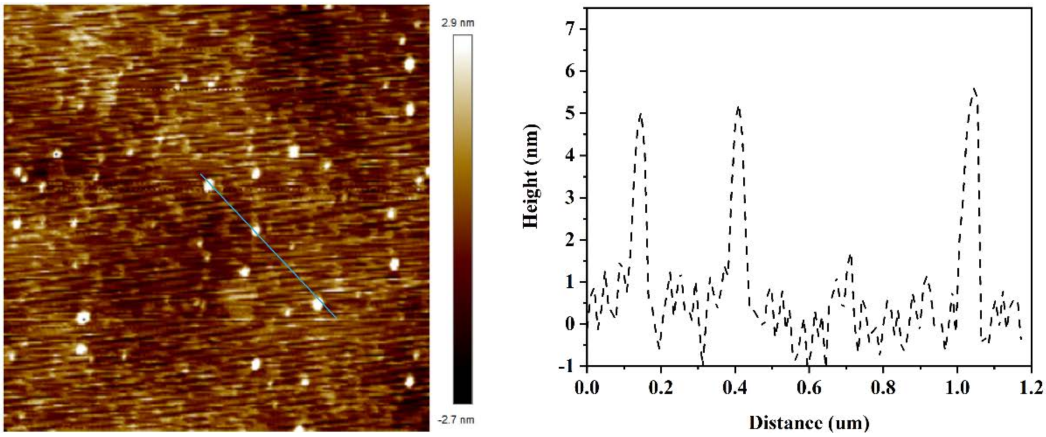


**Fig. S5.** (a) AFM image of the $NH_2$-GOQDs, (b) The height of $NH_2$-GOQDs on the white line.

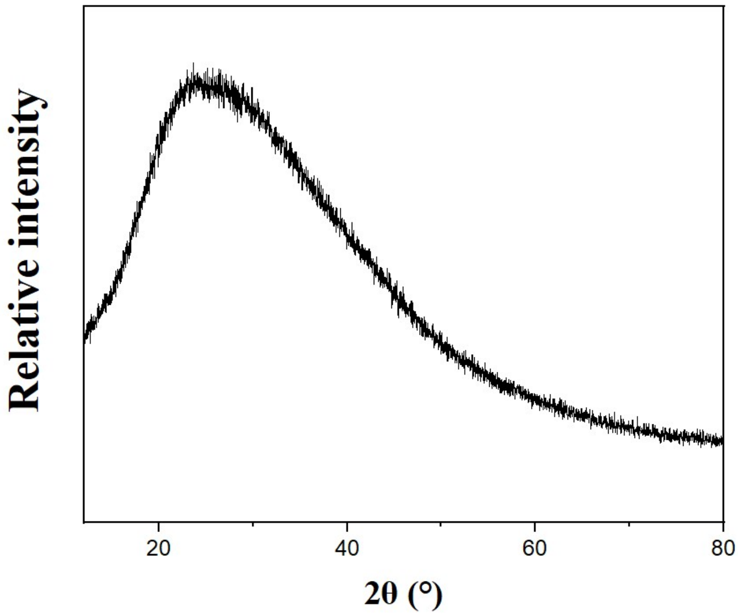


**Fig. S6.** XRD pattern of $NH_2$-GOQDs.

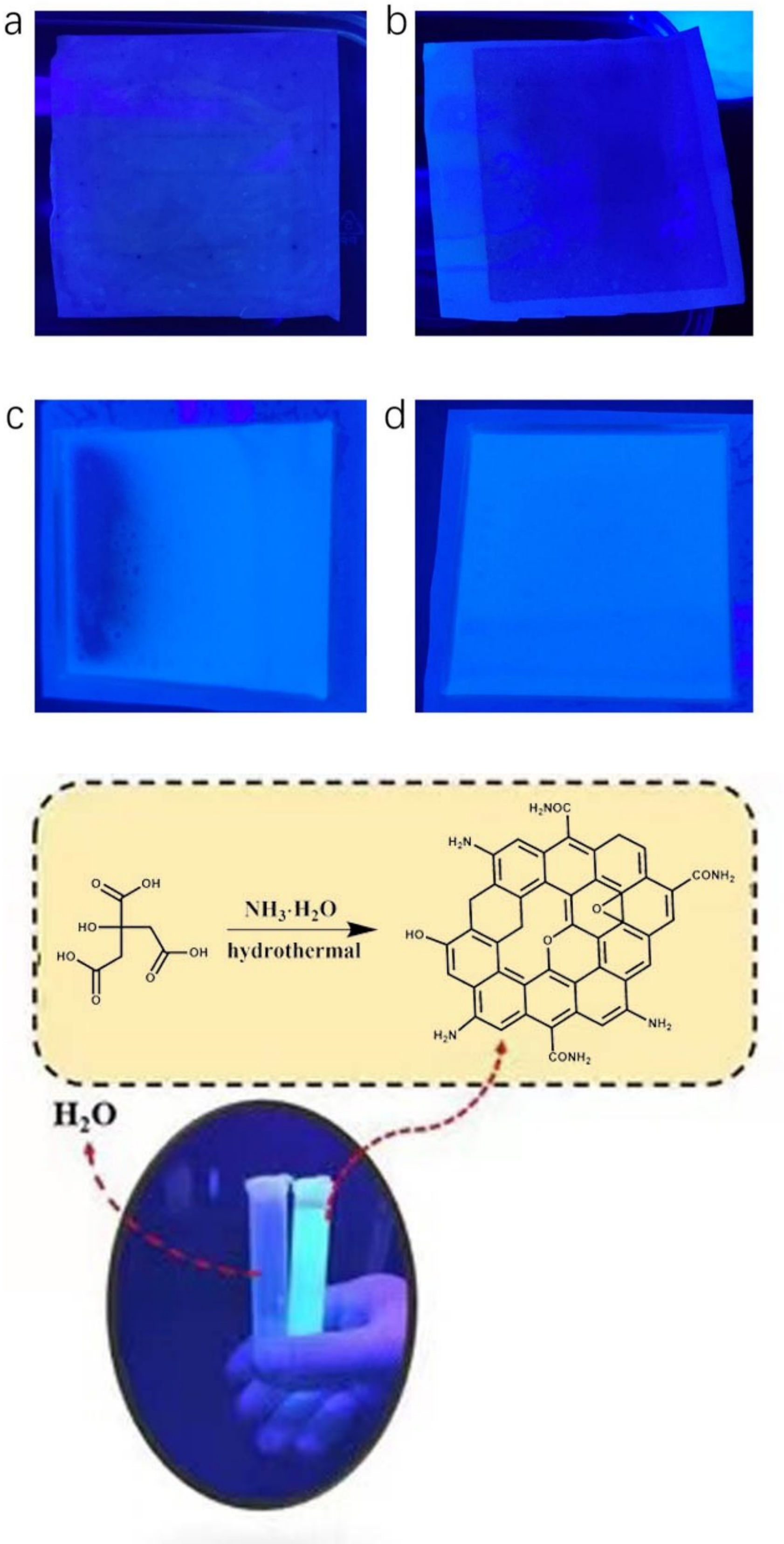


**Fig. S7.** Fluorescence reaction diagram of (a) TFC membrane (b) TFC-50 (c)TFC-100 (d) TFC-150.

**Table S1** Liquid surface energy parameters.

| liquid | $\gamma^{LW}$ (mJ/m$^2$) | $\gamma^+$ (mJ/m$^2$) | $\gamma^-$ (mJ/m$^2$) | $\gamma^{TOT}$ (mJ/m$^2$) |
|---|---|---|---|---|
| water | 21.8 | 25.5 | 25.5 | 72.8 |
| glycerin | 34.0 | 3.9 | 57.4 | 64.0 |
| diiodomethane | 50.8 | 0 | 0 | 50.8 |

**Table S2** XDLVO theoretical parameters[1].

| parameter | $y_0$ | $\lambda$ | $\varepsilon_0\varepsilon_r$ | $\kappa$ |
|---|---|---|---|---|
| value | 0.158 nm | 0.6 nm | $6.95\times10^{-10}$ C $^2$·J $^{-1}$·m$^{-1}$ | 0.104 nm$^{-1}$ |

**Table S3** Theoretical parameters, zeta potential, surface tension parameters, and cohesive free energy of foulant.

| sample | pH | $a_f$ (nm) | Zeta potential (mV) | $\gamma^{LW}$ (mJ/m$^2$) | $\gamma^+$ (mJ/m$^2$) | $\gamma^-$ (mJ/m$^2$) | $\gamma^{AB}$ (mJ/m$^2$) | $\gamma^{TOT}$ (mJ/m$^2$) |
|---|---|---|---|---|---|---|---|---|
| E. coli | 7.4 | 660 | -3.7 | 36.3 | 0.2 | 64.4 | 7.2 | 43.5 |

**Table S4** Contact Angle, zeta potential and surface tension parameters of TFC and TFC-100 membrane.

| sample | $\theta^W$ (°) | $\theta^G$ (°) | $\theta^D$ (°) | Zeta potential (mV) | $\gamma^{LW}$ (mJ/m$^2$) | $\gamma^+$ (mJ/m$^2$) | $\gamma^-$ (mJ/m$^2$) | $\gamma^{AB}$ (mJ/m$^2$) | $\gamma^{TOT}$ (mJ/m$^2$) |
|---|---|---|---|---|---|---|---|---|---|
| TFC | 79.1±2.2 | 63.4±1.8 | 43.1±1.6 | -20 | 37.97 | 2.04 | 0.01 | 0.34 | 38.31 |
| TFC-50 | 33.0±1.1 | 30±1.4 | 25.3±1.5 | -26 | 46.79 | 0.235 | 5.13 | 2.2 | 48.99 |
| TFC-100 | 27.0±1.2 | 65.2±1.5 | 15.6±0.7 | -23 | 48.92 | 0.13 | 13.85 | 2.69 | 51.62 |
| TFC-150 | 40.0±1.2 | 30.2±1.6 | 20.2±1.4 | -22 | 48.94 | 0.453 | 7.30 | 3.64 | 52.58 |

Superscripts W, G, and D represent water, glycerol, and 2 methyl iodide, respectively

**Table S5** Interaction free energy of the minimum equilibrium distance between TFC, TFC-100 membrane and foulant.

| sample | foulant | $\Delta G_{y0}^{LW}$ (mJ/m$^2$) | $\Delta G_{y0}^{AB}$ (mJ/m$^2$) | $\Delta G_{y0}^{EL}$ (mJ/m$^2$) | $\Delta G_{y0}^{TOT}$ (mJ/m$^2$) |
|---|---|---|---|---|---|
| TFC | E. coli | -2.64 | -25.49 | -0.13 | -28.26 |
| TFC-50 | E. coli | -5.89 | 1.55 | $-1.802\times10^{-7}$ | -4.34 |
| TFC-100 | E. coli | -6.291 | 8.965 | $-3.677\times10^{-6}$ | 2.674 |
| TFC-150 | E. coli | -6.31 | 4.45 | $1.299\times10^{-7}$ | -1.86 |

## Reference

[1] T. Lin, Z. Lu, W. Chen, Interaction mechanisms and predictions on membrane fouling in an ultrafiltration system, using the XDLVO approach, Journal of Membrane Science, 461 (2014) 49-58.