Water Research 218 (2022) 118406

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Review

Potential of biocompatible calcium-based metal-organic frameworks for the removal of endocrine-disrupting compounds in aqueous environments

Fahren Fazzer Sukatis [a], Sze Yee Wee [a], Ahmad Zaharin Aris [a,b,*]

[a] Department of Environment, Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[b] International Institute of Aquaculture and Aquatic Sciences, Universiti Putra Malaysia, 71050 Port Dickson, Negeri Sembilan, Malaysia

ARTICLE INFO

Keywords:
Calcium-based
Metal-organic framework
Endocrine-disrupting compounds
Adsorption

ABSTRACT

Rapid urbanization, industrialization and population growth have accelerated the amount and variety of emerging contaminants being released into the aqueous environment, including endocrine-disrupting compounds (EDCs). The introduction of these compounds constitutes a threat to human health and the environment, even at trace levels. Hence, new water treatment technologies are urgently required to effectively remove EDCs from water. The currently available technologies used in water remediation processes are expensive and ineffective, and some produce harmful by-products. Calcium-based metal-organic frameworks (Ca-MOFs) are porous synthetic materials that can potentially be applied as adsorbents. These MOFs are hydrolytically stable, biocompatible and low-cost compared with conventional porous materials. The structure of Ca-MOFs is maintained even though calcium metal centers in the structure can easily coordinate with water. Ca-MOFs and their composite derivatives have the potential for use in water purification because these biocompatible adsorbents have been shown to selectively extract a significant quantity of contaminants. This review highlights the potential of Ca-MOFs to adsorb EDCs from aqueous environments and discusses adsorbent preparation methods, adsorption mechanisms, removal capacity, water stability and recyclability. This review will support future efforts in synthesizing new biocompatible MOFs as an environmental treatment technology that can effectively remove EDCs from water, thereby improving environmental and human health.

1. Introduction

As the world population increases, water has become a crucial resource for domestic, commercial and industrial uses. These activities can lead to increased levels of contaminants being discharged. Various types of contaminants are found in water bodies, including endocrine-disrupting compounds (EDCs) (Schuwirth et al., 2018). Most EDCs originate from consumer products such as pesticides, personal care products, plastics and detergents (Liu et al., 2019a–c). These compounds are chemically active and can harm humans and animals by impacting the central nervous system and reproductive system (Wee and Aris, 2017). Even at trace levels, EDCs have a strong effect on the endocrine system and can bioaccumulate in the body (Ismail et al., 2017; Jun et al., 2019; Puma et al., 2010). EDCs constitute a wide range of both natural (e.g., hormones) and synthetic (e.g., industrial by-products) exogenous and emerging chemicals (Wee and Aris, 2017). EDCs are released into the environment through sewage systems and can then be taken up by organisms (Ismail et al., 2017). Fig. 1 depicts the sources and transport of EDCs through the environment before being taken up by humans. Numerous types of EDCs (Table 1) have been detected in wastewater treatment plant discharge and water bodies, such as pharmaceuticals and medical drugs (e.g. propranolol, ibuprofen and diclofenac), steroid hormones (e.g. testosterone, progesterone, 17β-estradiol and 17α-ethynylestradiol), polyhalogenated compounds (e.g. perfluorooctanoic acid and perfluorooctanesulfonic acid) and phenolic compounds (e.g. bisphenol A, bisphenol S and bisphenol F). These compounds are difficult to remove due to their hydrophobic characteristic and resistance to biodegradation (Jun et al., 2019; Joseph et al., 2019; Aris et al., 2014; Zuo et al., 2013).

Water treatment plants play a vital role in controlling the fate and transport of EDCs in the aquatic environment. These compounds can easily flow through the treatment system and are discharged into the environment without being removed by the treatment process (Can et al., 2014). Therefore, it is urgent to monitor the concentration of EDCs in the water system. Analytical instrumentation is often applied to detect EDCs present in water samples upon discharge (Kasonga et al., 2021;

* Corresponding author at: Department of Environment, Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
E-mail address: zaharin@upm.edu.my (A.Z. Aris).

https://doi.org/10.1016/j.watres.2022.118406
Received 23 December 2021; Received in revised form 28 February 2022; Accepted 4 April 2022
Available online 10 April 2022
0043-1354/