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Adsorption of Methylene Blue and In-situ Reactivation of Granular Activated Carbon (GAC) with Ozone

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Introduction and Background

- Ozone process is extensively used in the treatment of wastewater
- Ozone can break down colored substances like dyes in wastewater which improves the health quality and aesthetics of water[1]
- However, to treat heavily colored industrial wastewater (textile), a high volume and concentration of ozone is necessary
- GAC has been proven to be a superior material during the removal of dyes from water[2]
- GAC is either regenerated or disposed to landfill after adsorption; the being the most common
- This makes the individual application of ozone or GAC an expensive approach to treat wastewater with dyes

Objective and Hypothesis

- To concentrate methylene blue (MB) dye on GAC through column adsorption
- *In-situ* regeneration of GAC using ozone to improve the lifespan of GAC

Hypothesis: Concentration of methylene blue on GAC can reduce the amount of ozone needed to break down the same amount of dye as compared to applying ozone directly to treat the dye solution.

Methodology

GAC (2.0 g) was packed in a column (height 5 cm, diameter 1.1 cm).

A stock solution of 100 mg/L MB was then pumped into the column.

Effluent concentration of MB was measured on spectrophotometer at 668 nm.

After reaching the breakthrough point (10 mg/L), the column was connected to ozone generator to regenerate and oxidize adsorbed MB.

Fig. 1

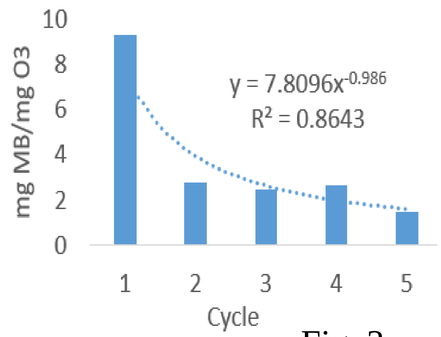

Fig. 3

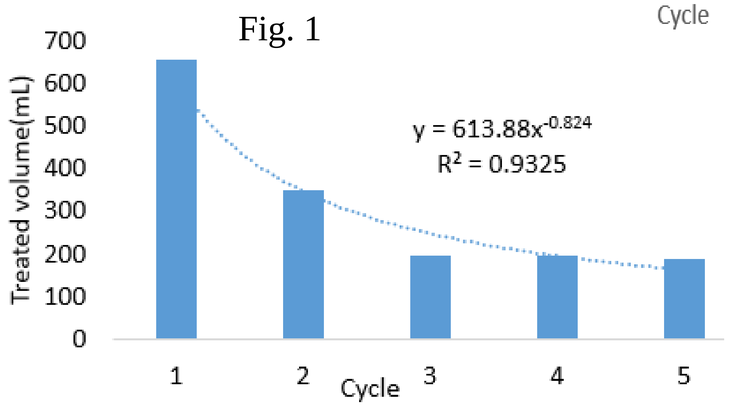

Fig. 2

Results and Discussion – Regeneration

In the first cycle, over 650 mL of MB solution was treated. The high performance is attributed to large pores of GAC (2.24 nm)[1].

In addition, the presence of carboxylic acid, phenols, pyrones, and the aromatic structure of the graphene layer improves the adsorption.

The localization of charge on nitrogen in MB facilitates electrostatic interactions, hydrogen bonding formation, electron donor-acceptor, and π–π dispersion interaction.

After regeneration with ozone, the adsorption capacity of GAC dropped by ~50% (Fig. 2). We believe that ozone broke the unsaturated bonds of MB, and it also attacked adsorption groups like carboxylic acid, phenols, pyrones[3]. FTIR could confirm this.

The adsorption capacity after regeneration followed a power function of $y = 613.88\,x^{-0.824}$

Results and Discussion – Adsorption

In the first cycle, the mass of ozone required to break down the adsorbed MB was 9.3 mg MB/mg O_3, and decreased according to the function $y = 7.81x^{-0.986}$ (Fig. 3).

The direct injection of ozone into MB solution treats only 0.07 mg MB/mg O_3.

Assuming a continual decrease in adsorption of MB onto GAC, the combination of ozone and GAC is more efficient than ozone alone for 120 cycles.

Conclusion

The combination of ozone and GAC improves the operating cycle of the GAC column. This reduces the operating costs and landfill waste of GAC.

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