International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 03 | March - 2023 Impact Factor: 7.185 ISSN: 2582-3930

MIL53 Based Metal Organic Framework for Removal of Dye from Waste Water by Adsorption

CHETNA CHAUDHARI[a], DR. ROHIT LADE[b]

[a]Department of Industrial Chemistry, Parul Institute of Applied Sciences, Parul University, Vadodara-391760, INDIA.

[b]Department of Chemical Engineering, Parul Institute of Technology, Parul University, Vadodara-391760, INDIA.

ABSTRACT

To treat wastewater containing vat dyes, a newly method of based on MIL 53 (Al-Fe) @SiO_2 was created and used in a combine to desegregated process toward off followed by adsorption. Coal fly ash was used in the synthesis of MIL 53 (Al-Fe) @SiO_2. As compared to raw fly ash obtained by coal, the newly synthesized material, MIL 53 (Al-Fe) @SiO_2, present remarkable changes in physical and chemical properties, which improve and become greater its adsorption capacity by three times. In adding, the FTIR examination and analyzed investigation shows that the Compared to MIL 53 (Al) and MIL 53 (Fe)@SiO_2, freshly synthesis MIL 53 (Al-Fe) @SiO_2 exhibits a reduced electron-hole recombination rate. 53 (Al)@SiO_2. The highest adsorption capacity of the MIL 53 (Al-Fe) @SiO_2 was 692.942 mg g1 and highest degradation of 89.89 and 99.98% when exposed to visible and UV light subjection, separately This study demonstrates that suggested MIL 53 (Al-Fe) @SiO_2 outperforms the traditional materials in the removal of hazardous contaminants from industrial effluents.

KEY WORDS: Vat dyes, MIL53(Al-Fe) @SiO_2, Adsorption.

I. INTRODUCTION

An agent that is coloured and chemically attached to the surface it is applied to is called a dye. Textiles, leather, paints, pictures, cosmetic and pharmaceutical items, biological stains, and food are among the principal thing's dyes are used for. Vat is short for vessel. The name of dyes comes from incense. The term "vat dye" refers to the natural dyes that are maintained in a wooden vat and dissolve through a fermentation process. They are used in a particular dye bath in which a potent reducing agent, like hydrosulphite, reduces the dye to a soluble form.

Insoluble color that must be boiled before use are insoluble dyes. Of all the dyes, it possesses the finest fastness. The best overall fastness qualities, including wash fastness, light fastness, and chlorine fastness, are found in cup dyes, which are among the priciest dyes used to colour cellulosic textiles. When dying work garments, uniforms, or other textiles, they are preferable and repeated industrial washing is anticipated for clothing.

The metal iron is used in metal organic framework is example are zinc, copper, iron, zirconium, while terephthalic acid, trimeric acid or 2-methylimidazole have been commonly used as organic linkers, MOFs have numerous advantages if their use as adsorbents in synthesis. Another advantage is the high surface area and porosity of MOFs, which can help with adsorption site availability and diffusion of toxic or radioactive metal ions through the framework.

When charcoal is submerged in a colourful solution, the charcoal absorbs the coloured particles, causing the solution to turn coloured. Adsorption is the process by which atomic, molecular, and discolouring ionic species of one substance gather on the surface of another. The phenomena of attraction and retention of a substance's molecules on the surface of a liquid or solid, leading to a larger concentration of molecules on the surface, is known as adsorption. Various industries like leather, textile, paint, print and so on utilize dyes for different applications.

Dyes are one of the major sources of water pollution as they are disposed off from various industries. Dyes consist of various types of toxic compounds. These compounds cause many physico-chemical changes in the properties of water which adversely affects the environment. In addition, wastewater containing dyes which have toxic components inhibit the process of photosynthesis. Vat dye, which are classified as cationic dyes have numerous adverse effects on human health such as increased heart rate, inflammation of leptomeningeal disease, nausea and vomiting, jaundice, persistent eye human and animal injuries, neuronal apoptosis, injuries such as burning sensation in the mouth and methemoglobinemia. In addition, due to its complex structure, Vat dye is highly stable at normal room temperature and pressure. Hence, Vat dyes disposal into the environment is posing a lot of problems to the Scientists. Wastewater treatment has evolved successfully but still there are various issues such as high operating costs, complicated operation, incomplete removal of harmful substances, inefficient reduction in pollutant level and production of large quantities of sludge. For above factors adsorption has successfully proven to be a productive, cost-effective and simplified process. Only one drawback of adsorption is that no chemical reaction occurs, and hence no degradation of pollutant takes place. Recently, a lot of research has been performed on photo-catalytic degradation due to its ability to completely degrade and its persistence towards low-concentration pollutant. Adsorption process can be detailed as (i) firstly adsorbate particles are adhered on the surface of the material, (ii) the adsorbed molecules are irradiated by light radiation and electrons are injected shifting the material in the conduction band of the photocatalyst and within this conduction band O_2 captured electrons and hydroxyl radicals are generated (OH·) (iii) this OH· radical degrades adsorbed molecules of dye

II. EXPERIMENTAL WORK

Materials

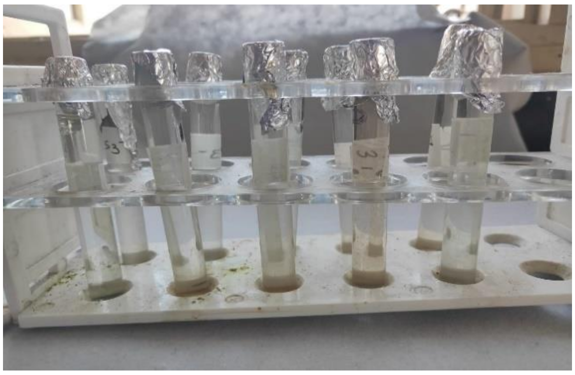
Raw fly ash (obtained from lignite coal), Waste aluminium foil paper, Ferric chloride [98%], N, N-Dimethyl formamide [98%], Formic acid dimethylamine, Terephthalic acid Nitric acid [70%concentrated], Distilled water, Vat dye waste water, Methanol was used.

Method

SYNTHESIS OF THE METAL ORGANIC FRAMEWORK

First, we take coal fly ash to wash with distilled water and dry it 110°C in hot air oven after this process mixture are dry. Secondly, the waste aluminium foil washed with distilled water and then put in hot air oven in 3 hours for 110°C. after heating the aluminium foil paper to crushed them powder lick substance are ready. After the ratio of fly ash and aluminium are 1:0.6 to go thru process then the add ferric chloride add too different first fly ash then aluminium foil and ferric chloride ratio like S1 = 2.5:1.5:2, S2 = 1.875:1.125:3, S3 = 1.25:0.75:4, S4 = 0.625:0.375:5. After mixture to heat in heating mantel in 130°C in 1 hour then mixture are dry. After then ratio of dry mixture and terephthalic acid. After the mixing then another beaker to prepared a N, N-Dimethyl formamide and distilled water 1:2 ratio. Both the mixture is heat in 45 minutes in 45°C After stir the mixture and kept in closed autoclave. In autoclave at temp. 120°C And 15 PSI (Pressure) for 2 h. then cooled down the autoclave and mixture wash with methanol and distilled water. Then dry the mixture in oven 85°C and mixed are dry and power like metal organic framework are ready to previous work and study.

Adsorption activity



The adsorption experiment is conducted in batch mode using solution of vat dye waste water. the effect if different ml like, First, we take waste dye water 1000 ml. and then mixed with 0.001,0.002,0.005 gm metal organic framework. in which waste dye is mixed with 0.001gm metal organic framework and then heated with 30°C for 10 minutes. After that waste dye is mixed with 0.002gm metal organic framework and then heated with 40°C for 10 minutes. And then, waste dye is mixed with 0.005gm metal organic framework and then heated with 50°C for 10 minutes.

III. RESULT AND DISCUSSION

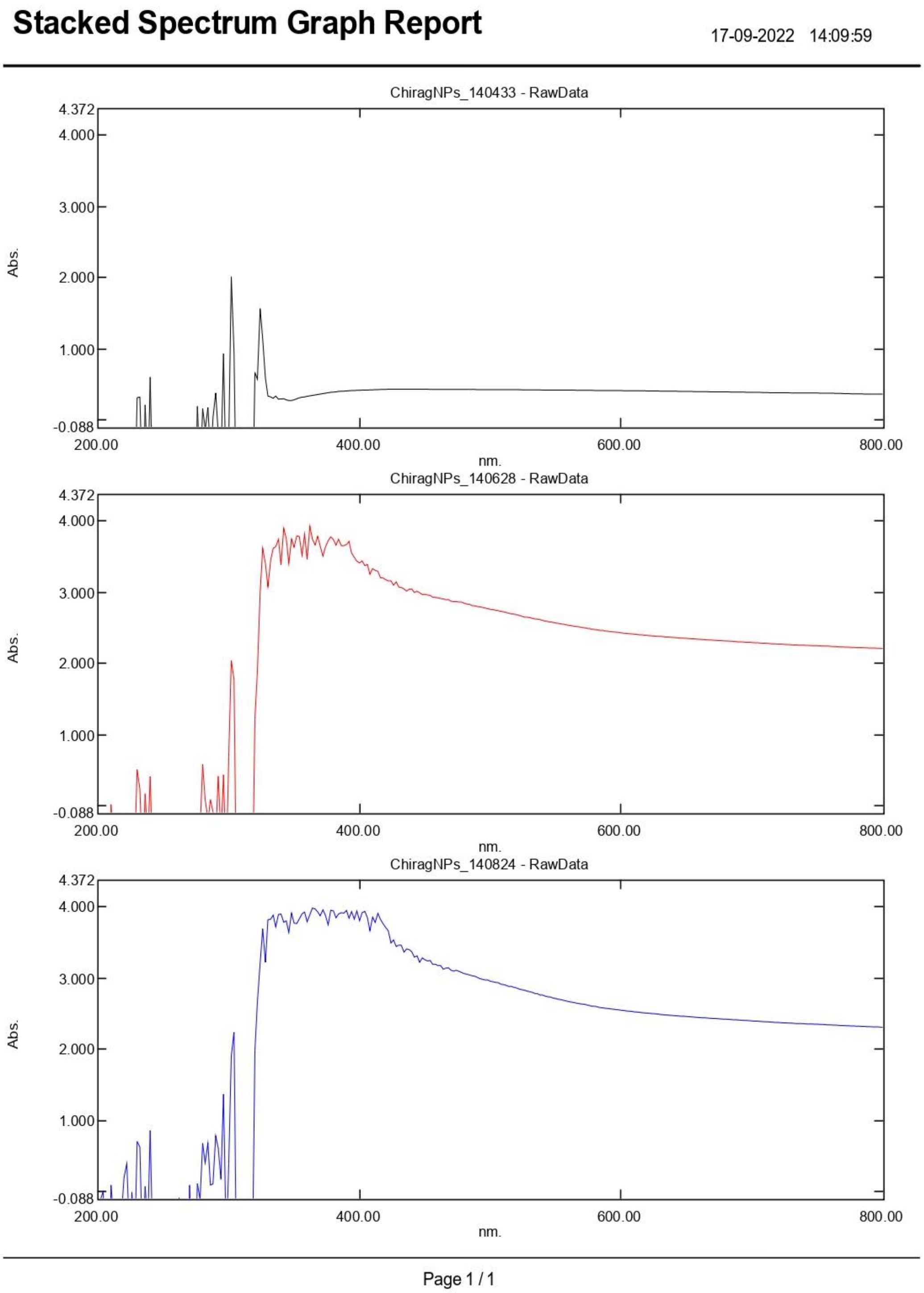


Figure 1 UV Analysis spectrum of Fly Ash, Aluminium & Ferric Chloride

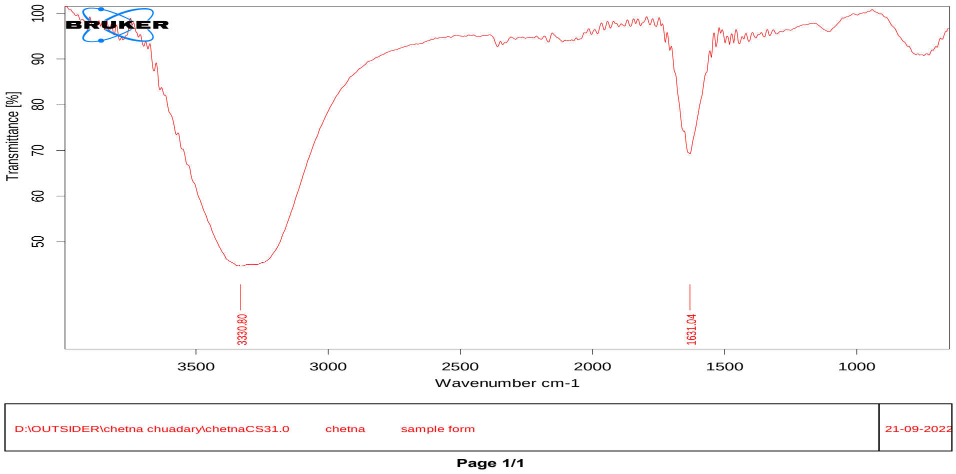


Figure 2 FTIR Analysis spectrum of Fly Ash, Aluminium & Ferric Chloride

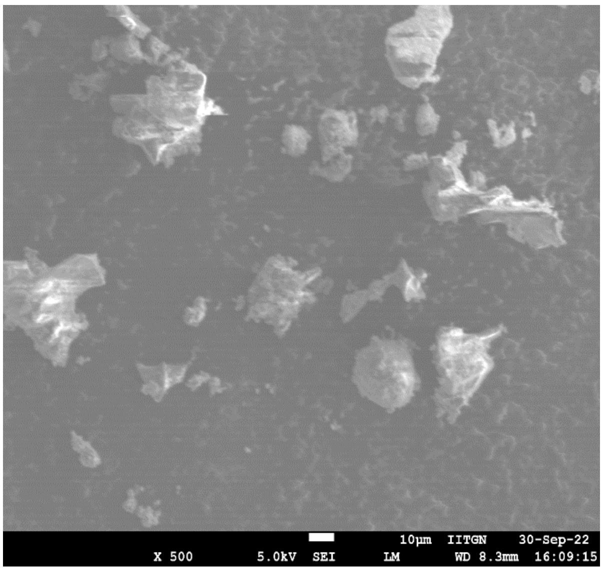


Figure: 3 SEM Analysis

The metal organic composite's adsorption capacities were tested after it was manufactured using various component weight ratios. The experimentally determined adsorption capacity of the produced MOF composites is depicted in Fig. 1. Inferred from the experimental data research showing that the MOF composite's adsorption capability is increasing to a certain extent when iron content increases (i.e., fly FeCl3 = 2.5:1.5:2 for aluminium foil, and above that with increasing the The adsorption capability was declining due to the iron concentration. The cause of this aggregation of the composite particles may be the cause of the occurrence. Thus Using MIL 53, the following experimental investigations were examined. (Al-Fe)@SiO2, a synthetic material made from fly ash and S3. aluminium Foil made of: FeCl3 = 2.5:1.5:2)

IV. CONCLUSION

In this work, a silica supported bimetallic MOF composite was produced, which shows a high adsorption capacity and significantly great adsorption property. The metal oxide composite also shows a pretty adequate regeneration capacity. The coexistence of aluminium and iron incorporated with SiO2 enhances its photocatalytic activity by inhibiting its electron and hole recombination and reducing band gap than those of pure MIL 53 (Al) and MIL 53 (Al)@SiO2. The integrated mechanism followed by adsorption not only reduces the harmful pollutant from wastewater but also ensures its degradation. Moreover, it helps in the regeneration process of the photocatalytic adsorbent. The newly synthesized MIL 53 (Al-Fe)@SiO2 has proved a significantly batter adsorption and photocatalytic property for both the removal and degradation of harmful pollutants. Therefore, the novel MOF composite can be used as a promising advanced material for wastewater treatment technology.

ACKNOWLEDGEMENT

The author is thankful to the Parul Institute of Applied Science for financial support to carry out this work. The author is also grateful & acknowledge for the use of research facilities provided by Lab Assistants, Department of Industrial Chemistry, Parul Institute of Applied Sciences, Parul University, Vadodara.

REFERENCES

[1] Morsy, S.A.G.Z.; Tajudin, A.A.; Ali, M.S.M.; Shariff, F.M. Current development in decolorization of synthetic dyes by immobilized laccases. Front. Microbiol. 2020, 11, 572309.

[2] Hunger, K. Industrial Dyes: Chemistry, Properties, Applications; Wiley-VCH Verlag GmbH & Co. KGaA: Weinheim, Germany, 2003.

[3] Katheresan, V.; Kansedo, J.; Lau, S.Y. Efficiency of various recent wastewater dye removal methods: A review. J. Environ. Chem. Eng. 2018, 6, 4676–4697.

[4] Millange, Franck; Walton, Richard I. (2018-09-03). "MIL-53 and its Isoreticular Analogues: a Review of the Chemistry and Structure of a Prototypical Flexible Metal-Organic Framework". *Israel Journal of Chemistry*. **58** (9–10): 1019–1035.

[5] V.K. Gupta, D. Pathania, S. Agarwal, P. Singh, Adsorptional photocatalytic degradation of methylene blue onto pectin-CuS nanocomposite under solar light, J. Hazard. Mater. 243 (2012) 179–186.

[6] Y.-H. Wu, T. Wu, Y.-W. Lin, Photoelectrocatalytic degradation of methylene blue on cadmium sulfide–sensitized titanium dioxide film, Mater. Res. Bull. 118 (2019) 110500,

[7] M. Bergaoui, A. Nakhli, Y. Benguerba, M. Khalfaoui, A. Erto, F.E. Soetaredjo, S. Ismadji, B. Ernst, Novel insights into the adsorption mechanism of methylene blue onto organo-bentonite: adsorption isotherms modeling and molecular simulation, J. Mol. Liq. 272 (2018) 697–707, https://doi.org/10.1016/j. molliq.2018.10.001.

[8] J. Guo, S. Yuan, W. Jiang, H. Yue, Z. Cui, B. Liang, Adsorption and photocatalytic degradation behaviors of rhodamine dyes on surface-fluorinated TiO2 under visible irradiation, RSC Adv. 6 (2016) 4090–4100.

[9] S. Kant, D. Pathania, P. Singh, P. Dhiman, A. Kumar, Removal of malachite green and methylene blue by Fe0.01Ni0.01Zn0.98O/polyacrylamide nanocomposite using coupled adsorption and photocatalysis, Appl. Catal. B Environ. 147 (2014) 340–352.

[10] P. Raizada, P. Singh, A. Kumar, G. Sharma, B. Pare, S.B. Jonnalagadda, P. Thakur, Solar photocatalytic activity of nano-ZnO supported on activated carbon or brickgrain particles: role of adsorption in dye degradation, Appl. Catal. A Gen. 486 (2014) 159–169.

[11] M. Wen, G. Li, H. Liu, J. Chen, T. An, H. Yamashita, Metal-organic frameworkbased nanomaterials for adsorption and photocatalytic degradation of gaseous pollutants: recent progress and challenges, Environ. Sci. Nano 6 (2019) 1006–1025.

[12] S.G. Khasevani, N. Faroughi, M.R. Gholami, Metal-organic framework-templated synthesis of t-ZrO 2 / γ - Fe 2 O 3 supported AgPt nanoparticles with enhanced catalytic and photocatalytic properties, MaterRes.Bull.126(2020)110838.

[13] T. Loiseau, C. Serre, C. Huguenard, G. Fink, F. Taulelle, M. Henry, T. Bataille, G. F´erey, A rationale for the large breathing of the porous aluminum terephthalate (MIL-53) upon hydration, Chem. - Eur. J. 10 (2004) 1373–1382.

[14] M.A. Moreira, J.C. Santos, A.F.P. Ferreira, U. Müller, N. Trukhan, J.M. Loureiro, A. E. Rodrigues, Selective liquid phase adsorption and separation of ortho-xylene with the microporous MIL-53(Al), Sep. Sci. Technol. 46 (2011) 1995–2003.

[15] W. Mei, H. Song, Z. Tian, S. Zuo, D. Li, H. Xu, D. Xia, Efficient photo-Fenton like activity in modified MIL-53(Fe) for removal of pesticides: regulation of photogenerated electron migration,Mater.Res.Bull.119(2019)110570,https://doi.org/10.1016/j.materresbull.2019.110570

[16] R. Liang, F. Jing, L. Shen, N. Qin, L. Wu, MIL-53(Fe) as a highly efficient bifunctional photocatalyst for the simultaneous reduction of Cr(VI) and oxidation of dyes, J. Hazard. Mater. 287 (2015) 364–372, https://doi.org/10.1016/j. jhazmat.2015.01.048.

[17] J. Kou, L.B. Sun, Fabrication of metal-organic frameworks inside silica nanopores with significantly enhanced hydrostability and catalytic activity, ACS Appl. Mater. Interfaces 10 (2018) 12051–12059.

[18] J.M. Kim, C.H. Shin, R. Ryoo, Mesoporous molecular sieve with binary transition metal (Zr-Cr) oxide framework, Catal. Today 38 (1997) 221–226.