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Rapid and efficient removal of estrogenic pollutants from water by using beta- and gamma-cyclodextrin polymers

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Abstract:

The existence of estrogenic hormones in water systems has a potential adverse impact on the environment and public health. Cyclodextrin (CD) can encapsulate small molecules to form host-guest complexes with high stability; thus, it is being applied to remove pollutants in water systems. Beta-cyclodextrin (β-CD) and gamma-cyclodextrin (γ-CD) have different cavity diameters, which directly affect their inclusion ability. Therefore, it`s predicted that there may be a certain difference in the adsorption performance of β-CD- and γ-CD-based polymers. In this study, mesoporous polymers of β-CD and γ-CD were prepared, and their adsorption efficiency on estrogen pollutants, including 17β-estradiol (E2), 17α-ethinylestradiol (EE2), and bisphenol A (BPA), at environmentally relevant concentrations was investigated. The results indicated that both β-CD polymer (β-CDP) and γ-CD polymer (γ-CDP) exhibited rapid and efficient removal of the three estrogens and maintained high performance after regeneration. The adsorption processes fitted well with the pseudo-second-order and Langmuir isothermal adsorption model. γ-CDP exhibited better adsorption ability on E2 and EE2 than β-CDP. These phenomena were further clarified by the inclusion mechanism between CDs and estrogens gained from Job's plot and molecular docking. β-CD can only embed one estrogen molecule in its cavity, whereas γ-CD can embed two E2 or EE2 molecules due to its larger cavity. In addition, both β-CDP and γ-CDP can efficiently remove other estrogens such as estrone, estriol, diethylstilbestrol, octyl phenol, and nonylphenol. This study showed the potential of CD polymers, especially γ-CDP, in rapidly and efficiently removing estrogen pollutants.

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