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Sludge-based activated carbon: Characterization and performance for removal of methylene blue from aqueous solution

by

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Abstract: Domestic wastewater treatment plants in the United Arab Emirates (UAE) produce 122 thousand tons of dried sludge annually. About 70% of this sludge is dumped in landfills. Sludge is an energy-rich organic material that could be converted into activated carbon by thermal or chemical processes. Potassium hydroxide has shown great potential as an activating agent for producing high-quality sludge based activated carbon (SBAC). However, its use adds to the cost of the production process. Thus, there is a need for an alternative activating agent that is not costly. One possible chemical is carbide lime

which is a by-product of acetylene production. The UAE produces about 4500 metric tons of waste carbide lime annually that ends up in landfills. Thus, this study aimed to assess the potential use of waste carbide lime for producing SBAC. The study also aimed at comparing the physiochemical and sorptive properties of SBAC produced with carbide lime and those produced using KOH. The study investigated the effect of activation temperature, activation time, impregnation ratio, and activating agent on porosity, surface area, surface chemistry, morphology, and sorption behavior. The results indicate that SBACs have a porous surface with irregular channels. The surface chemistry is also rich in polar and charged functional groups and cationic minerals which facilitate adsorption. Furthermore, comparison was made between the sorption behavior of produced SBACs towards methylene blue and that of commercial activated carbon. Results indicated that carbide lime is a viable alternative to KOH for SBAC production. Carbide lime produced the best sorbent for methylene blue for SBAC prepared at an activation temperature of 700 ^{o}C with a 1:1 impregnation ratio when activated for 60 min and post-treated with 5M HCl. Sorption studies for methylene blue removal showed that SBAC produced with carbide lime has a capacity of 255 mg/g. Rate studies showed that sorption of methylene blue could be adequately described by pseudo first order and pseudo second order rate models, indicating occurrence of chemosorption as well as physisorption. Equilibrium sorption of methylene blue on SBAC material is nonlinear and generally follows the Langmuir and Sips models. The maximum sorption capacity of SBAC generated with carbide lime is comparable to SBAC produced using KOH and commercial-activated carbon. Results of this study indicate that carbide lime could be a suitable replacement for KOH as an activating agent, and the produced SBAC can effectively be used to remove dyes from the waste stream. These findings could help in the waste management of sludge and carbide lime for treatment of contaminated wastewater. Future work could investigate the optimum conditions for production of SBAC using carbide lime and for methods of SBAC regeneration. Additional studies could investigate the use of SBAC activated with carbide lime for removal of emerging organic contaminants as well as inorganic contaminants.

Keywords: Activated carbon, sludge-based activated carbon, chemical activation, wastewater treatment, sorption studies, characterization, modeling