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# Exploring the effects of pyrolysis time for biochar production from rice husk to be used in various environmental remediation applications

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Biochar considered a carbonaceous material obtained from thermal treatment of unwanted biomass under oxygen limited conditions. This paper aims to offer an insight to further understand the effect of pyrolysis time on biochar physicochemical characteristics and sorption capacity for the removal of a model dye compound such as Methylene Blue (MB) from aqueous solutions. Biochars were produced from pyrolyzing untreated rice husk (RH) at 850$^{o}$C for 1 (RH1), 2 (RH2), 4 (RH4), and 6 (RH6) h. Biochar yield, BET surface areas and pH values were monitored with pyrolysis time. Sorption experiments were performed with 3 mg of each biochar (sorbent) added in 20 mL of MB solution at a concentration of 20 mg/L. Biochar yield was reduced as the pyrolysis time increased. The highest biochar yield was 36% (RH1) and the lowest was observed for RH6 (26%). After 1 h of pyrolysis, the biochar yield is linearly decreased by 2% per h of extra pyrolysis. Biochar surface properties constitutes an important parameter for biochar applications such as catalysts supports or sorbents for water treatment. Based on the results, pyrolysis time is significant for these properties. Hence, the increase of pyrolysis time corresponds to an increase of pore volume and pore size. The t-plot disclose that the biochar pore volume increased from 0.15 to 0.28 cm$^3$/g as the pyrolysis time also increased from 1 to 6 h. Apart of the significant changes of biochar porosity, a noteworthy increase of specific surface area (SSA) was not observed. The SSAs of the tested biochars were 280, 354, 393, and 386 m$^2$/g for RH1, RH2, RH4, and RH6, respectively. Biochar produced from RH is alkaline in nature and as the pyrolysis time extended from 1 to 6 h the pH value was reduced, possibly due to the increase of ash content. More specifically, the pH values ranged from 10.3 (RH1) to 9.5 (RH6). At 24 h, the sorption capacities of RH1, RH2, RH4, and RH6 biochars were 6, 22, 32, and 38 mg/g, while at 8 days, that they reached equilibrium, the sorption capacities were increased to 16, 58, 125, and 127 mg/g, respectively. The sorption experiments disclosed the vital role of pyrolysis time on the sorption of MB. The RH biochars demonstrated different removal abilities which significantly increased as the pyrolysis time also increased from 1 to 4 h. RH4 and RH6 exhibited similar removal capacities, suggesting that 4 h pyrolysis time of untreated RH is enough time for yielding an optimum sorbent.

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