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Graphene oxide: an alternative to graphene that ought to be explored in water purification, treatment and desalination means

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From its first isolation almost 20 years ago, graphene has caught the attention of many researchers and innovators [1,2], owing to its exceptional physical, mechanical, and electrical as well as its high aspect ratio and 2-dimensionality. This means that there are varied applications and devices that can be manufactured from graphene and operated at high efficiency including as a membrane material in water purification and desalination. However, significant modifications such as the instigation of nanopores ought to be undertaken and economically this instigation of nanopores hinders its commercialization in this realm [3-5]. Currently, both top-down and bottom-up approaches exist in producing graphene however, to date, large-scale production of high-quality graphene is proving to be a challenge [6].

Nonetheless, graphene oxide (GO) is proving to be a significant substitute in many applications as it can be fabricated in a facile manner at an industrial scale [7]. With a very large aspect ratio, hydrophilicity and 2-Dimentionality GO is an excellent candidate as a separation desalination and purification membrane [8]. Its use, however, is still in its primary stage of research and more understanding of the performance and separation mechanisms ought to be undertaken. Moreover, challenges pertaining to its use as a separation membrane ought to be identified and alleviated to produce efficient and reliable separation membranes and absorbents. Among the key challenges in its use now is the widening of the membrane pore-gap (tortuous gap) from the accumulation of water molecules onto the hydrophilic oxygenated functional groups. [9,10]. It is therefore fundamental to modify the GO membranes to ensure their efficient use over time.

Various attempts are currently being undertaken to try to enhance the GO membranes for performance as a separation membrane by countering the pore-gap widening problem. For instance, Huang et al. looked at how chemically reducing the GO membranes to remove the oxygenated functional groups that entrap water molecules can improve performance [11]. Despite the improvement in solute rejection rate, reducing the concentration of hydrophilic oxygenated functional groups resulted in reduced water contact angle culminating in reduced flux which is counterproductive, especially at industrial scale [12,13]. Abraham et al. also used the nanosheet physical confinement through the use of an epoxy encapsulant [14]. However, despite excellent sodium chloride removal at 99% efficiency, the main challenge with this method is scalability for mass production [14]. Other attempts to enhance the performance of these graphene oxide membranes continue to be undertaken including the incorporation of crosslinkers to interconnect the graphene oxide sheets and thus alleviating the pore-gap widening problems.

A key advantage to the use of graphene oxide in the realms of water purification and desalination is that it offers mechanical strong, hydrophilic separation membranes that offer high solute rejection and flux. It can be fabricated in a facile economic manner [15]. Significantly, different precursors/raw materials to graphene oxide exist, these include most high-grade carbon-containing materials such as coal, graphite, and even coconut shells [16]. This is advantageous, especially to the developing countries of Sub-Sahara Africa with abundant raw materials for the production of graphite and potentially graphene oxide.

Additionally, there are other significant applications of graphene oxide ranging from use as a nanofiller to strengthen the mechanical and chemical properties of polymers, as a flame-retardant agent, and also sporadically as an anticorrosive and antimicrobial coating. It can thus be explored beyond the realms of separation membranes in water purification and other applications as a significant replacement for pristine graphene [17].

Disclosure statement

No potential conflict of interest was reported by the author.

References

1. Randviir EP, Brownson DA, Banks CE. A decade of graphene research: production, applications and outlook. Mater Today. 2014;17(9):426-432.
2. Novoselov KS, Geim AK, Morozov SV, Jiang DE, Zhang Y, Dubonos SV, et al. Electric field effect in atomically thin carbon films. Science. 2004;306(5696):666-669.
3. Kandjou V, González Z, Acevedo B, Munuera JM, Paredes JI, Melendi-Espina S. Influence of graphene oxide's characteristics on the fabrication and performance of crosslinked nanofiltration membranes. J Taiwan Inst Chem Eng. 2021;119:158-165.
4. Kandjou V, Perez-Mas AM, Acevedo B, Hernaez M, Mayes AG, Melendi-Espina S. Enhanced covalent p-phenylenediamine crosslinked graphene oxide membranes: Towards superior contaminant removal from wastewaters and improved membrane reusability. J Hazard

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Mater. 2019;380:120840.
5. Ma J, Ping D, Dong X. Recent developments of graphene oxide-based membranes: A review. Membranes. 2017;7(3):52.
6. Poh HL, Šaněk F, Ambrosi A, Zhao G, Sofer Z, Pumera M. Graphenes prepared by Staudenmaier, Hofmann and Hummers methods with consequent thermal exfoliation exhibit very different electrochemical properties. Nanoscale. 2012;4(11):3515-3522.
7. Hummers Jr WS, Offeman RE. Preparation of graphitic oxide. J Am Chem Soc. 1958;80(6):1339.
8. Kandjou V, Hernaez M, Casal MD, Melendi-Espina S. Crosslinked graphene oxide membranes: Enhancing membrane material conservation and optimisation. J Taiwan Inst Chem Eng. 2022;136:104434.
9. Zheng S, Tu Q, Urban JJ, Li S, Mi B. Swelling of graphene oxide membranes in aqueous solution: characterization of interlayer spacing and insight into water transport mechanisms. ACS Nano. 2017;11(6):6440-6450.
10. Mo Y, Zhao X, Shen YX. Cation-dependent structural instability of graphene oxide membranes and its effect on membrane separation performance. Desalination. 2016;399:40-46.
11. Huang L, Chen J, Gao T, Zhang M, Li Y, Dai L, et al. Reduced graphene oxide membranes for ultrafast organic solvent nanofiltration. Adv Mater. 2016;28(39):8669-8674.
12. Abdolhosseinzadeh S, Asgharzadeh H, Seop Kim H. Fast and fully-scalable synthesis of reduced graphene oxide. Sci Rep. 2015;5(1):10160.
13. Omidvar M, Soltanieh M, Mousavi SM, Saljoughi E, Moarefian A, Saffaran H. Preparation of hydrophilic nanofiltration membranes for removal of pharmaceuticals from water. J Environ Health Sci Eng. 2015;13:1-9.
14. Abraham J, Vasu KS, Williams CD, Gopinadhan K, Su Y, Cherian CT, et al. Tunable sieving of ions using graphene oxide membranes. Nat Nanotechnol. 2017;12(6):546-550.
15. Tang L, Li X, Ji R, Teng KS, Tai G, Ye J, et al. Bottom-up synthesis of large-scale graphene oxide nanosheets. J Mater Chem 2012;22(12):5676-5683.
16. Zaaba NI, Foo KL, Hashim U, Tan SJ, Liu WW, Voon CH. Synthesis of graphene oxide using modified hummers method: solvent influence. Procedia Eng. 2017;184:469-477.
17. Homaeigohar S, Elbahri M. Graphene membranes for water desalination. NPG Asia Mater. 2017;9(8):e427.

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