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Enrichment of polychlorinated biphenyl 28 from aqueous solutions using Fe_3O_4 grafted graphene oxide

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HIGHLIGHTS

- Using Fe_3O_4@GO as the sorbent of MSPE.
- The first time using Fe_3O_4@GO to adsorb trace levels of PCBs in water samples.
- Investigation of Fe_3O_4@GO's adsorption characteristics and sorption isotherm.
- Establishment of a highly selective and sensitive MSPE–GC–MS analytical method.

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ABSTRACT

In this paper, Fe_3O_4 nanoparticle (Fe_3O_4 NPs) grafted graphene oxide (Fe_3O_4@GO), are successfully synthesized and used for the extraction of 2,4,4′-trichlorobiphenyl (PCB 28) from a large volume of water solution. With the magnetic solid-phase extraction (MSPE) technique based on the Fe_3O_4@GO sorbents, it requires only 30 min to extract trace levels of PCB 28 from 200 mL water samples. The Fe_3O_4@GO was analyzed by using powder X-ray diffraction (XRD), transmission electron microscopy (TEM), Fourier Transform infrared (FT-IR) spectroscopy, and Vibrating sample magnetometer (VSM), specific surface area analyzer. The adsorption kinetics, adsorption capacity of the adsorbent, and the effect of the solution pH and desorption conditions on the removal efficiency of PCB 28 were investigated. The second-order kinetic equation best describes the sorption kinetics. The results showed that Fe_3O_4@GO was a suitable material in the pre-concentration and immobilization of PCB 28 from large volumes of aqueous solutions in polychlorinated biphenyl pollution cleaning.

1. Introduction

Polychlorinated biphenyls (PCBs) are a class of chlorinated aromatic hydrocarbon chemicals that are now known as a part of the persistent organic pollutants (POPs) [1]. The occurrence of polychlorinated biphenyls (PCBs) in water systems is currently a major problem of global concern because of their harmful impact on ecosystem health and on the safety of human food supplies [2]. Moreover, PCBs are an example of the typical persistent organic toxins present in the natural environment ubiquitously, and they are highly toxic, resistant to degradation, and have the property of high bioaccumulation [3]. Therefore, the determination of trace PCBs in water samples turned out to be a great challenge due to the poor aqueous solubility of PCBs. The effective enrichment and identification of lowly concentrated PCBs in the environment is attracting a great deal of research attention due to human health concerns [4–9]. Low chlorinated PCBs are significant for the evaluation of the transport and overall fate of PCBs because of their relatively high aqueous solubility [10]. Herein, 2,4,4′-trichlorobiphenyl (PCB 28), a primary congener of toxic PCBs in the environment, is selected as the model substance to investigate the sorption properties of PCBs.

In recent years, a new procedure for SPE, based on the use of magnetic or magnetically modified adsorbents called magnetic solid-phase extraction (MSPE), has been developed [11]. The magnetic adsorbents have emerged as a new generation of materials for environmental decontamination since magnetic separation simply involves applying an external magnetic field to extract the adsorbents. So the separation process in MSPE can be performed directly in crude samples containing suspended solid material without the need of additional centrifugation or filtration, which makes separation easier and faster [12,13]. At the same time, loading of the magnetic nanoparticles can avoid or decrease the possibility of serious agglomeration and restacking of the graphene sheets.

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