The Effect of Magnetite-Activated Carbon Nanocomposite on Removing Various Water Pollutants

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Background

Magnetite-Activated Carbon: The main decontaminant used in the multiple experiments carried out. The MAC nanoparticles have a cleansing effect on polluted solutions around them, and this effect was tested in the experiments. It was created by the following chemical equation:

$2FeCl_3\,(aq) + FeCl_2\,(aq) + 8NH_3\,(l) + 4H_2O\,(l) \rightarrow Fe_3O_4\,(s) + 8NH_4Cl\,(aq)$

Fisher Universal Indicator Solution: One of two solutions tested for the effect of the MAC nanocomposite on removing the pollutants. It is a pH indicator from pH of 4 to pH of 10, and depending on the acidity or basicity, it changes colors.

Methylene Blue: A dye that is the other of the pollutants being used to test the efficacy of the MAC nanocomposite.

Goal of the Study: The goal of this project was to see how effective the Magnetite-Activated Carbon Nanocomposite is at removing Fisher Universal Indicator as well as Methylene Blue from water. In addition, the efficacy of the MAC was compared to the effect of just Activated Carbon.

Experimental Design: To test this, the process of removing the Fisher Universal Indicator solution was done twice, once with the Magnetite-Activated Carbon and once with the Activated Carbon. In addition, methylene blue solution with MAC and AC was exposed to UV light.

Methylene Blue Solution

Procedure: First, the methylene blue had to be made. To do this, 2.50 mg of methylene blue was put in 2.00 L of water, making the concentration be around 3.91 x 10^{-6} mol/L. Then, 10.0 mg of activated carbon was put into 1 beaker, and 10.0 mg of magnetite activated carbon and 10.0 mg of twice MAC went into 2 other beakers. The solutions were exposed to UV light, and every three minutes, UV Vis data would be taken.

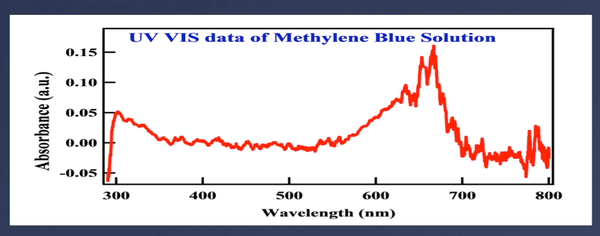
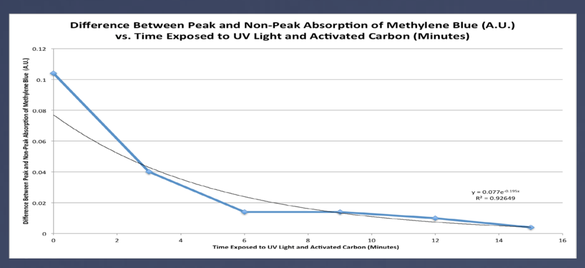


Figure 6. The graph showing the dissociation of Methylene Blue with Activated Carbon. The absorption decreases almost in a linear fashion, and the exponent is equal to -0.195.

Figure 5. Data from the UV Vis Spectroscopy Device showing the Absorbance of the 3.91 x 10^{-6} M Methylene Blue Solution.



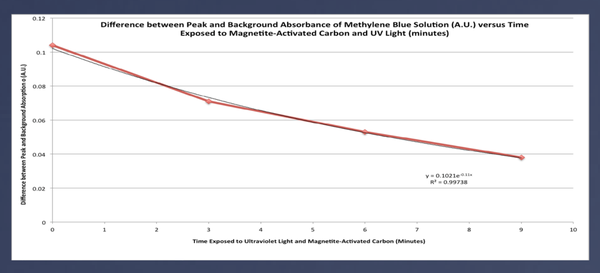
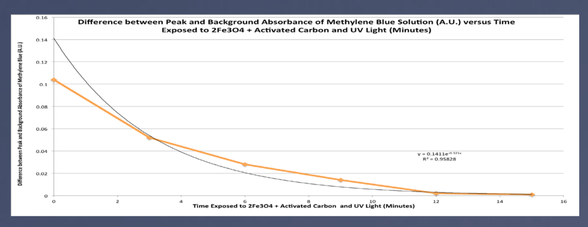


Figure 8. The graph of the dissociation of Methylene Blue with $2Fe_3O_4$+Activated Carbon. The absorbance decreases in an exponential fashion, and the exponent is -.321.

Figure 7. The graph showing the dissociation of Methylene Blue with Magnetite-Activated Carbon. The absorbance decreases almost in a linear fashion, and the slope is equal to -0.11..



Results and Conclusion: The results show that the solution containing $2Fe_3O_4$+Activated Carbon was the most purified, followed by the AC, and then the MAC. In addition, the rate constants for the decays were, in the order of the graphs: 0.00928 s^{-1}, 0.00594 s^{-1}, and 0.0109 s^{-1}, also showing that the $2Fe_3O_4$+Activated Carbon solution purified the methylene blue the fastest due to the presence of a magnetic field, because of this, it can dissociate large molecules in water.

FUI Solution

Procedure: To prove that the MAC worked, we had to put it into a 50 mL beaker, and to that same beaker, we had to add 10 mL of the solution containing 2% (w/w) solution of Fisher Universal Indicator in a 10:1 ratio with the pH 6 Buffer. Then, the mixture was to be put into a stirrer for 3-5 minutes, then allowed to settle on a magnet.

Results: The experiment yielded interesting results for the removal of the FUI solution from water. The figures below will describe the results, and how they were obtained.

Figure 1. Before testing the MAC's potential as a decontaminant, there must be verification that the substance produced is indeed a MAC. This is an X-Ray Diffraction image confirming that MAC and $2Fe_3O_4$+Activated Carbon were produced.

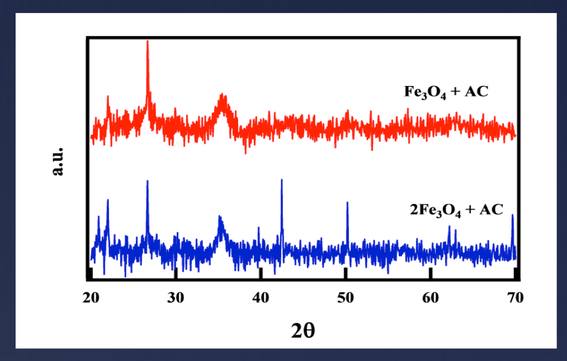


Figure 3. Same set up as figure 1, except with the activated carbon instead of the magnetite-activated carbon. Only difference is test tube 2, which contains the water that the Activated Carbon alone decontaminated.

Figure 2. The final appearance of the experiment. Test Tube 1 contains 5 mL of "polluted" water with 0.1 M Sodium Hydroxide. 2 contains 5 mL of the cleaned water, as well as one drop of both 0.1 M HCl and 0.1 M NaOH. 3 contains HCl. 4 Contains NaOH. 5 contains 2 mL of Polluted Water, 2 mL of H_2O. 6 contains the ethanol solution.

Figure 4. Same set up as figure 1, except with two times the Fe_3O_4 and activated carbon inside. The only difference is test tube 2, which contains the water which the powder containing twice the magnetite decontaminated.

Conclusion: The results clearly show that the nanocomposites containing magnetite were successful at decontaminating the water and being recyclable. The activated carbon powder alone decontaminates the water, yet it can only be used once for decontamination because the particles do not condense or settle; they are uniformly dispersed throughout the mixture.

Conclusion and Future Work

For the Fisher Universal Indicator solution, the Magnetite and Twice Magnetite-Activated Carbon solutions were the most effective at cleaning up the solution, because it was easier to test the recyclability and reusability of the MAC solutions. For the Methylene Blue solution, the order of efficacy was: $2Fe_3O_4$+Activated Carbon; Activated Carbon; Fe_3O_4+Activated Carbon, due to the fact that the rate constants decreased in that order. This experiment can be replicated with some other pollutants, and the efficacy of the nanocomposites can be tested.

References

[1] Chang, Ho, Chaochin Su, Chih-Hung Lo, Liang-Chia Chen, Tsing-Tshih Tsung, and Ching-Song Jwo. "Photodecomposition and Surface Adsorption of Methylene Blue on TiO2 Nanofluid Prepared by ASNSS." Materials Transactions 45.12 (2004): 3334-3337. Print. [2] Furlan, Ping, and Michael Melcer. "Removal of Aromatic Pollutant Surrogate from Water by Recyclable Magnetite-Activated Carbon Nanocompoite: An Experiment for General Chemistry." *Journal o Chemical Education* (2014): 1966-1970. Print

Acknowledgements

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