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Mini Review

Recent Advances in Graphene based Membrane for Water Desalination

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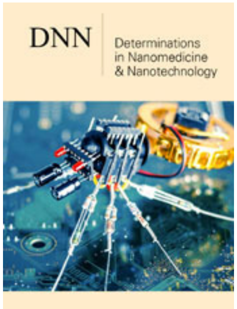

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Abstract

"The world is thirsty", this sentence has spread widely in most scientific events. According to forecasts based on population data reported by the World Bank and FAO's AQUASTAT database of freshwater availability, it appears that by 2050, 2 billion people living in 44 countries are likely to suffer from water scarcity. Hence, research has focused on developing accurate solutions to provide fresh waters. Currently, the desalination technologies have been presented as an efficient alternative to solve water scarcity. In this perspective, nano porous materials have a lot to offer compared to existing desalination technologies. Herein, the authors provide a mini-review presenting recent advances in the use of graphene in desalination and water purification fields, as well as the various challenges and opportunities to guide future studies in this field.

Keywords: Water treatment; Desalination; Graphene; Water purification

Abbreviations: RO: Reverse Osmosis; ED: Electrodialysis; NF: Nanofiltration

Introduction

Nowadays, membrane technologies are experiencing a revolution and considerable progress in desalination, purification and separation applications [1]. In this context, Reverse Osmosis (RO) as a membrane technology was mainly introduced to treat brackish water in the 1970s [2]. Nevertheless, advances in membrane technology and nanomaterials have allow the use of the RO technology for seawater applications [3]. Interestingly, membrane-based technologies, including RO, Electrodialysis (ED), and Nanofiltration (NF), have become the most dominant technologies for water desalination [4]. However, these technologies suffer from several issues such as the environmental impact, water permeability, high capital cost, and membrane scaling, fouling, and deterioration [2]. In this regard, research has tended to develop a new material, for desalination membranes, with excellent chemical stability, advantageous dimensional selection characteristics. Since it discovers in 2004, graphene has attracted a great interest due to its unique properties citing physical, mechanical, thermal and optical properties, which have been highlighted in most areas of science and engineering [3,5]. Besides, several attempts towards the development of graphene-based membranes have been described in literature. Hence, the number of investigations has drastically increased from about 810 publications in 2004 to more than 7,77000 publications in 2022 [6]. Furthermore, the reported findings demonstrated that nano porous graphene and its derivatives can be ideal two-dimensional nanomaterials candidates to developed reverse osmosis membrane with enhancement desalination performances such as salt rejection and water flow [7]. Moreover, they revealed the ability to remove several issues arose with conventional water purification or desalination methods. Interestingly, the architecture of the graphene surface can allow extremely high-water retention rates, high levels of flux, and a low potential for fouling, because nanopores are the only translocation pathways for water and ions [8].

Recently, it has been demonstrated that the simplest protocol for preparing the graphene-based desalination membrane is to create nanoscale pores in the graphene layer [9,10]. Indeed, this is because water can penetrate nanometer-sized pores, while salt ions that are larger than water molecules cannot, due to the ultra-thin thickness of the membrane [8]. More interestingly, a complete salt rejection has been proven to be possible using hydroxylated graphene membrane pores with a diameter of 0.45nm [11]. It is worth noting that porous graphene sheet needs to be transferred to a substrate such as silicon nitride and ceramics to be used as a membrane for desalination [12]. However, many reports have described that transferring graphene nanomaterials to a substrate is the most delicate step that damages the membrane. Thus, final electron microscopy imaging is strongly recommended to determine if a tear has occurred after transfer. Besides, the exposition of the membrane to an oxygen plasma etching or ion bombardment create controllable pores in graphene sheets by removing carbon atoms from the lattice, with larger and higher density of pores [8].

Conclusion

Graphene derivatives-based desalination membranes are currently considered the next-generation membranes that are inexpensive, sufficiently stable, and highly selective while being high permeability. A general agreement behind the fabrication of graphene-based membranes is to use a very thin, solid and stable material with calibrated flow passages to provide high water flows while collecting impurities.

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