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on frontiers in materials science

$MoSe_2$ membrane for efficient water-dye separation and desalination

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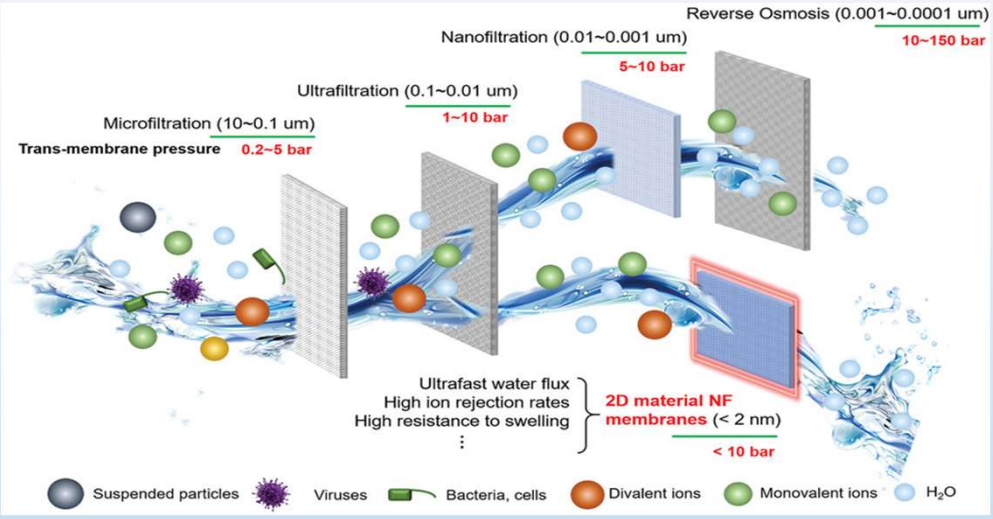
Introduction

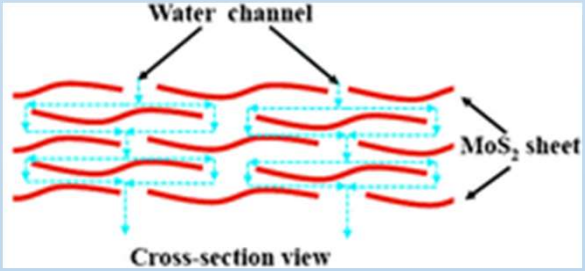
- Fresh water shortage and energy resource depletion have been two formidable challenges for decades.
- Membrane based separation- Energy efficient route.
- Membrane- A semipermeable barrier that allows selective permeability.



Advanced Science, **2021**, 2102493

Membrane requirement

- high water flux
- high rejection rates of ions,
- high resistance to swelling, chemical and bio-fouling resistant.

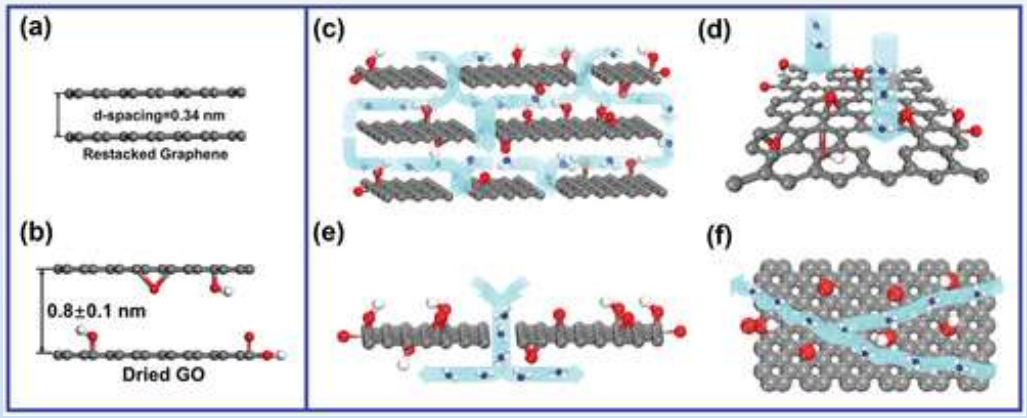


Chem. Commun., **2013**, 49, 10718-10720

2d materials

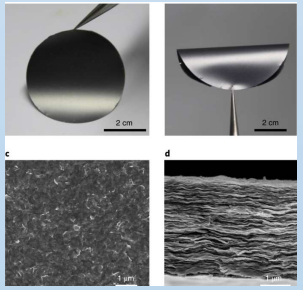
- In 2d materials, one dimension is restricted. Eg:- Graphene, MoS_2 etc.
- Because of sheet like morphology, these materials are easy to fabricate into membrane with nano pathways.

Mechanism of ion transport:

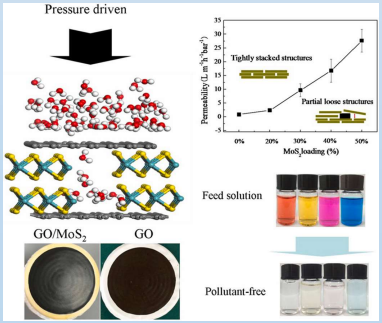


Chem. Sci., 2017,**8**, 1701-1704

Nature Materials , **2019**, 18, 1112–1117



MoS_2 membrane



Journal of Membrane Science, **2019**, 574,112–123

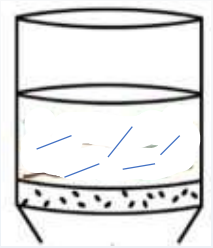
$MoSe_2$ Membrane Preparation

Bulk $MoSe_2$

Exfoliation

1. Li intercalation
2. Exfoliation in H_2O

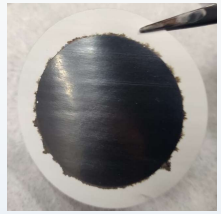
$MoSe_2$ Nanosheets



PVDF Substrate,
Pore size 100 nm

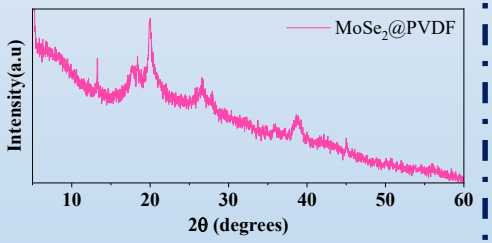
Fabrication

20mL $MoSe_2$ in 100 mL water

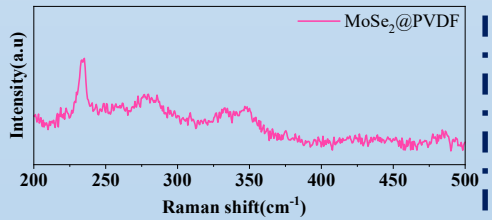


Results and Discussion

XRD



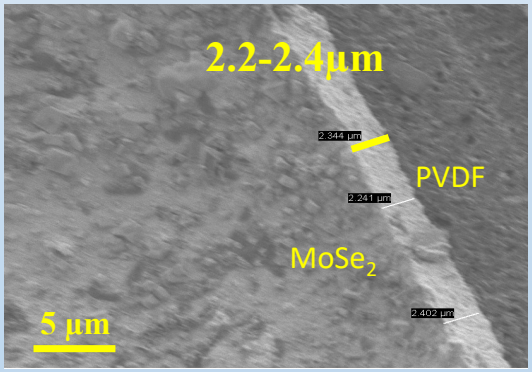
Raman spectra



Effect of air drying on $MoSe_2$ membrane

Membrane was found to develop cracks on drying hence to keep membrane intact membrane was always kept in moist condition.

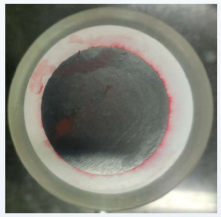
SEM- For membrane thickness

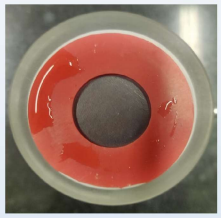


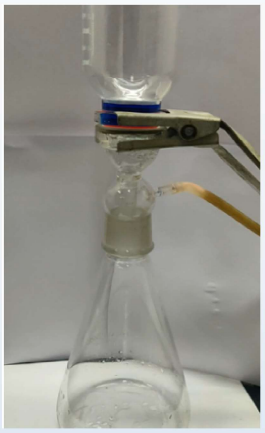
Membrane thickness was observed around 2.2-2.4µm

Dye Separation

Dye Filtration Setup

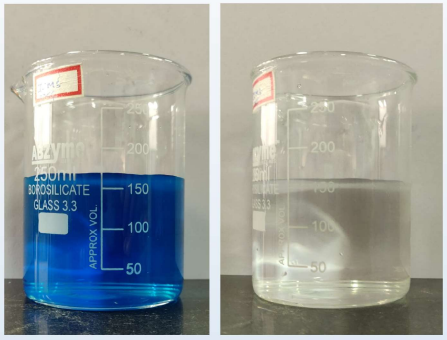


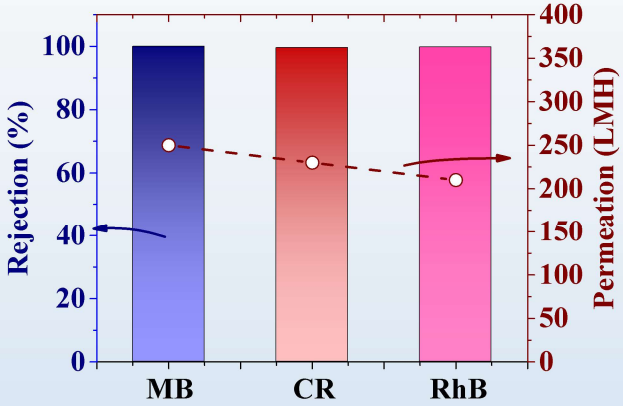


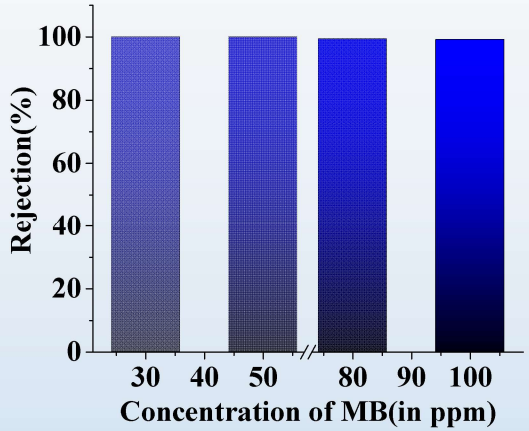


MB (30ppm)

Feed Permeate







In typical experiment, Dyes with concentration of 30 ppm were filtered and the permeate was collected for analysis.

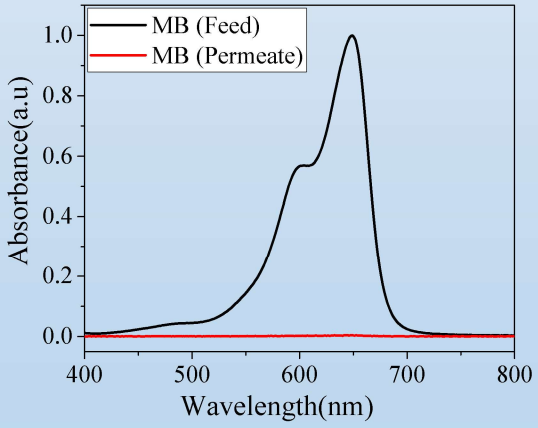
Rejection observed was over **99.5-99.7%** with Flux **220-270 L m^{-2} h^{-1}**

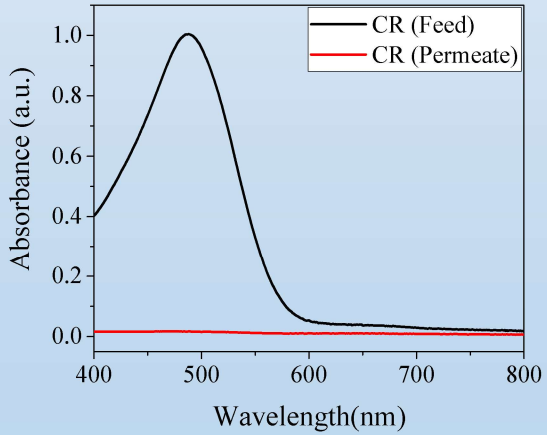
MB

CR

RhB

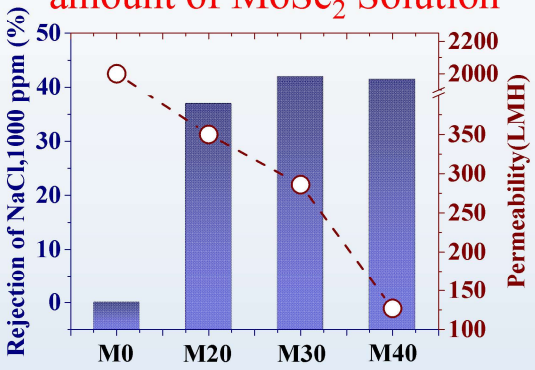
MB- Methylene Blue
CR- Congo red
RhB- Rhodamine B



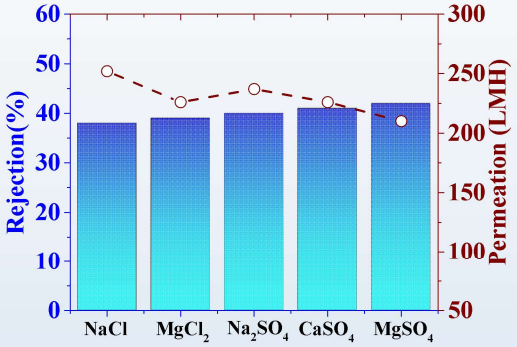


Desalination Performance

Membrane prepared with increasing amount of $MoSe_2$ Solution

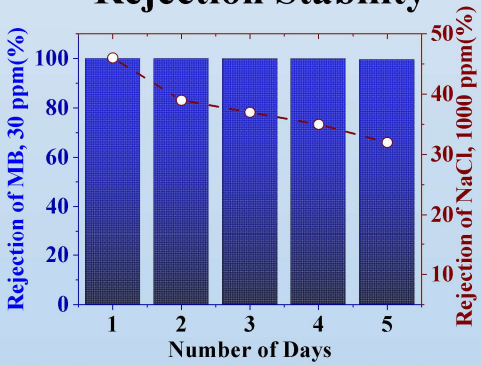


Desalination performance with different salts, 1000 ppm

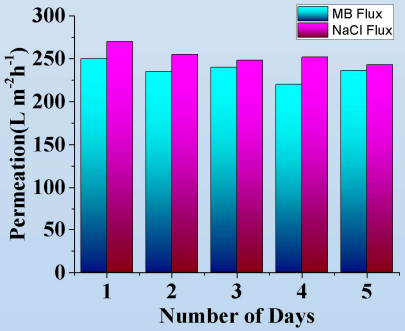


- M30 membrane was selected for desalination with various salts.
- The salt rejection was observed around ~40% with higher flux of 210 $L.m^{-2}.h^{-1}$

Rejection Stability

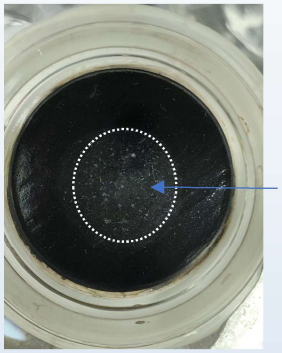


Permeation Stability

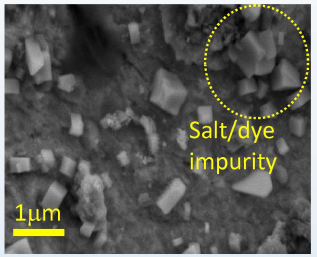


- For Dye separation, MB rejection was almost 100% after 5 days.
- For salt separation, NaCl rejection was decreased to 32%. It maybe attributed to slight swelling of membrane.

Post Desalination / Dye Separation

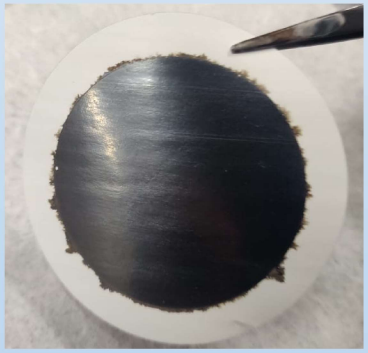


Salt deposited at surface of the membrane

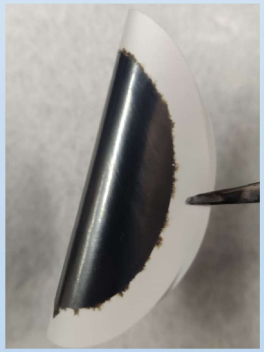


Impurities of salt/dyes deposited on the surface of membrane.

Physical Stability



Flat



Bent

Cross flow

Conclusion

1. For first time, $MoSe_2$ membrane was prepared and utilised successfully for dye separation and desalination.
2. $MoSe_2$ membrane showed excellent dye separation efficiency of almost 100% with high flux of 270 L $m^{-2}h^{-1}$.
3. Desalination was also performed for various salts at 1000 ppm and salt rejection was found to be around 40% with salt solution flux greater than 200 L $m^{-2}h^{-1}$
4. Stability tests were performed, and it was observed that membrane is stable in wet state for almost 5 days.

Acknowledgement

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Thank You