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Amine functionalized magnetic nano-composite materials for the removal of selected endocrine disrupting compounds and its mechanism study

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ABSTRACT

A novel adsorbent successfully synthesized using recyclable silica, nano magnetite and N1-(3 trimethoxisilylpropyl) diethylenetriamine (TRIS) denoted as MNCMT. Three endocrine disrupting compounds (EDCs) such as bisphenol A (BPA), ibuprofen (IBP) and clorofibric acid (CFA) were selected as model drugs for this study. The sorption capacities of EDCs by MNCMT were found to be 182.6 mg g^{-1} for BPA, followed by CFA at 101.8 mg g^{-1} and 72.6 mg g^{-1} for IBP. The removal process matched with Langmuir isotherm and pseudo second order kinetic models with determination coefficient (R^2) above 0.99. The adsorbent was regenerated, recovered and reused for multiple cycles of adsorption. The physical-chemical properties and experimental data revealed that the chemical sorption is more dominant than physical sorption. Hydrogen bonding, π-π and electrostatic attractions provide intrinsic information on the removal mechanism.

1. Introduction

Endocrine disrupting compounds (EDCs) is an exogenous substance that alter the functions of the endocrine system and causes adverse health effects in an intact organism or population [1–4]. Hospitals, landfills, domestic wastes and agricultural discharges are major sources of EDCs. These sources have been reported to contain various concentrations of EDC ranging from nano to micrograms per liter. [5–7]. Contamination of EDCs are mostly non–biodegradable and causes serious environmental problems once it combines with the nearest rivers, lakes, and ponds, made it worst as its concentrations kept increasing. [8].

EDCs such as bisphenol A (BPA), ibuprofen (IBP) and clofibric acid (CFA) were found in various aqueous system [9–11]. BPA considered as one of the most critical EDCs because it induces infertility and impotency [2,12,13]. IBP, a non-steroidal anti inflammation drug (NSAID) and CFA a drug metabolites, both have toxicity effect and detected in many water sources [14–17].

Conventional methods such as coagulation, flocculation and sedimentation have failed to remove EDCs in water [11,18,19]. There have been many attempts to develop and apply technologies such as biological treatment, advanced oxidation, precipitation, membrane filtration, ion exchange and adsorption for the removal of EDCs. [2,11,18,20]. Biological treatment is slow and require optimum pH and temperature but failed to remove the EDCs completely, while advance oxidation process (AOPs) are energy intensive, burdened by expensive equipment investment and produces toxic by-products [11,21].

Scientists and engineers have diverted their focus on adsorption because it was found to be more practical and economical. [22,23]. New and innovative adsorbents with higher sorption rate and capacity were preferred because they have longer lifespan, cost efficient and reusable. Regeneration and reusability were additional requirements, which could enhance the adsorption process and reduces the operational and maintenance cost [17].

Nano structured adsorbents (NSA) were favored due to their bottle neck features, high surface area and large pore volume to remove pollutants [24,8,17]. However, due to their fine sizes, the release of micro-pollutants retained NSAs to the environment could cause secondary pollution and health hazards [8]. Silica based nano-structured adsorbents (NSAs) such as Santa Barbara Amorphous compound (SBA-15) and Mobil composition of matter (MCM-41) proven to have good removal affinities for EDCs [8,25].

Instead of expensive filtration application, development of effective magnetic adsorbent coupled with a magnetic separation system could be a better alternative to recover and reuse the adsorbent [26]. In recent literature, SBA-15 and MCM-41 has reported to form biomolecules

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