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Review

Progress in electrospun polymeric nanofibrous membranes for water treatment: Fabrication, modification and applications

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ABSTRACT

Research on membrane technologies has grown exponentially to treat wastewater, recycle polluted water and provide more freshwater. Electrospun nanofibrous membranes (ENMs) exhibit great potential to be applied in membrane processes due to their distinctive features such as high porosity of up to 90% and large specific surface area. Compared with other nanofiber fabrication techniques, electrospinning is capable of developing unique architectures of nanofibrous scaffolds by designing special assemblies, and it is facile in functionalizing nanofibers by incorporating multi-functional materials. This review summarizes the state-of-the-art progress on fabrication and modification of electrospun polymeric membranes with a particular emphasis on their advances, challenges and future improvement in water treatment applications. First, we briefly describe the complex process governing electrospinning, illustrate the effects of intrinsic properties of polymer solutions, operational parameters and surrounding environment conditions on the formation of nanofibers and resultant nanofibrous membranes, and summarize various designs of electrospinning apparatus. That is followed by reviewing the methods to prepare multifunctional composite ENMs, assorted into three categories, including modification in nanofibers, loading target molecules onto nanofibers surface, and implementing selective layers on the ENM surface. Comprehensive discussion about past achievements and current challenges regarding utilization of composite ENMs in water treatment are then provided. Finally, conclusions and perspective are stated according to reviewed progress to date.

Contents

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Nomenclature

1.3-DBP	1,3-dibromo propane
1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
AGMD	Air gap membrane distillation
AS-MBR	Active sludge MBR
BSA	Bovine serum albumin
CA	Cellulose acetate
CNTs	Carbon nanotubes
DCMD	Direct contact membrane distillation
DEAE	Diethylaminoethyl
E. coli	Escherichia coli
ECH	Epichlorohydrin
EMBR	Extractive membrane bioreactor
ENMs	Electrospun nanofibrous membranes
EO	Engineered osmosis
f-CNTs	Functionalized carbon nanotubes
FO	Forward osmosis
F-PBZ	Fluorinated polybenzoxazine
GA	Glutaraldehyde
GO	Graphene oxide
GS	Gas separation
ICP	Internal concentration polarization
IP	Interfacial polymerization
LbL	Layer-by-layer self-assembly
MBR	Membrane bioreactor
MD	Membrane distillation
MF	Microfiltration
MWCNTs	Multiwalled CNTs
MWCO	Molecular weight cut-off
NF	Nanofiltration
PA	Polyamide
PAN	Polyacrylonitrile
PCL	Polycaprolactone
PDMS	Polydimethylsiloxane
PDT	Poly(dodecylthiophene)
PE	Polyethylene
PEI	Polyetherimide
PEO	Poly(ethylene oxide)
PES	Polyethersulfone
PET	Polyethylene terephthalate
PLA	Poly(L-lactide)
PP	Polypropylene
PPy	Polypyrrole
PRO	Pressure retarded osmosis
PS	Polystyrene
PSU	Polysulfone
PTFE	Polytetrafluoroethylene
PU	Polyurethane
PVA	Polyvinyl alcohol
PVC	Polyvinyl chloride
PVDF	Polyvinylidene fluoride
PVP	Poly(vinylpyrrolidinone)
RH	Relative humidity
RO	Reverse osmosis
S. aureus	Staphylococcus aureus
SEM	Scanning electron microscope
SF	Silk fibroin
SGMD	Sweeping gas membrane distillation
SWCNTs	Single-walled CNTs
TBT	Tributyltin
TFC	Thin film composite
TF-MBR	Trickling MBR
TFNC	Thin film nanofiber composite
TMC	Trimesoyl chloride
TPC	Terephthaloyl chloride
UF	Ultrafiltration
UV	Ultraviolet
VMD	Vacuum membrane distillation
WK	Wool keratose

1. Introduction

Water is essential for survival and well-being of humans, and therefore ensuring sufficient water resources is crucial. However, it has been reported that more than 80 countries around the world encounter severe water shortage and about 25% of the population do not have adequate access to fresh water with satisfactory quantity and quality [1]. In addition, water scarcity is exacerbated by growing population and rapid economic development. Construction of massive infrastructure in the form of pipelines, aqueducts and dams dominated the water agenda in the 20th century, offering tremendous benefits to billions of people [2]. But these approaches for water management, reservation and transportation are not enough to address the water crisis. More fresh water resources should be provided by treating wastewater and desalinating seawater to fulfil the growing water demands.