



Synthesis and evaluation of activated carbon from rice husks for removal of humic acid from water

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Abstract

Activated carbon was synthesized from the New Rice for Africa (NERICA) rice husk variety, followed by its evaluation for removal of humic acid from water. Product values of carbon yield, C and total specific surface area, $a_{s,BET}$ were employed as the performance criterion. The best physically activated carbon resulted from char activation at 800 °C for 10 min, leading to $a_{s,BET}$ and $C \times a_{s,BET}$ values of 756.8 and 402.7 m² g⁻¹, respectively. The best chemically activated carbon resulted from 30 wt% H₃PO₄ activation of rice husk at 400 °C for 30 min, leading to $a_{s,BET}$ and $C \times a_{s,BET}$ values of 2258.4 and 1058.7 m² g⁻¹, respectively. Despite the higher $a_{s,BET}$ value, the maximum adsorption capacity of the best chemically activated carbon (5.3 mg g⁻¹) was found lower than 8.9 and 27.2 mg g⁻¹ exhibited by the chemically activated carbons prepared at 500 and 600 °C, respectively. The best adsorption conditions included carbon dose of 0.5 g, solution pH of 2, and contact time of 60 min. The adsorption capacity of the prepared activated carbons (27.2 mg g⁻¹) was comparable to that of the commercial activated carbon (30.40 mg g⁻¹). The analyses of the adsorption isotherms and kinetics revealed that the experimental data fits well the Langmuir isotherm model, as well as the pseudo-second-order kinetic model. The latter suggests that the adsorption of humic acid onto the activated carbon was controlled by the chemisorption process. Overall, the study revealed that the NERICA rice husk variety has good prospects for preparation of activated carbons for humic acid adsorption.

Keywords NERICA 1 · Rice husk variety · Activation · Activated carbon · Humic acid · Adsorption

Highlights

- NERICA 1 rice husk (RH) variety was physically and chemically activated.
- Steam activation of RH resulted in surface area as high as 1016.5 m² g⁻¹.
- H₃PO₄ activation of the RH resulted in surface area as high as 2258.4 m² g⁻¹.
- Carbon dose 0.5 g, pH 2, contact time 60 min found optimal to adsorb humic acid.
- Maximum adsorption capacity by the prepared activated carbons was 27.2 mg g⁻¹.

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1 Introduction

Humic acid constitutes the major fraction of natural organic matter (NOM) practically present in all drinking water sources. It is derived from decaying plant and animal biomass present in the aquatic and terrestrial environments [1]. Its presence in drinking water sources causes numerous problems in water treatment and distribution systems. For instance, humic acid reduces water quality by causing unpleasant odors, tastes, and color of drinking water, which forms metal complexes, making them harder to treat, promotes bacterial regrowth within water distribution systems, and interacts with chlorine, forming carcinogenic disinfection by-products (DBPs) harmful to human health [2, 3]. These, and many other human health concerns make humic acid removal from water, a critical process at the water treatment plants. Unfortunately, only 10–50% of the humic acid can be removed by the commonly employed conventional water treatment method, involving coagulation, flocculation, sedimentation, and filtration [4, 5]. More efficient methods are therefore needed to remove humic acid from water, including membrane separation [6], ion