

Supplementary Material

Recyclable composite membrane of polydopamine and graphene oxide modified polyacrylonitrile for organic dye molecules and heavy metal ion removal

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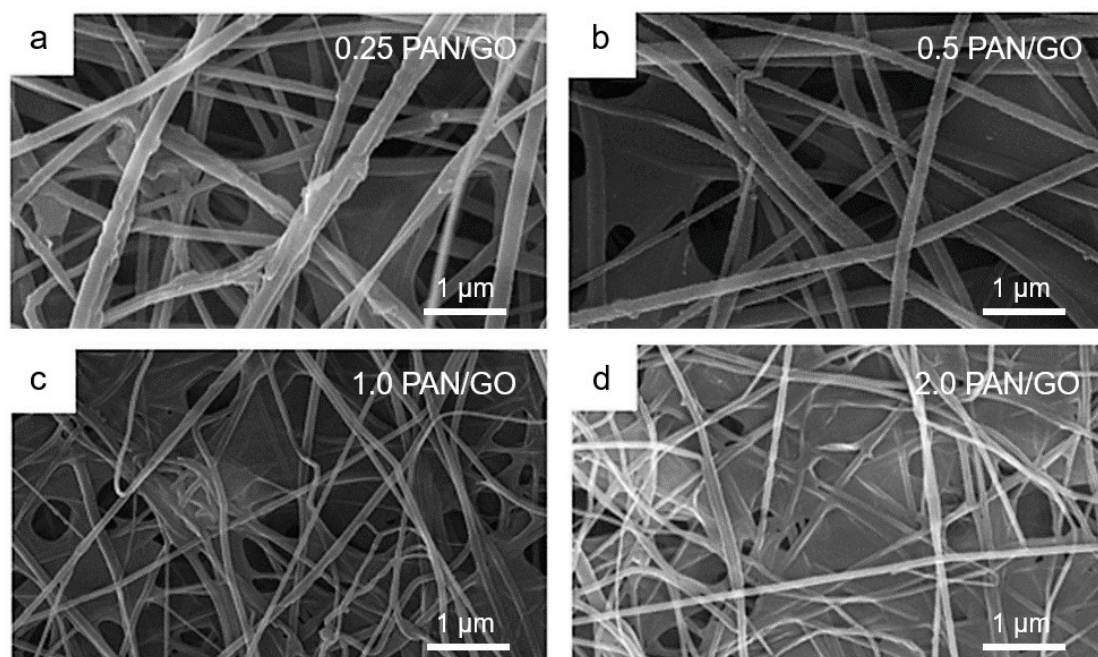


Figure S1. SEM images of (a) 0.25 PAN/GO, (b) 0.5 PAN/GO, (c) 1.0 PAN/GO and (d) 2.0 PAN/GO.

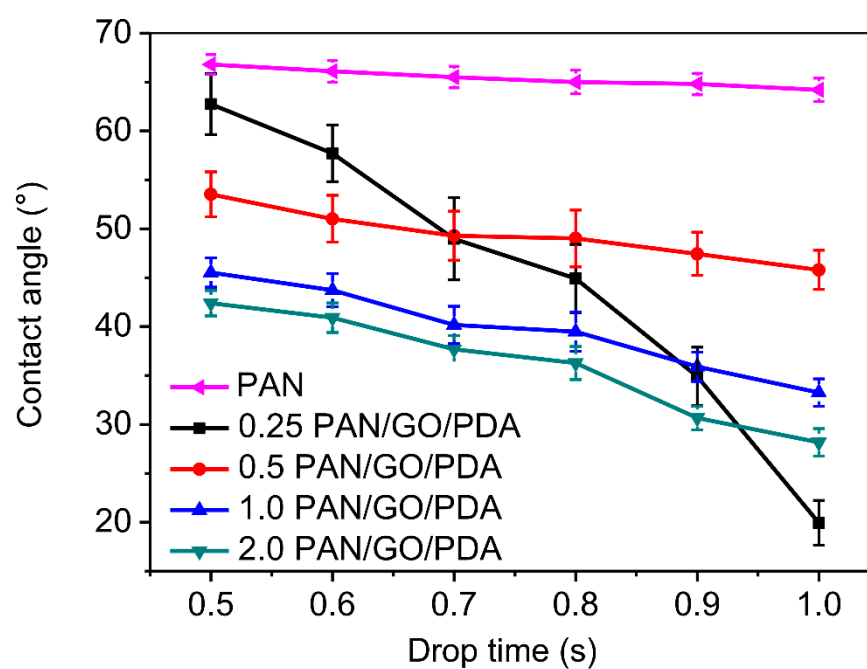


Figure S2. Water contact angles of composite membranes along with drop time, including PAN, 0.25 PAN/GO/PDA, 0.5 PAN/GO/PDA, 1.0 PAN/GO/PDA and 2.0 PAN/GO/PDA membranes.

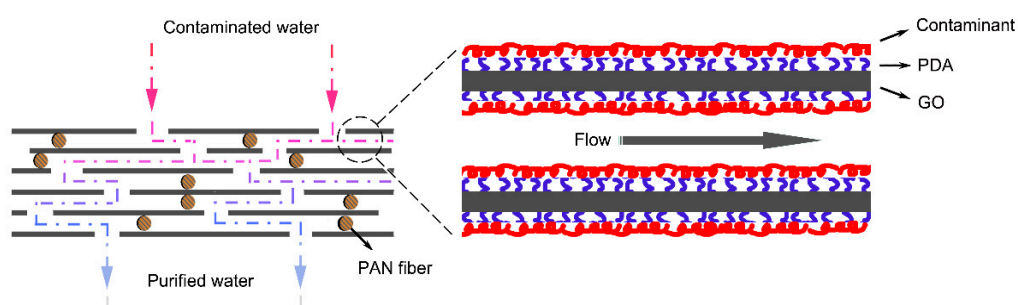


Figure S3. Schematic diagram of gravity driven filtration.

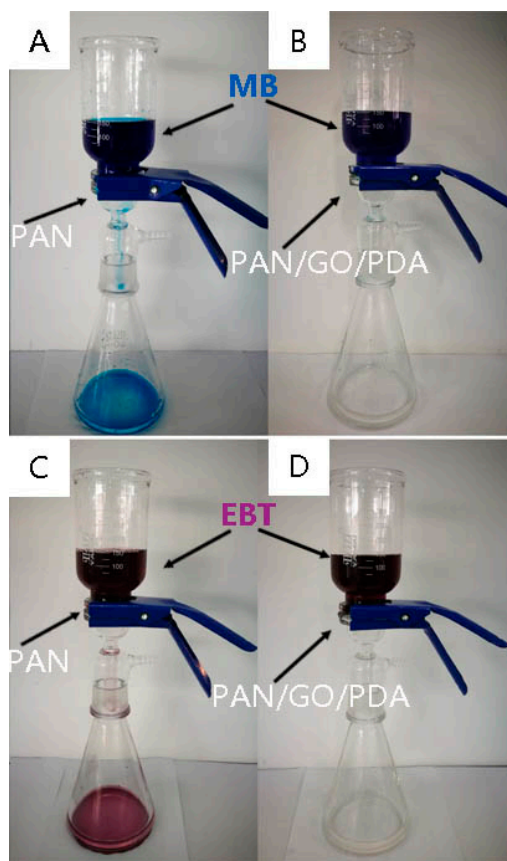


Figure S4. Comparison of filtration effect between ordinary PAN film and PAN/GO/PDA film without external pressure. (A) and (B) show the results of PAN and PAN/GO/PDA adsorbing MB, respectively; (C) and (D) show the results of PAN and PAN/GO/PDA adsorbing EBT, respectively.

For the study of adsorption isotherms, the dye solution (100 mL) (MB pH = 10 or EBT pH = 1) with different concentrations (range from 30 to 200 mg L⁻¹) was mixed with membranes 2.0 PAN/GO/PDA (10 mg). then, the container was transferred into a thermostatic shaker, which was operated at a rotate speed of 150 rpm and a temperature of 25°C for 12 h. The following equation was used for the calculation of absorbed amount of dye at equilibrium:

$$q_e = \frac{(C_0 - C_e)V}{m} \quad (S1)$$

where C_0 (mg L⁻¹) is the initial concentration of dye; V (L) is the volume of the solution and m (g) is the mass of the membrane; q_e (mg g⁻¹) and C_e (mg L⁻¹) are the equilibrium adsorbed amount and concentration of dye, respectively.

Langmuir model:

$$\frac{C_e}{q_e} = \frac{(1 + C_e K_L)}{q_m K_L} \quad (S2)$$

Freundlich model:

$$\ln q_e = \ln K_F + \frac{1}{n} \ln C_e \quad (S3)$$

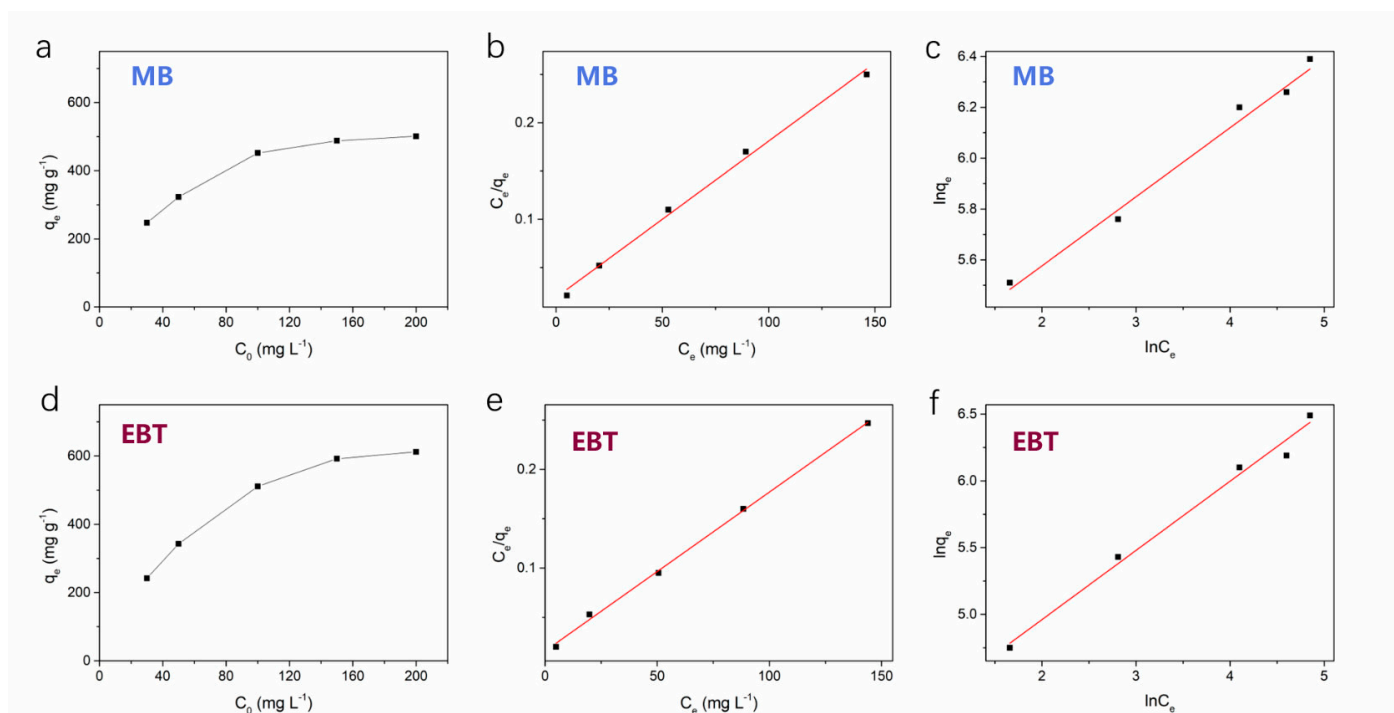


Figure S5. (a) and (d) represent the variation of equilibrium adsorption capacity versus initial concentration of MB (pH 10) and EBT (pH 1) solution, respectively; (b) and (c) represent the Langmuir and Freundlich isothermal models for the adsorption of MB, respectively; (e) and (f) represent the Langmuir and Freundlich isothermal models for the adsorption of EBT, respectively.

As shown as Figure S5, it's clearly seen that either in adsorbing MB or in adsorbing EBT, the Langmuir model exhibits larger R^2 , which indicates that the Langmuir model is more suitable in describing the adsorption behavior of organic dyes by the 2.0 PAN/GO/PDA sample. Beyond that, the experiment also shows the maximum adsorption capacity toward MB and EBT, respectively. The results are listed in Table S1 and S2 and compared with other adsorbents.

Table S1. Evaluated model parameters of the adsorption isotherms for MB onto 2.0 PAN/GO/PDA membrane.

Isotherms	Langmuir	Freundlich
Parameters	$q_m = 491.4 \text{ mg g}^{-1}$ $K_L = 0.07178 \text{ L mg}^{-1}$ $R^2 = 0.9944$	$1/n = 0.25634$ $K_F = 155.8896 \text{ L mg}^{-1}$ $R^2 = 0.9883$

Table S2. Evaluated model parameters of the adsorption isotherms for EBT onto 2.0 PAN/GO/PDA membrane.

Isotherms	Langmuir	Freundlich
Parameters	$q_m = 613.5 \text{ mg g}^{-1}$ $K_L = 0.0165 \text{ L mg}^{-1}$ $R^2 = 0.9979$	$1/n = 1.2512$ $K_F = 67.4561 \text{ L mg}^{-1}$ $R^2 = 0.9844$

Table S3. XPS spectra peak position of C1s, N1s and O1s and atomic ratios of PAN/GO NFMs and PAN/GO/PDA NFMs.

Name	Peak position (eV)	Atomic ratio (PAN/GO)	Atomic ratio (PAN/GO/PDA)
C1s	285.3	74.44	72.41
O1s	532.1	12.80	10.70
N1s	339.5	12.76	16.89

Table S4. Comparison of mechanical properties of PAN/GO-PDA composite membranes and other typically reported electrospinning membranes.

Materials	Tensile strength (MPa)	Young's modulus (MPa)	Refs.
PAN electrospun membrane	~4.6	~75	[1]
PAN NFMs modified with PDA	~10.5	~165	[1]
PSu NFMs modified with PDA	~2.2	~40	[1]
PAN NFMs modified with PVDF particles	7.7	106	[2]
PAN /JCNs composite membrane	~14	-	[3]
PAN-GO-SiO ₂ membrane	~7.8	~128	[4]
PEO/PAN/GO	4.08	124	[5]
PNPMs	7.6	-	[6]
PAN/Mt	~14.75	-	[7]
PAN-PVC/MWCNT	2.84	90.70	[8]
TPU/ACNT/AgNPs/PDMS	12.26	4.03	[9]
PD5T5 membrane	11.68	-	[10]
YAG membrane	5.63	-	[11]
PLA/TiO ₂ nfs fabrics	3.68	97.32	[12]
PLA/SSS	~4.85	~145.6	[13]
2.0 PAN/GO/PDA composite membrane	~16.8	~232.1	<i>This work</i>

Table S5. Comparison of the maximum adsorption capacities (q_m , mg/g) toward MB and EBT between the adsorbent reported in literature and the composite PAN/GO/PDA nanofiber membrane in this work. The maximum adsorption capacities were calculated through the Langmuir adsorption model.

MB adsorption			EBT adsorption		
Adsorbent	q_m (mg/g)	Ref.	Adsorbent	q_m (mg/g)	Ref.
m-ALG/RH	344	[14]	Magnetite/pectin NPs	103.41	[15]
BPCMC-g-poly (NaAc-co-AM)	333.3	[16]	mLCSCar0.2	280	[17]
Fe ₃ O ₄ -xGO	526.32	[18]	Magnetic graphene oxide	210.53	[19]
mGO/PVA-CG	270.94	[20]	CNU2	650.34	[21]
PPy/TiO ₂	273.22	[22]	Activated clay	53.95	[23]
PSSC	136.99	[24]	DXC	47.02	[25]
GO/CA	974.7	[26]	MSGT	167.01	[27]
Graphene	153.85	[28]	B-CuFe-CS	806.4	[29]
PVDF/PDA/PPy	370.4	[30]	MgAl	540.91	[31]
2.0 PAN/GO/PDA	491.4	<i>This work</i>	2.0 PAN/GO/PDA	613.5	<i>This work</i>

Table S6. Comparison of the adsorption capacities toward Cu^{2+} between the adsorbent reported in literature and the composite 2.0 PAN/GO/PDA nanofiber membrane in this work.

Adsorbent	pH	Adsorption capacity (mg g^{-1})	Ref.
PANI/ Fe_3O_4 -polythiersulfone	6.0	104.45	[32]
MWCNT- NH_2 -CS/PVA	5.5	20.1	[33]
PAN/ Fe_3O_4 @ Fe_3O_4	6.0	35 ± 2	[34]
MWCNT-PEI/PAN	7.0	112.5	[35]
aPAN/BPEI NMs	6	209.53	[36]
GO/PPy/ MnO_2	-	38.4	[37]
PVA/ GO nanofiber film	7	57.88	[38]
PGCB	4	83.3	[39]
CS-CD	-	49.97	[40]
2.0 PAN/GO/PDA	4.78	62.9	<i>This work</i>

Porosity calculation equation:

$$\text{porosity}(\varepsilon)\% = \frac{(m_w - m_d)/\rho_w}{\frac{m_w - m_d}{\rho_w} + \frac{m_d}{\rho}} \times 100\% \quad (\text{S4})$$

Where m_w and m_d are the mass of wet and dry membrane respectively, ρ_w and ρ are density of water and PAN.

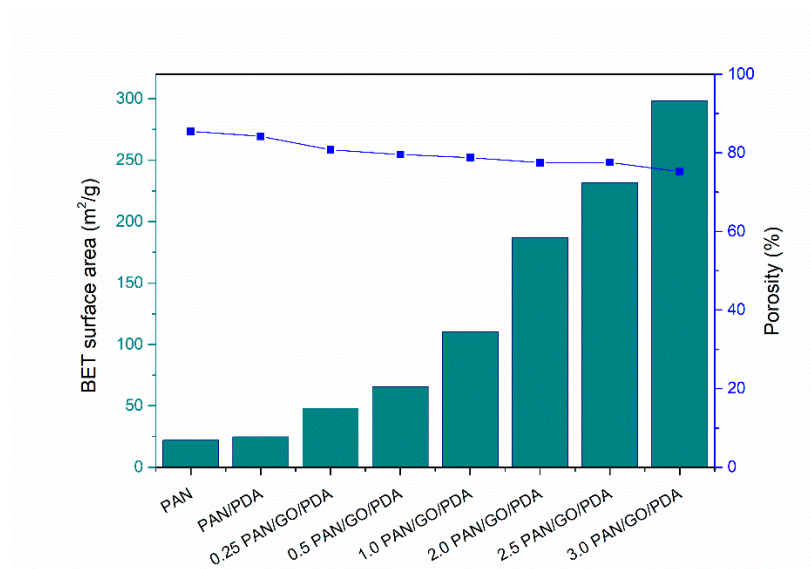


Figure S6. BET surface area and porosity results of different membranes.

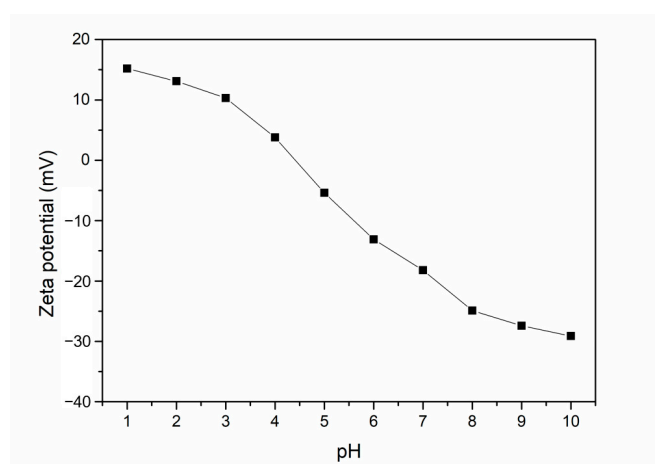


Figure S7. Zeta-potential of sample 2.0 PAN/GO/PDA under different pH values.

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