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Methylene blue adsorption onto swede rape straw (*Brassica napus* L.) modified by tartaric acid: Equilibrium, kinetic and adsorption mechanisms

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HIGHLIGHTS

- ▶ Swede rape straw modified by tartaric acid (SRSTA) is an efficient dye adsorbent.
- ▶ It is the first time to modify swede rape straw into bioadsorbent to remove dye.
- ▶ The dye adsorption capacity of SRSTA is high, competitive to activated carbon.
- ▶ The adsorption mechanism and kinetics were systematically investigated.

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ABSTRACT

The aim of this study was to develop a promising and competitive bioadsorbent with the abundant of source, low price and environmentally friendly characters to remove cationic dye from wastewater. The swede rape straw (*Brassica napus* L.) modified by tartaric acid (SRSTA) was prepared, characterized and used to remove methylene blue (MB) from aqueous solution at varied operational conditions (including MB initial concentrations, adsorbent dose, etc.). Results demonstrated that the equilibrium data was well fitted by Langmuir isotherm model. The maximum MB adsorption capacity of SRSTA was 246.4 $mg\ g^{-1}$, which was comparable to the results of some previous studied activated carbons. The higher dye adsorption capacity could be attributed to the presence of more functional groups such as carboxyl group on the surface of SRSTA. The adsorption mechanism was also discussed. The results indicate that SRSTA is a promising and valuable absorbent to remove methylene blue from wastewater.

1. Introduction

Every year, millions of tons of highly colored wastewater are discharged from different sources including plastic, textile, leather, cosmetics, paper-making, printing and dye manufacturing industries (Feng et al., 2011; Liu et al., 2012). It is very important to treat the colored synthetic compounds as they are hazardous to human being and environments. Methylene blue is one of the most important synthetic dyes that can negatively affect photosynthesis (Vargas et al., 2012). Many techniques, such as adsorption, coagulation, flocculation, oxidation, etc., have been developed to remove synthetic dyes from aqueous solutions (Somasekhara Reddy et al., 2012; Yu et al., 2012). Adsorption technology is one of the widely used treatment technologies to remove synthetic dyes from wastewater because of the negligible one-time investment, separation-easy and use-conveniently (Asgher and Bhatti, 2012).

Although activated carbon (AC) is regarded as the highest efficient adsorbent, it is too expensive to be employed in purifying dye-contaminated wastewater, especially in large scale waters (Chatterjee et al., 2011). Consequently, various low-cost adsorbents, such as crude biomass, chemically modified biomaterials and some industrial wastes were investigated in order to provide a competitive substitute for ACs in purifying the colored wastewater (Mahmoud et al., 2012; Piccin et al., 2012). But these low-cost adsorbents (e.g., crude biomaterials) were either inefficient in adsorption capacity (Zhou et al., 2011) or may cause more serious damage to the environment during the production (e.g., most chemical modified adsorbents) (Dawood and Sen, 2012; Rivera-Utrilla et al., 2011). Thereafter, to improve the adsorption capacity of crude bioadsorbents such as various agro-based straws and to lower the negative effects (such as HCl, NaOH, H_2SO_4, etc.) during the development of bioadsorbents, tartaric acid (TA), a carboxylic

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