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Hierarchical porous NiO architectures as highly recyclable adsorbents for effective removal of organic dye from aqueous solution

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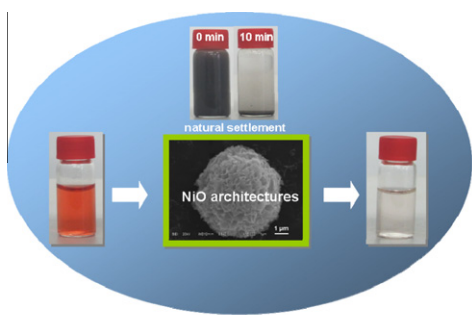
HIGHLIGHTS

- ▶ Hierarchical porous NiO architectures were successfully synthesized.
- ▶ NiO architectures were used for the efficient removal of Congo red in water.
- ▶ The kinetics and isotherm of the adsorption process were studied.
- ▶ Facile solid/liquid separation and regeneration were achieved.

GRAPHICAL ABSTRACT



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ABSTRACT

Hierarchical porous NiO architectures were successfully synthesized by a facile additive-free solvothermal route combining a calcination process. The as-prepared porous architectures were characterized by X-ray diffraction (XRD), scanning electronic microscopy (SEM), X-ray energy dispersive spectroscopy (EDS), Fourier transform infrared spectroscopy (FTIR), and nitrogen adsorption–desorption techniques. The NiO architectures exhibited the excellent performance for the removal of Congo red (CR) from aqueous solution. The kinetics and isotherm of adsorption process were determined and modeled in detail, which were found to obey the pseudo-second-order kinetics and Freundlich isotherm model, respectively. Moreover, NiO architectures can be recycled by a facile solid/liquid separation followed by a simple heat treatment, which could retain the high removal efficiency in three successive cycles. This study suggests that hierarchical porous NiO architectures could be explored as a new adsorbent with high efficiency and recyclability for removing organic dye pollutants from aqueous solution.

1. Introduction

Increasing worldwide water pollution has become one of the serious environmental problems facing global society. In particular, the discharged organic dyes from various industries can cause severe health problems in animals and human beings, since they are poorly biodegradable and fairly stable to light and heat [1]. Therefore, the efficient removal of organic dye pollutants from water has become a crucial issue from an environmental viewpoint. For this reason, various methods have been developed to treat the dye-containing wastewater, including ion-exchange [2], coagulation/flocculation [3], adsorption [4], chemical oxidation [5], ozone treatment [6], membrane filtration [7] and photocatalysis [8]. Among them, adsorption is efficiency, versatility and convenience for the treatment of pollutants at high concentrations. To date, a variety of materials have been developed as adsorbents for this purpose, including activated carbon [9], zeolite [10], clay [11], polymer [12], and byproduct [13]. However, these conventional adsorbents suffer from either the limited adsorption capacity or the low

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