Microwave-assisted preparation of pumpkin seed hull activated carbon and its application for the adsorptive removal of 2,4-dichlorophenoxyacetic acid

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HIGHLIGHTS

► Highlight the renewable use of pumpkin seed hull.
► Explore the potential of microwave irradiation.
► Short activation time of 12 min.
► To evaluate the adsorptive removal of 2,4-dichlorophenoxyacetic acid (2,4-D).
► Maximum monolayer adsorption capacity for 2,4-D of 260.79 mg/g.

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ABSTRACT

This study explores the feasibility of pumpkin seed hull as a potential raw precursor for preparation of mesoporous activated carbon by microwave induced KOH activation. The pumpkin seed hull activated carbon (PSHAC) was characterized by pore structural analysis, zero-point-of-charge, Fourier transform infra-red spectroscopy and scanning electron microscopy. The adsorptive performance of PSHAC was quantified using pesticide, 2,4-dichlorophenoxyacetic acid (2,4-D) as model adsorbate. The effects of contact time, initial concentration, and solution pH on the adsorption process were evaluated. Results indicated high percent of removal, with the adsorptive removal of 98.28%, 97.57%, 96.03%, 93.40%, 78.11% and 65.07% at the initial concentration 50, 100, 150, 200, 300 and 400 mg/L, respectively. Kinetic studies showed that the adsorption process was well described by the pseudo-second-order kinetic model. The adsorption isotherm was analyzed using the nonlinear Langmuir, Freundlich and Temkin isotherm models. The best fit was obtained with the Temkin isotherm model, predicting a uniform distribution of binding energy over the heterogeneous surface binding sites. The maximum monolayer adsorption capacity of 2,4-D for PSHAC was identified to be 260.79 mg/g.

1. Introduction

Activated carbon adsorption is a widely used technique for the removal of organic and inorganic pollutants from the water and gases environment due to the high surface area, porosity and specific surface chemistry [1]. Despite its prolific use in water treatment, a major limitation of the use of activated carbon is the high cost of solid adsorbent. A developing research interest to establish the production of activated carbon from low cost and renewable precursors has been witnessed [2,3]. It was shown that the textural properties of the prepared activated carbons depend primarily on the specific precursor and the preparation method [4,5]. In this regard, the abundance and availability of agricultural by-products make them a good choice as this will reduce the cost of waste disposal and provide an effective solution to environmental problems [6].

Pumpkin seeds, also known as pepitas, are small, flat, green, and edible seeds. It is usually served as snack that can be found hulled or semi-hulled at most grocery stores [7]. The pumpkin seeds oil, made by pressing the roasted, hulled pumpkin seeds, is today an important export commodity of Austria and Slovenia. The refining process however, is accompanied by the co-production of pumpkin seed hull [8]. This urged research towards upgrading of the available biomass from the oil refineries. To our best knowledge, the preparation of activated carbon by pumpkin seed hull (PSH) has not been attempted.

Microwave technology is gaining importance as a promising technology for research and industrial applications [9,10].