Strategies for Enhanced Photocatalytic Membranes on Water Purification

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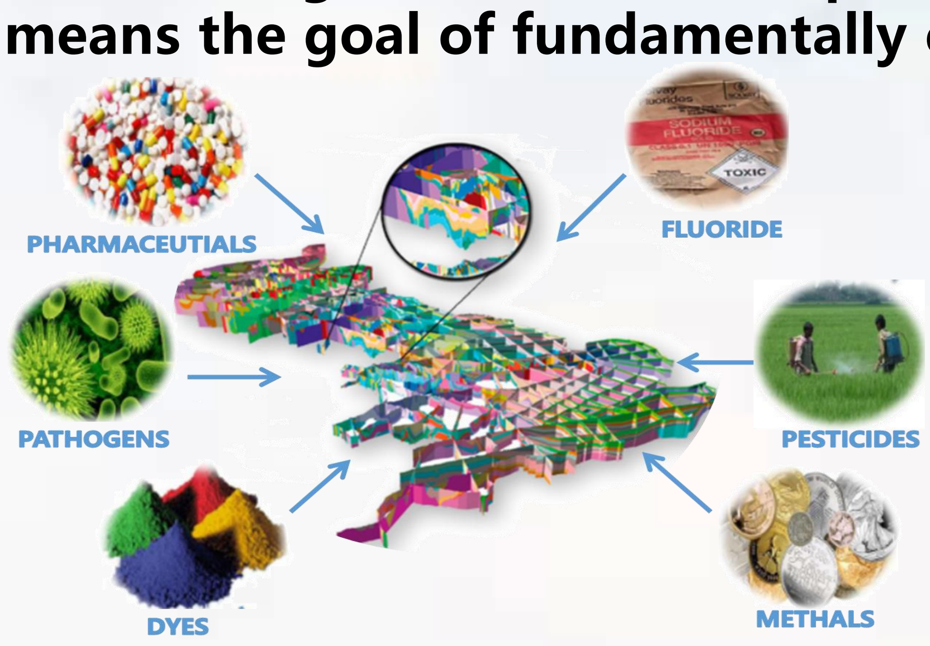
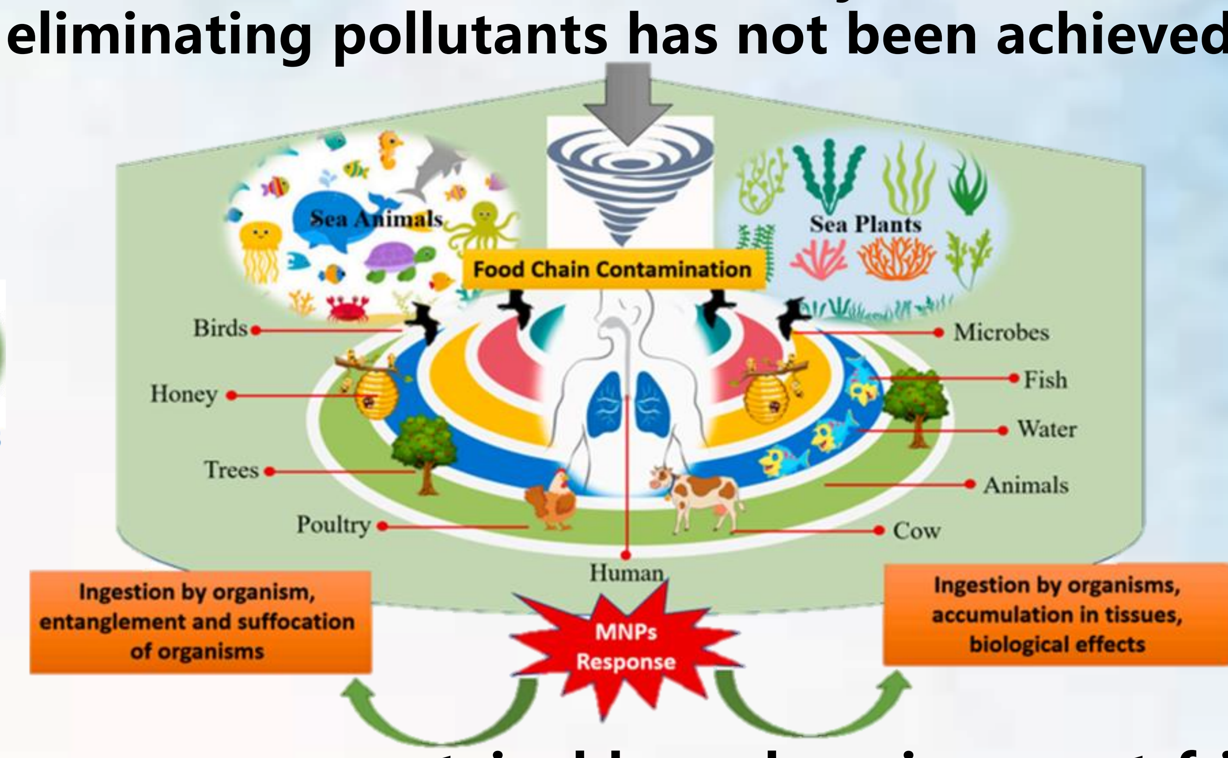
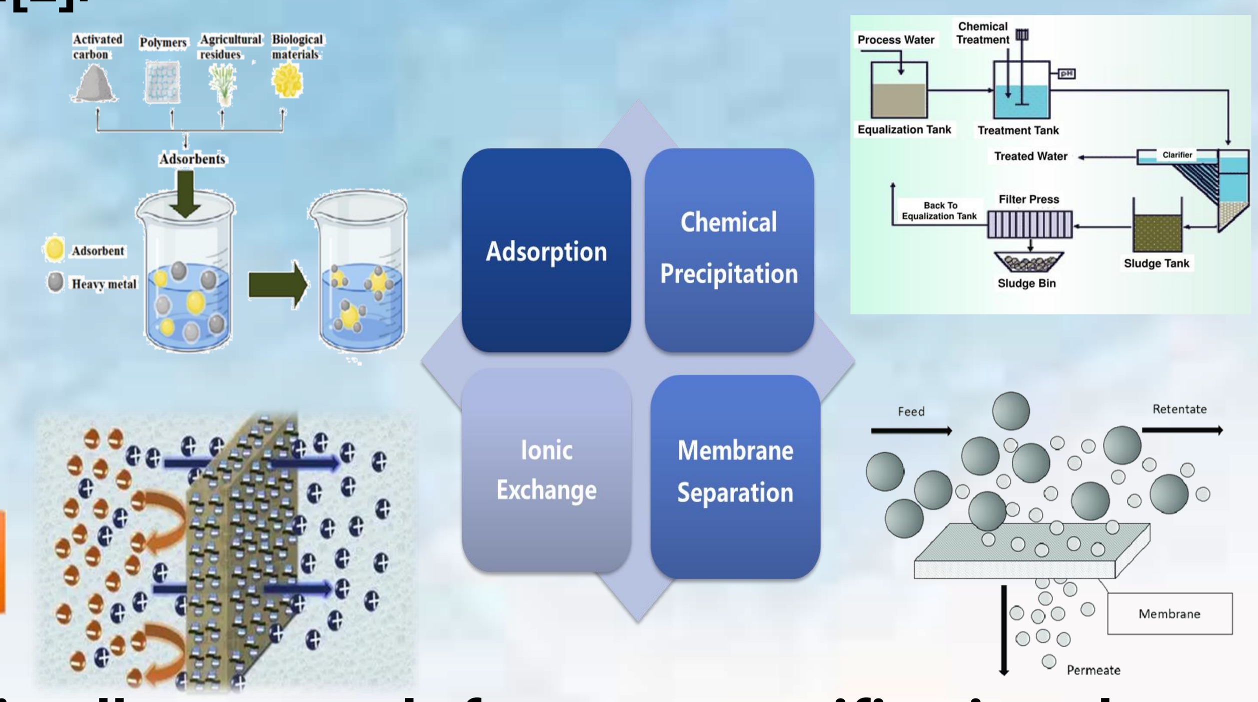
Introduction

- Growing technologies, increasing population and environmental pollution lead to severe contamination of water. Industrial wastewater contains various dangerous compounds, which have serious adverse effects on aquatic life and humans [1].
- Several physical/conventional techniques have been employed to solve the wastewater crisis. However, the major disadvantage of these techniques is the formation of secondary waste that cannot be reprocessed and discharged, which means the goal of fundamentally eliminating pollutants has not been achieved[2].







Motivation

- Photocatalytic membranes provide an energy sustainable and environment friendly approach for water purification due to the synergistically enhanced efficiency and self-cleaning performance[3].
- Compared with traditional purification reactors, photocatalytic membranes combines the advantages of physical separation and chemical decontamination in one single unit. Besides, this system can solve the recovery problem of photocatalysts, preventing the secondary pollution caused by the leaching of nanoscaled particles into the environment, and effectively retard the membrane fouling by virtue of photocatalysis[4].

Integrative model of photocatalytic membranes: Design and Optimization

Chemical Mechanism of Photocatalysis

I. Semiconductors absorb the photons with energies greater than or equal to their own band gap and excite photogenerated electron-hole pairs.

II. Photogenerated carriers transfer toward the surface under an electric field or diffusive motion.

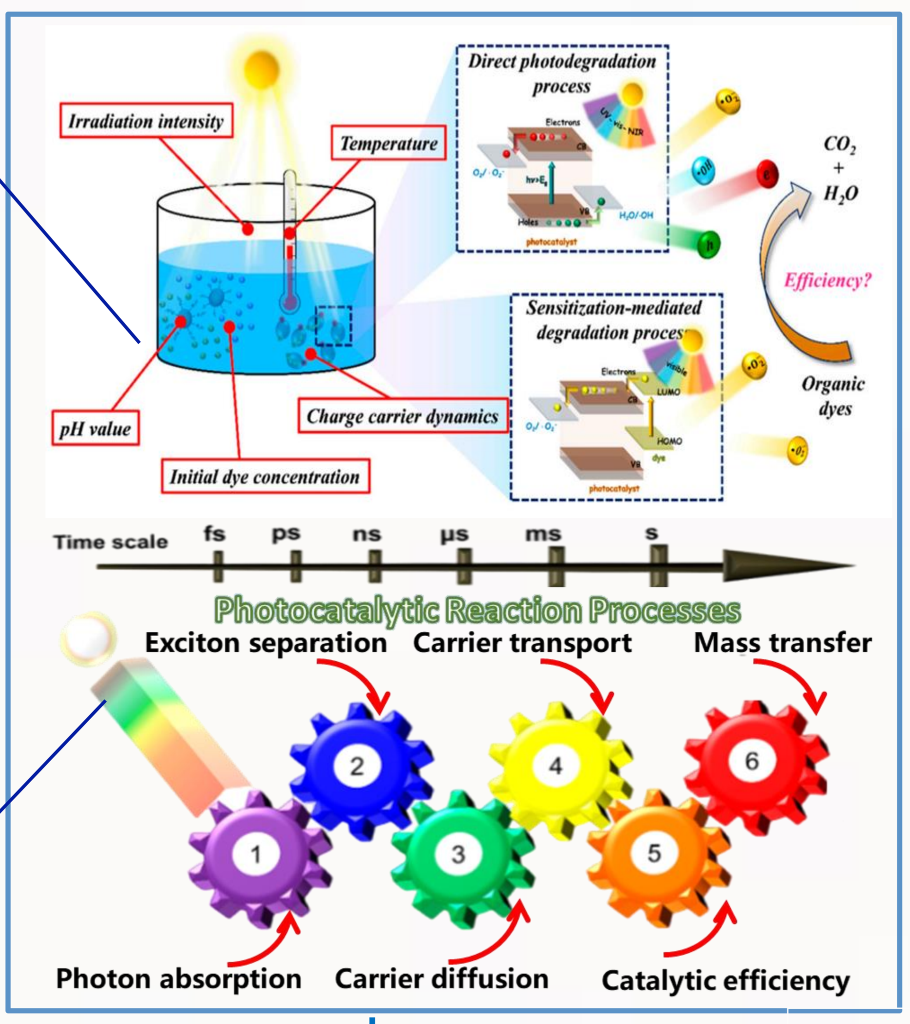
III. Electrons and holes react with substances adsorbed on the catalyst surface in reduction and oxidation reactions, respectively.

IV. Pollutants are degraded by generated active substances (h^+, ·OH, ·O2$^-$).

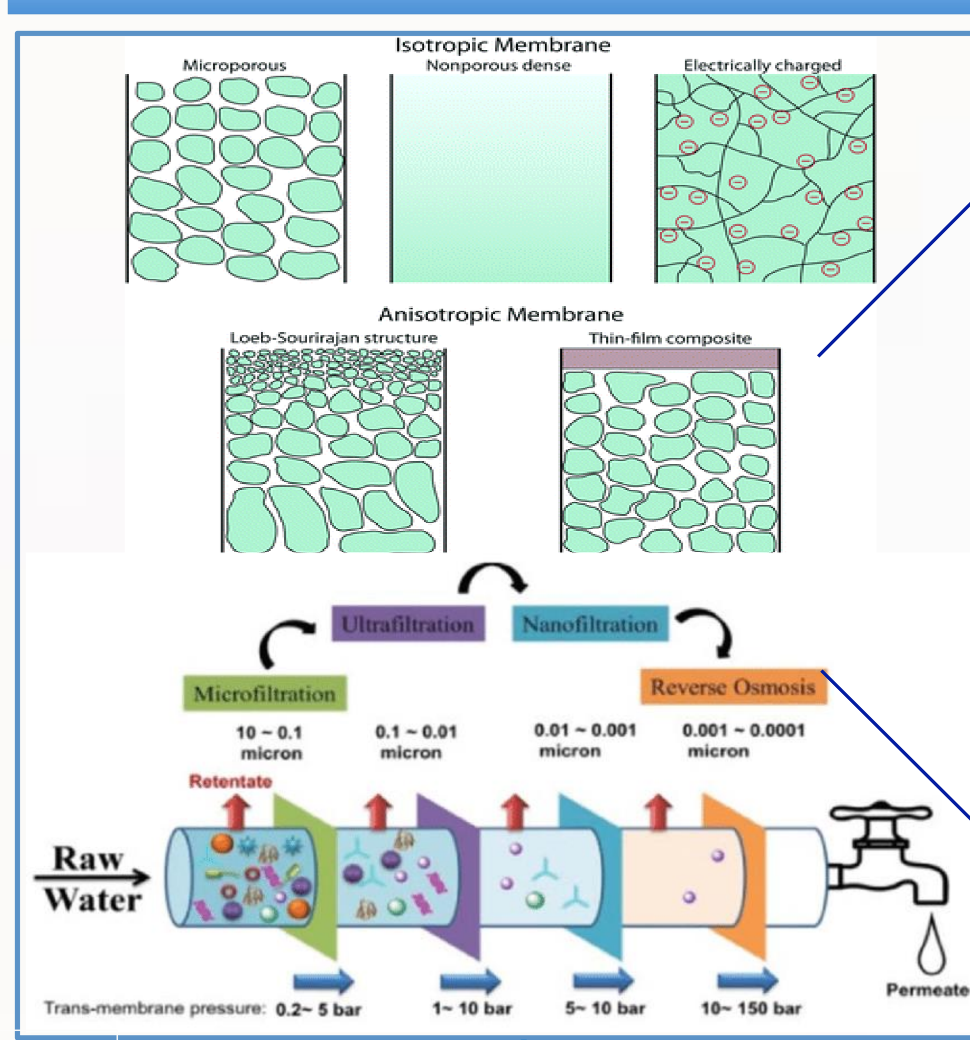
Challenges of Photocatalysis

- Interfacial charge transfer
- Improve the charge separation
- Inhibition of charge carrier recombination

Photocatalytic Degradation



Membrane Separation



Classes and Structures of Membranes

A membrane is a thin physical interface that moderates certain species to pass through depending on their physical and/or chemical properties.

- Isotropic membranes are chemically homogenous in composition. Examples include microporous membranes, nonporous dense films, and electrically charged membranes.
- Anisotropic membranes contain phase-separation membranes and composite membranes such as thin-film, coated films, and self-assembled structures.

Limitation of Membranes Application

Relying on the sieving effect of membrane pores to remove pollutants, resulting in a trade-off effect between membrane permeability and selectivity.

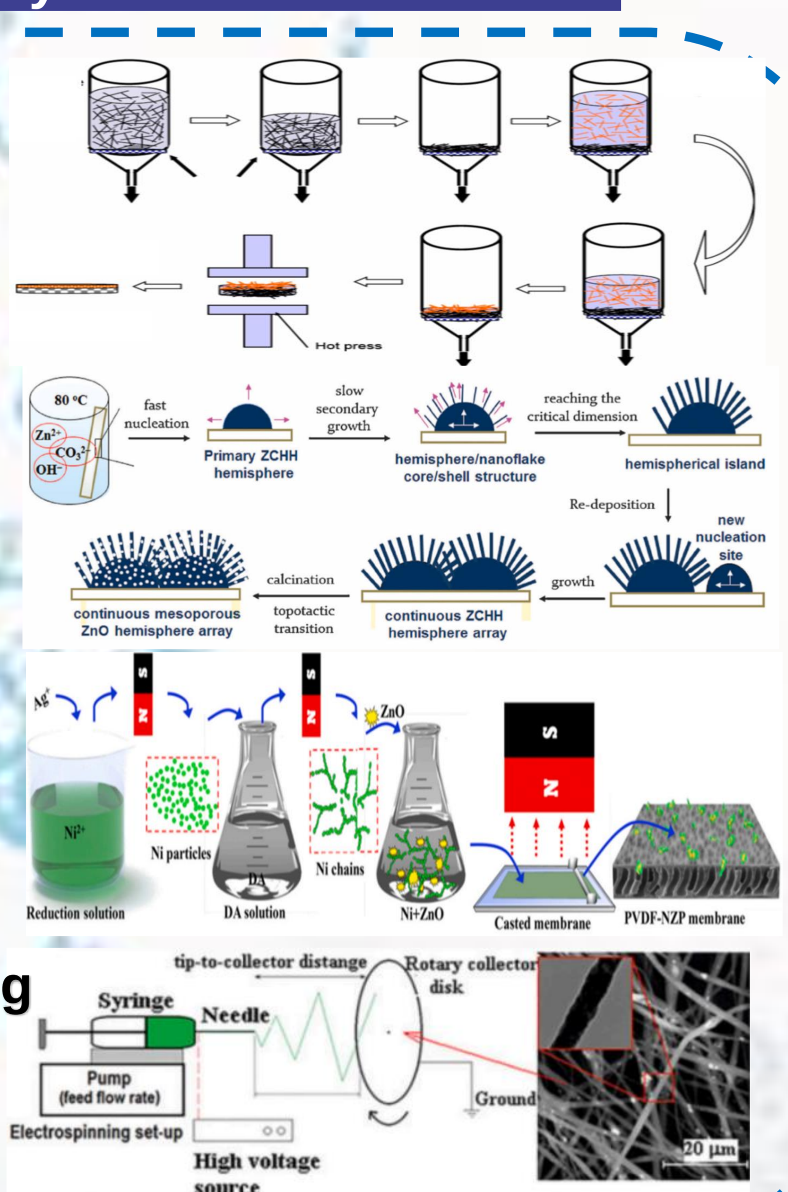
Synthesis Methods

Hydrothermal Synthesis

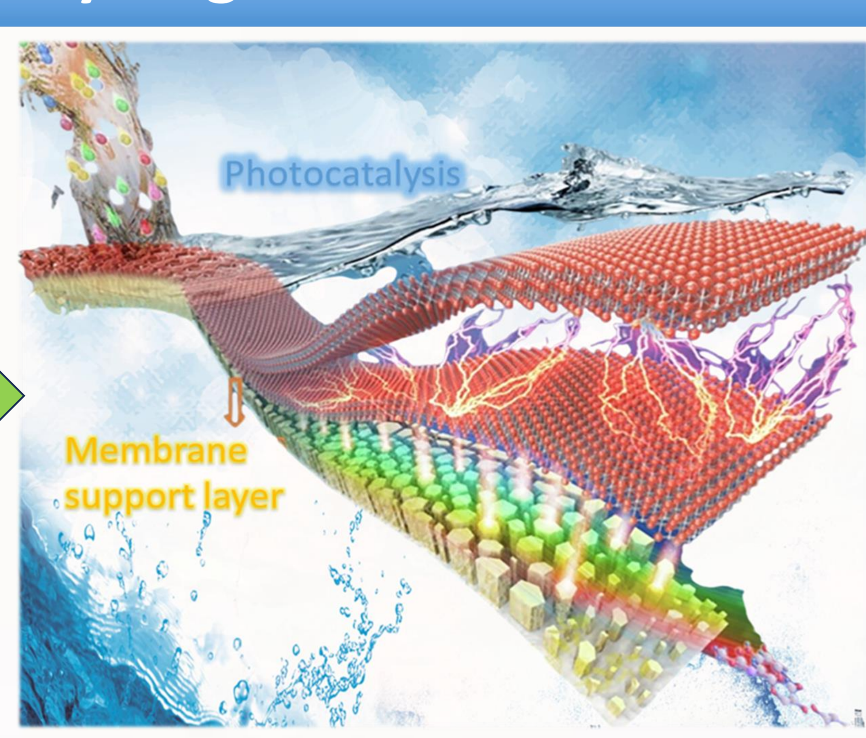
Liquid phase Deposition

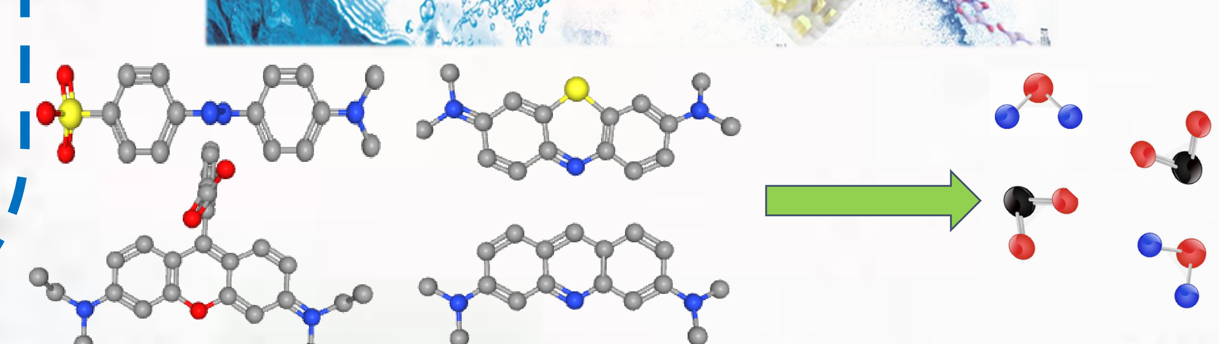
In-situ Reduction

Electrospinning



Synergistic Effect Revelation





Organic Pollutants

H_2O, O_2

Operational Parameters

Ions: The presence of ions influence positive or negative the rate of the photocatalytic process by scavenging holes (h^+) and hydroxyl radical (•OH) .

Catalyst Loading: The optimum loading of the catalyst depends on the structure and the morphology of the membrane, light intensity and the flow rate of water.

pH: Determining the optimal pH of the solution will enhance the flow and reduce membrane fouling.

Light Intensity: Enhancing light intensity is beneficial to improve catalytic performance, but it may also leads to the instability of the membrane.

References

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