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The comparison of charcoal activation processes to improve methylene blue adsorption for water treatment.

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Abstract: A series of charcoal activation processes was performed to absorb and remove methylene blue (MB) from synthetic solutions. The MB adsorption can also promote valuable measurements for charcoal activated processes evaluation. The higher activations efficiencies were obtained using potassium chloride, potassium carbonate and water stream. The activated charcoal removal percentages were 90, 88 and 79 % respectively, the surface coverage degree (Θ) 2.87, 5.72 and 6.04 % and surface area of 230.0, 145.0 and 121.9 (m^2/mg).

Keywords: adsorption, dye, charcoal activation, methylene blue

Introduction

There are more than 100.00 commercially available dyes in the market and over 7.105 tones of different kinds of dyes are produced annually. The water discharge represents acute and chronic problems due their high toxicity, carcinogenic properties. The MB adsorption calculations can also be used to perform the comparison of charcoal activation processes efficiency. Some charcoal activation processes were indicated in literature, Table 1. In literature, was also found the activation agent zinc chloride and phosphoric acid, but they were not considered due the high toxicity of Zn, as toxic metal, and phosphate high commercial cost. The adsorbed quantity of MB is proportional of the total carbon surface area. The 0.254 mg of adsorbed MB/m^2 an indication area of 20.8 10^{-2} nm^2 for MB molecule (Zhou, 2006)

Table 1. In literature the comparison of surface area obtained for different charcoal activation processes.

Activation Agent	Surface area (m^2 g^{-1})	References
K_2CO_3	1.065	MESTRE *et al* (2011)
Steam	1.185	ALTENOR *et al* (2009)
H_3PO_4	1.272	ALTENOR *et al* (2009)
$ZnCl_2$	1.249	KHALILI, N. R. et al (2000)

Langmuir isotherm calculations can be used to quantify and characterize the adsorption processes, Eq. I and II. The calculation of surface coverage degree (θ) of the activated charcoal can indicate with activation process was more efficient.

$$C_e/q_e = 1/K_L + (b_L/K_L)\, C_e \qquad \text{I}$$

$$\theta = bCe/(1+bCe) \qquad \text{II}$$

Where: q_e is the solid phase equilibrium concentration (mg g^{-1}), C_e the liquid phase equilibrium concentration (mg mL^{-1}) and K_L (mg g^{-1}) and b_L (L mg^{-1}) are the Langmuir constants and θ is the surface coverage degree.

Material and Methods

MB is a potent cationic dye with maximum spectrophotometric adsorption of light around 650 nm and the molecule occupies an area of about 2.04 10^4 nm^2. The MB adsorbed mass is an important indication of the surface coverage degree (θ) of the activated charcoal. The activation processes were performed using 30 g of milled eucalyptus charcoal (diameter < 0.074 mm) mixed with the activation agents in water and the suspensions was kept mixing in rotational shaker for 6 hours. Afterwards the suspension was filtrated and the treated solid were dried at 90°C for 24 hours. The adsorption processes were studied using MB solution in different initial concentrations with 1,0g of activated charcoal. The adsorption processes were followed collecting and analyzing the suspension aliquots each 30 minutes of stirring time. All collected aliquots were centrifuged for 15 minutes on 1500 rpm and the spectrophotometer UV-Vis VARIAN E1 was used to measure the MB absorbance after solid separation. The analytical curve was preparing using MB standards. The systems reach the equilibrium after 120 min of continuous stirring.

Results and Conclusions

The Langmuir isotherm calculations and the surface coverage degree for the most efficient activation processes were calculated, Eq I and II. The charcoal activated with potassium chloride, potassium carbonate and water steam showed the higher removal percentages: 90, 88 and 79 % respectively, the surface coverage degree (Θ) of 2.87, 5.72 and 6.04 % and surface area of 230.0, 145.0 and 121.9 (m^2/mg), Table 2.

Table 2.The comparison of removal percentage and surface coverage degree obtained for different charcoal activation processes. .

Activation Processes	**Average Removal %**	**K_L** (mg g^{-1})	**b_L** (L mg^{-1})	Θ %	Surface Area (m^2 /MB mg)
KCl	90	0.940	0.81	2.87	230.0
$KHCO_3$	88	0.119	0.564	5.72	145.0
Water Steam	79	0.775	1.02	6.04	121.9

The higher removal percentage and activation efficiency was obtained for KCl process. The potassium chloride and water steam shows promising aspects to be used as activation agent. Allowing the activated charcoal to be used in a commercial water treatment plant considered their low toxicological and cost aspect, with high efficiency after surface area improvement.

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