Supplementary information

Enhancing Reverse Osmosis Desalination Performance of Thin-film Nanocomposite Membranes by Incorporating Tannic Acid-Modified Graphitic Carbon Nitride Nanosheets

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1. Supplementary Figures

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1. Supplementary Figures

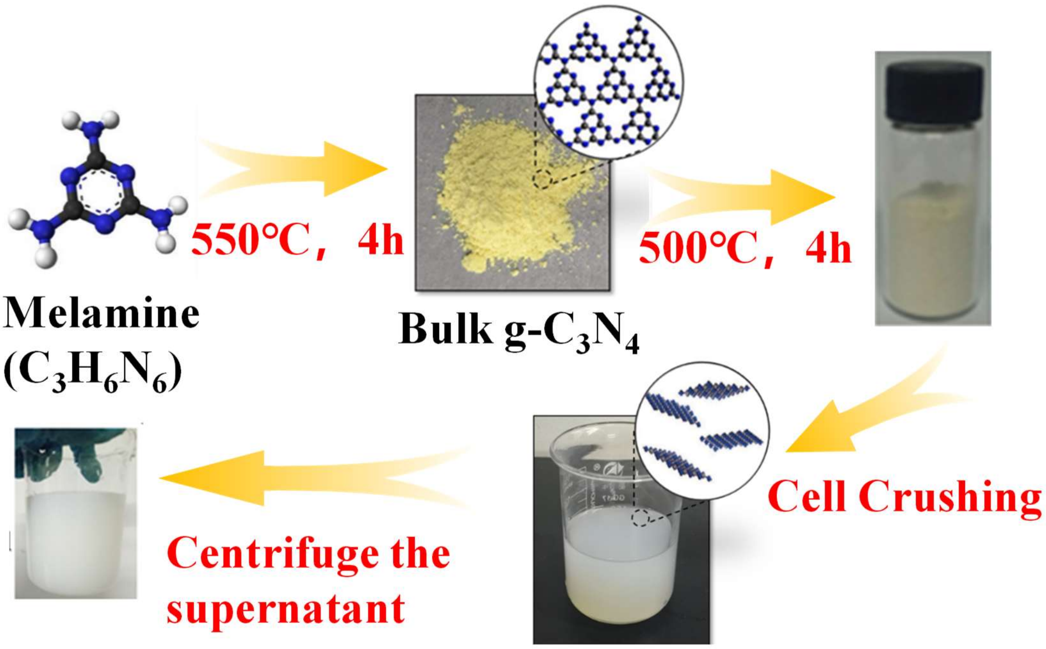

Fig. S1 Synthesis of CN nanosheets. CN nanosheets can be synthesized via a two-step thermal oxidation sintering method using melamine as the precursor material. The CN powder was dispersed in a 10% (v/v) ethanol solution and subsequently subjected to ultrasonic treatment using an ultrasonic cell disruptor for a designated period. Finally, the supernatant was collected to obtain the CN dispersion.

Fig. S2 Preparation of TFN membranes. The aqueous phase solution is poured into the membrane frame, ensuring the surface of the PSF membrane is fully immersed. After a 2 min soak, the membrane frame is tilted to drain the excess aqueous phase solution, and any remaining droplets on the surface of the base membrane are removed. Subsequently, the organic phase solution is poured into the membrane frame to react with the aqueous phase monomer for 1 min. The membrane frame is then held vertically to pour out the remaining organic phase solution. Finally, the membrane frame is placed into an oven set at 60 °C for a 5 min treatment.

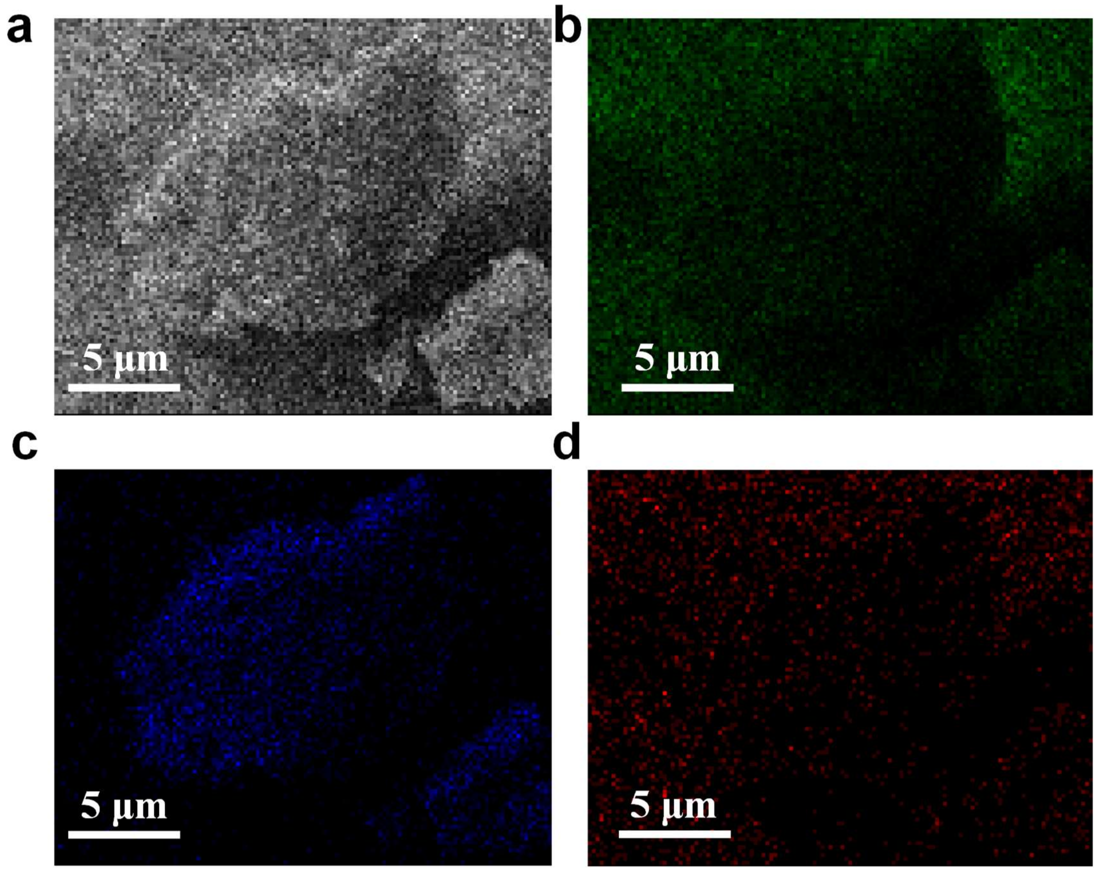

Fig. S3 Surface SEM image and corresponding EDS mapping images of the CN nanosheets. C (green), N (blue), O (red). The EDS images of CN nanosheets reveal that, in addition to C and N elements, these nanosheets contain a significant amount of O elements. This observation can be attributed to the presence of adsorbed water and hydroxyl groups on the surface, or to structural defects at the edges.

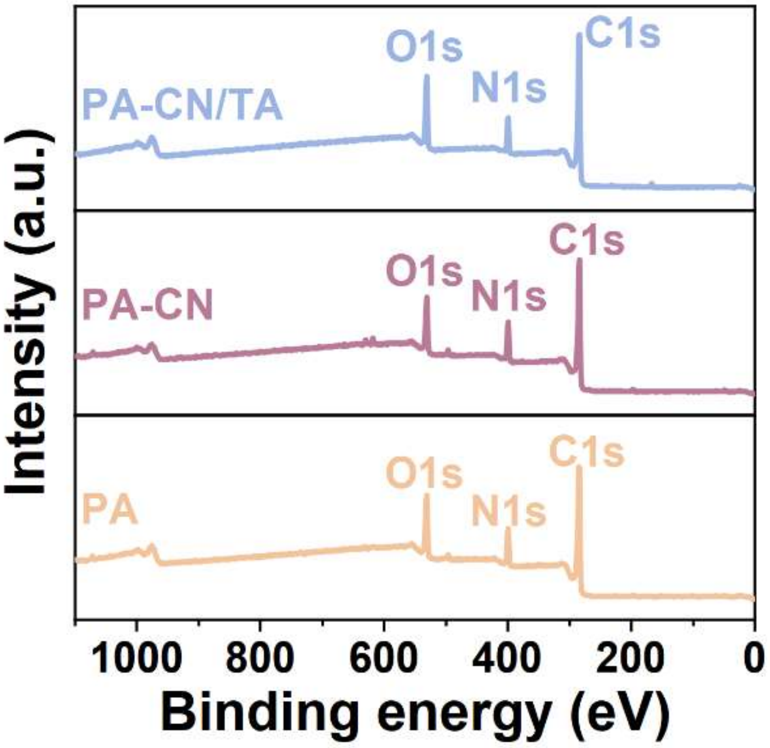

Fig. S4 XPS spectra of the PA, PA-CN and PA-CN/TA membranes. The relative content of each element can be semi-quantitatively determined by XPS spectroscopy, and the ratio of carbon to oxygen can serve as an indicator of the cross-linking degree of the RO membrane to some extent.

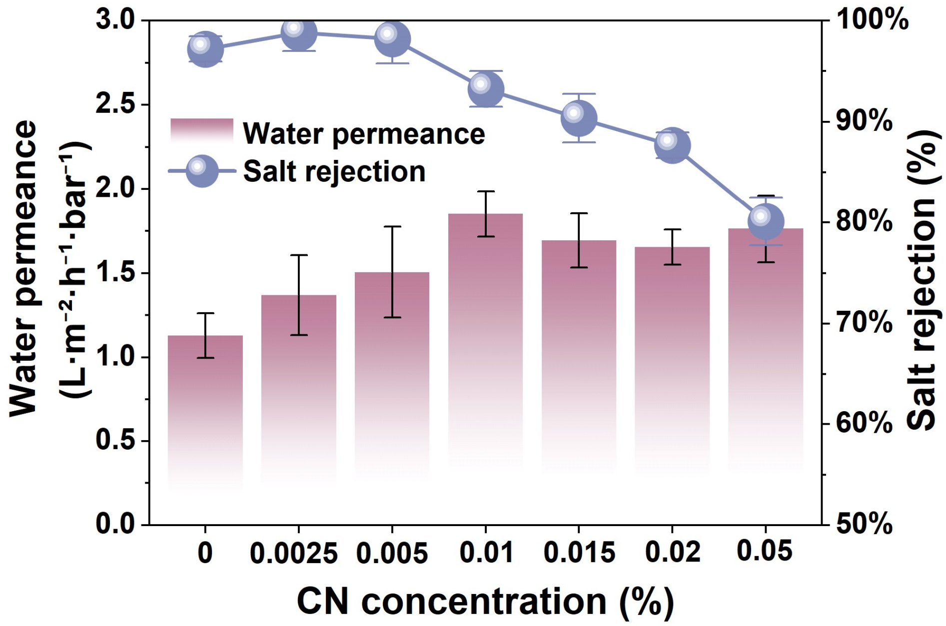

Fig. S5 Variation of desalination performance as a function of CN nanosheets concentration. The water flux of the RO membrane increases while the salt rejection decreases with increasing concentration of CN nanosheets. When the concentration is greater than 0.015%, the water flux shows no obvious pattern but the salt rejection significantly decreases, and the performance of the membrane is significantly affected. This phenomenon might be caused by the excessive loading of CN nanosheets, which leads to agglomeration and the formation of non-selective interfacial voids.

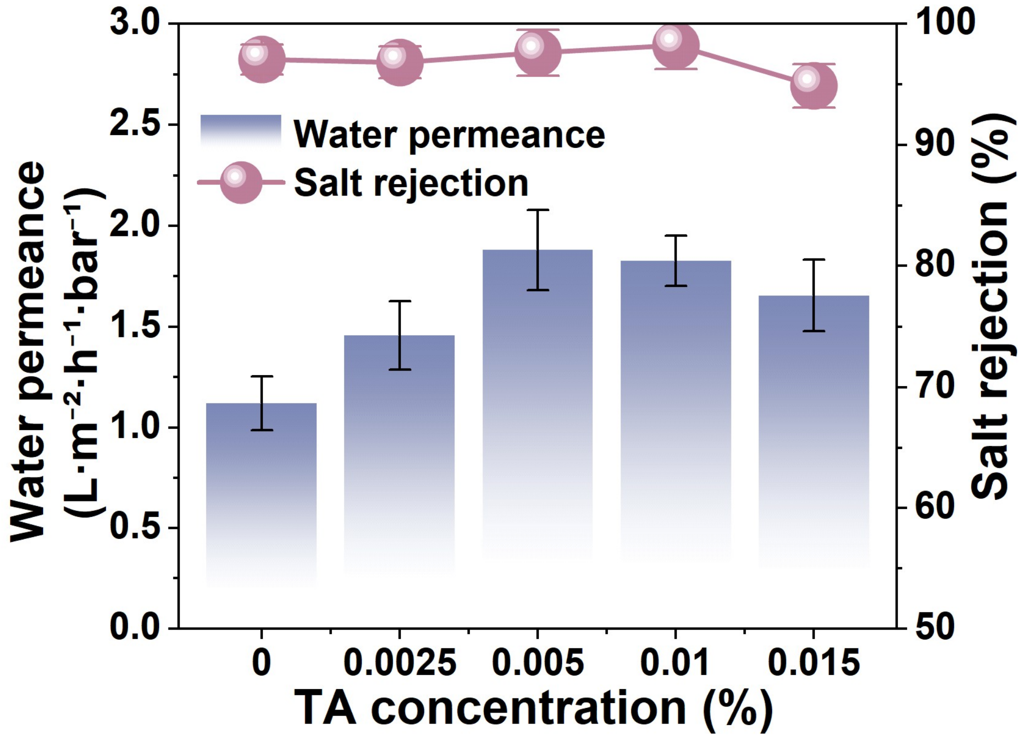

Fig. S6 Variation of desalination performance as a function of TA concentration. As shown in the figure, with the incorporation of TA, the water flux of the RO membrane increases. This is attributed to the fact that TA contains a large number of hydrophilic functional groups, and the phenolic groups form covalent bonds with acyl chloride groups in the organic phase solution, thereby enhancing the cross-linking degree of the RO membrane and improving its water flux while maintaining desalination stability.

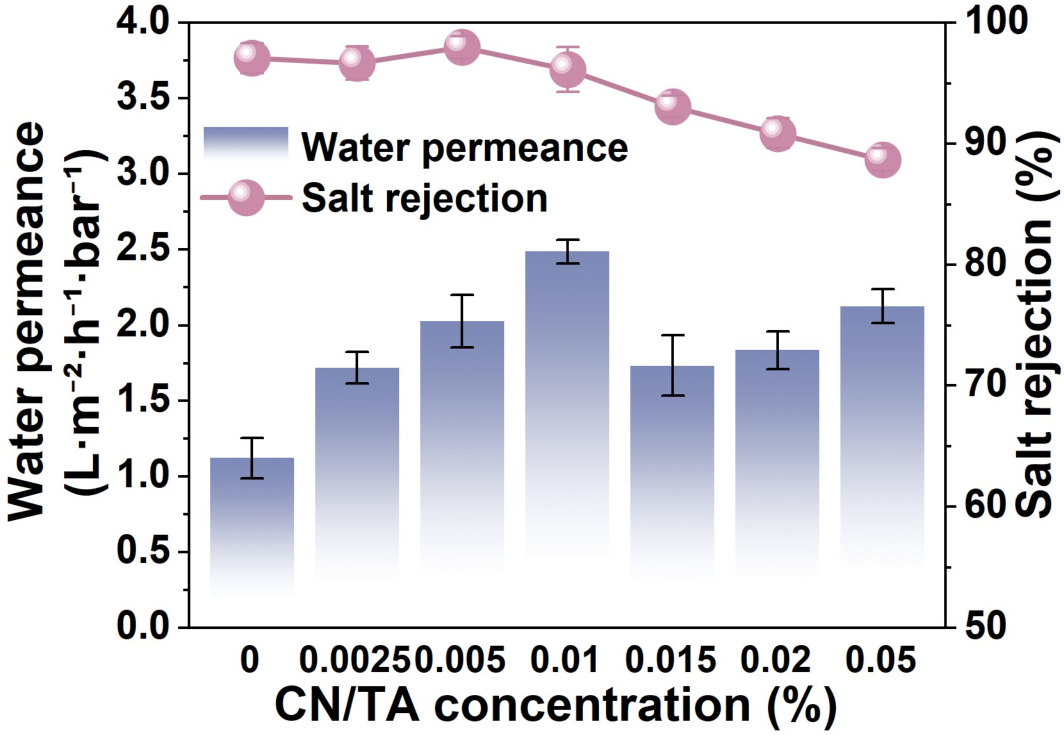

Fig. S7 Variation of desalination performance as a function of CN nanosheets concentration. When the concentration of CN/TA nanosheets was 0.01%, the performance of the TFN membrane reached its optimum, where the water permeance of the TFN membrane attained 2.49 $L\cdot m^{-2}\cdot h^{-1}\cdot bar^{-1}$, while a high NaCl rejection rate of 96.1% was maintained. When the concentration of CN/TA nanosheets exceeded 0.015%, the performance of the TFN membrane continuously declined and showed no obvious pattern. The agglomeration caused by excessive CN/TA loading has a significant impact on the performance of the membrane. However, compared to the case without adding TA (**Fig. S5**), the agglomeration phenomenon has been greatly reduced.

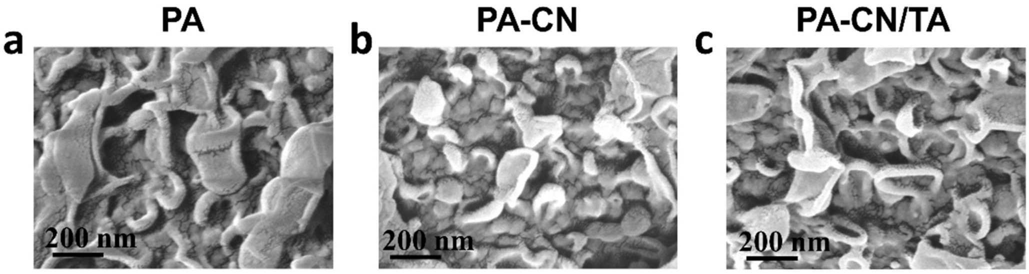

Fig. S8 High-magnification surface SEM images of the **(b)** PA, **(c)** PA-CN and **(d)** PA-CN/TA membranes.

2. Supplementary Tables

Table. S1 Desalination performance comparison of RO membrane in this work with similar nanomaterial incorporated TFN membranes in literature.

Nanofiller type	Water flux ($L \cdot m^{-2} \cdot h^{-1} \cdot bar^{-1}$)	Salt rejection (%)	Water flux enhancement rate （%）	References
Ag_2S	1.92	98.2	26.18	[1]
TiO_2(1)	1.4	98	72.84	[2]
COF(1)	2.41	98.4	81.2	[3]
CNC(1)	2.6	98	104.7	[4]
PANI	1.3	99.4	62.5	[5]
CNT(1)	1.9	97.9	44	[6]
LDHs	2.68	99.4	33.3	[7]
mGO	2.13	99.3	22.2	[8]
COF(2)	2.28	97.1	55.45	[9]
CNC(2)	1.82	98.6	44	[10]
GO(1)	1.57	96.28	91.93	[11]
Si	2.28	97	51.9	[12]
CNT(2)	2.7	97.6	71.4	[13]

Continued **Table. S1**

Nanofiller type	Water permeability ($L\cdot m^{-2}\cdot h^{-1}\cdot bar^{-1}$)	Salt rejection (%)	Water flux enhancement rate （%）	References
CuO	2.18	97.4	80.16	[14]
GOQD	2.34	98.8	51.8	[15]
TiO_2(2)	3.42	99.45	49.56	[16]
GO(2)	3.57	98.7	66.8	[17]
Mxene	2.53	98.5	48.82	[18]
BN	4.0	96.4	25.39	[19]
ZIF-8	3.74	98.7	43.8	[20]
CN/TA	2.49	97.6	118.4	This work

Table. S2 The price of raw materials

Material	Scale	Price (USD)	Manufacturer
Tannic acid	100g, 98%	12.35	Macklin (China)
Melamine	500g, 99%	11.27	Sinopharm Chemical Reagent Co., Ltd (China)
GO	2mg/ml, 100ml	1200	Sigma-Aldrich
GO	1mg/ml, 500ml	303.37	Xianfeng Nanomaterials Technology Co., Ltd (China)
polysulfone	$1m^2$	14.45	Beijing Originwater Technology Co., Ltd (China)

3. Supplementary References

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