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Magnetic ion exchange: Is there potential for international development?

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Abstract

Magnetic ion exchange (MIEX®) is an ion exchange resin developed as an additive to existing water treatment plants where additional organic matter is to be removed. The smaller size, magnetic properties and simple regeneration using NaCl distinguishes MIEX® from conventional ion exchange resins and hence its use in international development applications is investigated in this review article. MIEX® has been demonstrated to remove varying levels of dissolved organic matter, inorganic anions such as nitrate and sulphate and micropollutants including non-ionic pesticides. The removal efficiency can also be influenced by temperature, pH and presence of other anions. As MIEX® is unable to disinfect water, the most likely application within international development is as pre-treatment before disinfection or membrane filtration.

Keywords: Magnetic ion exchange; International development; Natural organic matter removal; Micropollutant removal

1. Introduction

Magnetic ion exchange (MIEX®) is a strong base anion exchange resin with magnetic properties that can be used to adsorb weak organic acidic ions from water [1]. The magnetic properties differentiate it from other ion exchange resins, as it allows for faster resin agglomeration and recovery [2]. The resin was developed with the purpose of removing dissolved organic carbon (DOC) from drinking water supplies [3]. While DOC by itself is relatively harmless, problems can occur when DOC is combined with chlorine, a common drinking water disinfectant, or bromide as they can form disinfection by-products (DBP), which are potential carcinogens [2]. In addition, the removal of DOC from water reduces the need for residual disinfection of bacterial regrowth during distribution, as well as customer complaints relating to taste, odour and colour of the water [4].

The objective of this paper is to review potential applications of this ion exchange resin in international development. One of the main problems facing international development is the provision of safe drinking water, with over 1.1 billion people lacking access to this basic need [5]. Waterborne diseases, associated with pathogenic bacteria, viruses and protozoa, are the

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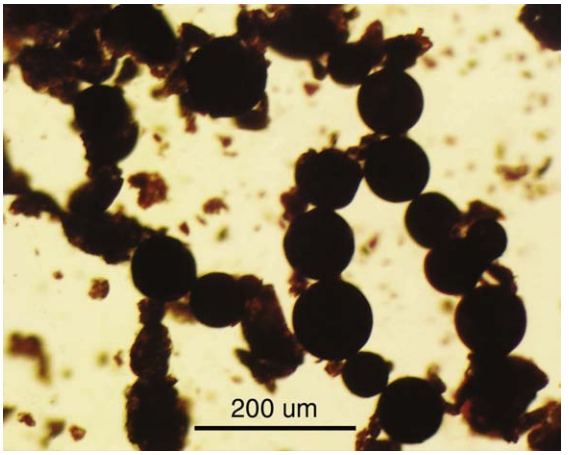

Fig. 1. Light microscope image of MIEX® resin.

most common cause of illness and death related to water and sanitation within developing countries [6]. Therefore, improved microbiological safety through the removal of pathogens is essential for international development. While MIEX® cannot be used to disinfect or physically remove bacteria or viruses, it can remove DPB precursors, reduce chlorine demand, and therefore reduce DPB risk [7]. In addition, it can be coupled with disinfection processes such as ozonation or membrane filtration such as ultrafiltration (UF).

This review will describe the principles of MIEX® and focus on its applicability to international development by discussing its ability to remove DOC, as well as a range of inorganic and organic contaminants from water and examine the possibility of MIEX® integration with existing water treatment options. The issue of brine waste disposal options will conclude the paper.

2. Process principles

2.1. Resin characteristics

MIEX® is an anionic exchange resin which consists of a magnetic core with a polymer shell (Fig. 1) [8]. The polymer, polyacrylate, is macroporous and contains quaternary amide functional groups, which assist with DOC removal through ion exchange [9]. MIEX® differs from traditional ion exchange resins due to its small size and magnetic properties. These changes were implemented to maximise organic removal and resin reuse. The resin beads have a mean diameter of 150–180 μm which is approximately 2–5 times smaller than other ion exchange resins [10]. As a result it has an increased surface area to volume ratio compared to other resins, meaning there are more exchange sites which increases exchange kinetics, therefore more DOC can be removed [2,7]. The magnetic core enables fast agglomeration and settling of resin particles, and this leads to high (up to 99.9%) resin recovery rates [11].

2.2. Adsorption and desorption

Adsorption and desorption are the chemical reactions that allow the process to function (Fig. 2). The

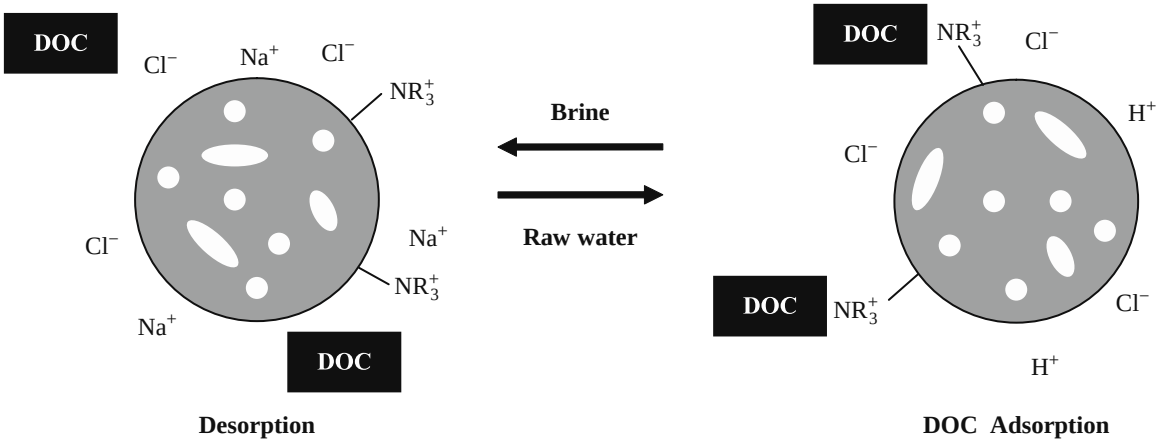

Fig. 2. MIEX® adsorption and desorption chemistry with NR_3^+ representing the quaternary amide exchange sites (adapted from [15]).