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Treatment of Textile Industrial Effluents by using Magnetite Nanoparticle

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***Abstract*: Increase in number of textile industries in India helps to develop the economy status of our country which also creates more challenges to the engineers, scientists and the environmentalists. This is because of increase in volume of effluent produced by the textile industries. The effluent coming out from the textile industry needs more treatment techniques and methods before it is discharged. Discharging effluent into the water sources without proper treatment pollutes the water source severely. Also, the solid wastes produced during the treatment of effluent create more problems on earth. Controlling pollution caused on water source has increase importance in recent years. The effluent discharged into the water source consists of dyes constitutes small proportion of water pollution. In India, the government enforces many norms with respect to the discharge level of various parameters like BOD, COD, color etc., and forcing textile industries to treat their waste effluent to an increasingly high standard. Currently, physic – chemical treatment techniques are widely used to treat the textile industries effluents but such methods are costlier. Even though this physico-chemical method removes the dyes from the effluent, it accumulates the concentrated sludge which creates a disposal problem. To find the alternative method to treat textile effluent, with low cost we tried to treat the effluent with nanoparticles which can be prepared from the naturally available material with low cost and which can be reproduced. This research work aims at an innovative synthesis and characterization of magnetite nanoparticle at bench scale. Further the synthesized nanoparticles are used (in a batch process) for treating various textile industrial effluents and reduce the pollutants level as prescribed by the PCB norms.**

***Keywords*: textile effluent, magnetite nanoparticles, characterization,**

1. Introduction

Environmental contamination by hazardous species is a wide spread problem, with sources of pollution arising from industrial activities and natural sources such as water contamination by dumping the textile and tannery wastes at water bodies. Environmental contamination by heavy metals for instance, is a wide spread problem. Because access to safe drinking water is the key to protect public health, clean water has become a basic need of all properly functioning societies [1]. Despite their presence at low concentration ranges, environmental pollutants possess serious threats to freshwater supply, living organisms and public health [2].

Contamination of water with toxic metal ions is becoming a severe environmental and public health problem. In order to achieve environmental detoxification, various techniques like: adsorption, precipitation, ion exchange, reverse osmosis, electrochemical treatments, membrane filtration, evaporation, flotation, oxidation and biosorption processes are extensively used [3-5]. Now-a-days latest treatment methods including nano-based materials such as nano adsorbents nanometals, nanaomembranes and photocatalysts Among these, adsorption is a conventional but efficient technique to remove toxic metal ions and bacterial pathogens from water. Industrial effluents are of various types and the majorly polluting effluents are released from textile, tannery, paper mills, refineries, etc. Nanoparticles, in particular, are being applied for treating textile and tannery effluents that cause water pollution affecting the aquatic organisms and our day-to-day lives

2. Synthesis and characterization of nanoparticles

Recent Literature shows that the development of novel and cost-effective nanomaterials for environmental remediation, pollution detection and other applications has attracted considerable attention. Recent advances suggest that many of the issues involving water quality could be resolved or greatly ameliorated using nanoparticles, nanofiltration or other products resulting from the development of nanotechnology [6]-[7].

This manuscript summarizes the synthesis and characterization of magnetite nanoparticles and using them, in a batch-wise manner, for treating textile industrial effluents.

A. Preparation of Nanoparticle

Magnetite (Fe_3O_4), or iron ferrite ($FeO.Fe_2O_3$) is a naturally occurring mineral. It can be easily prepared in the laboratory from solutions containing ferric and ferrous ions [8]-[9] Moreover the magnetite exhibits good adsorption characteristics with respect to a wide variety of species such as dissolved metals, particulate matter, and organic and biological materials, as an economical and environmentally inert material.

B. Origin of the nanoparticle

Magnetite, one of the important iron ores, can be found everywhere in nature, in igneous and metamorphic rocks. The presence of magnetite in nature is often a result of biological processes, but it can also have a lithogenic origin. It is found also in ocean floor, soils, rocks, meteorites, atmospheric dust, bacteria and other living organisms. It is also a common corrosion product of iron and steel. Magnetite (Fe_3O_4) is commonly found in the environment and can form via several pathways, including biotic and abiotic reduction of ferric iron oxides and the oxidation of ferrous iron and iron metal. Most of the Fe oxides, such as goethite, hematite, lepidocrocite, and maghemite are semiconductors, whereas magnetite exhibits properties closer to that of a metal.

C. Structural properties of nanoparticle

The magnetite crystal structure is inverse spinel with a unit cell consisting of 32 oxygen atoms in a face centered cubic structure and a unit cell edge length of 0.839 nm [10], responsible for both the magnetic property and the colour of the mineral. The black colour is due to the intervalence charge transfer between Fe^{2+} and Fe^{3+} in its crystal structure. The magnetic property in magnetite also stems from the Fe^{2+} and Fe^{3+} atoms being in tetra and octahedral sites as described above. The spins on the tetrahedral and octahedral sites are antiparallel and the magnitudes of the two types of spins are unequal [10]. In oxidizing atmosphere, magnetite is oxidized to maghemite or hematite, namely:

$$4\ Fe_3O_4 + O_2 \rightarrow 6\ Fe_2O_3$$

In a reducing atmosphere, for instance carbon, it can be reduced to or iron:

$$Fe_3O_4 + C \rightarrow 3FeO + CO$$
$$Fe_3O_4 + 4C \rightarrow 3Fe + 4CO$$

D. Synthesis methods

Magnetite nanoparticles are prepared by chemical precipitation method. 5 grams of Ferrous Sulphate and Ferric Chloride salts are taken. They are separately dissolved in 10 ml dilute ammonia solution. The final solution is obtained by thoroughly mixing the solutions of Ferrous Sulphate and Ferric Chloride salts dissolved in dilute ammonia. The final mixture is allowed to stand for 10-20 minutes for sedimentation of the magnetite particles. The solution containing sediment is filtered to get magnetite particles. The particles obtained are dried for 6-8 hours at about 80˚C in the hot air oven. Finally, the dried magnetite is finely powdered to get magnetite nanoparticles.

Fig. 1. Lab Synthesized Magnetite Nanoparticles

For different applications, several chemical methods can be used to synthesize magnetic nanoparticles: co-precipitation, reverse micelles and micro-emulsion technology, sol-gel synthesis, sonochemical reactions, hydrothermal reactions, hydrolysis and thermolysis of precursors, flow injection synthesis, and electro-spray synthesis [11]. The synthesis of super paramagnetic nanoparticles is a complex process because of their colloidal nature. For metal removal applications, an adequate surface modification of the nanoparticles is a critical aspect regarding both selectivity and aqueous stability of these materials. To this end, in the last decade, organic and inorganic functionalized Fe_3O_4 nanoparticles have been developed and modifications of the synthesis methods mentioned above have been proposed.

3. Materials and methods

A. Characterization of Nanoparticle

Magnetite is usually characterized by several methods providing information about chemical properties and crystal structure, among them: infrared spectroscopy, ultraviolet and visible spectroscopy (UV VIS), X-ray difractometry (XRD), thermal analysis, magnetometry, and Mossbauer spectroscopy. The surface and morphology can be investigated by X-ray photoelectron spectroscopy (XPS) and TEM or SEM microscopic techniques, as well.

Magnetite is usually characterized by several methods providing information about chemical properties and crystal structure. In this project the magnetite nanoparticles were undergone XRD and SEM analysis.

The XRD patterns of magnetite nanoparticles obtained at 250°C. The synthesized nanoparticles showed the diffraction peaks at 2θ = 21.14, 32.82 and 36.70 of Fe_3O_4 respectively, see Figure 2.

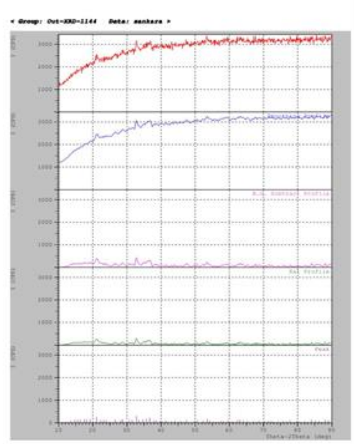

Fig. 2. XRD of Synthesized Magnetite Nanoparticles

SEM image of Fe_3O_4 sample indicated different shape and sizes of nanoparticles. SEM image also showed that the average nanoparticles size is about 29nm.

From the characterization studies it is evident that the prepared magnetite particles possess the characteristics of standard magnetite nanoparticles and can be used for treating various effluents.

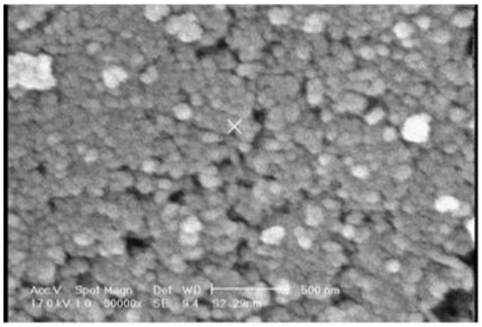

Fig. 3. SEM Image of Synthesized Magnetite Nanoparticles

4. Results and Discussion

A. Variation of COD

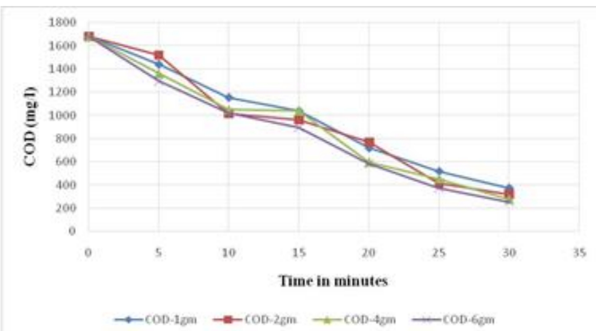

Fig. 4. Variation of COD as a function of time for textile wash water for different weight fractions of magnetite nanoparticles

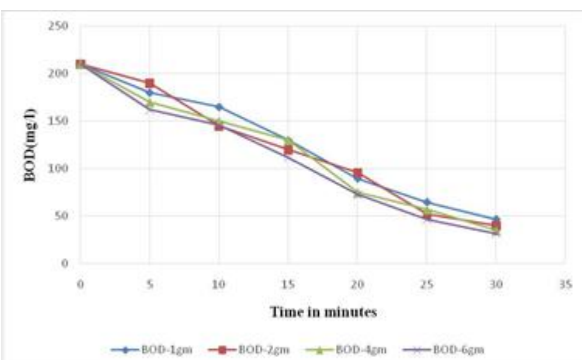

Fig. 5. Variation of BOD as a function of time for textile wash water for different weight fractions of magnetite nanoparticles

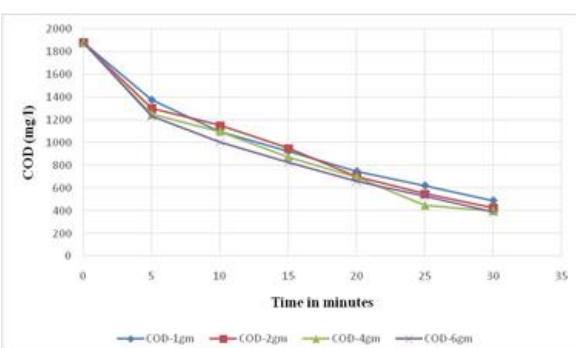

Fig. 6. Variation of COD as a function of time for dye bath effluent for different weight fractions of magnetite

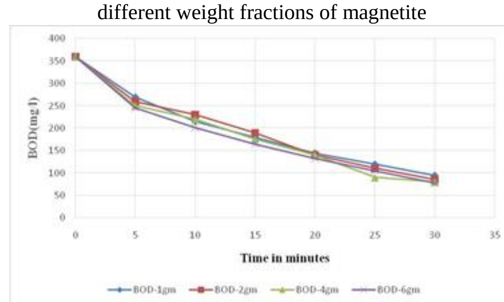

Fig. 7. Variation of BOD as a function of time for dye bath effluent for different weight fractions of magnetite nanoparticles

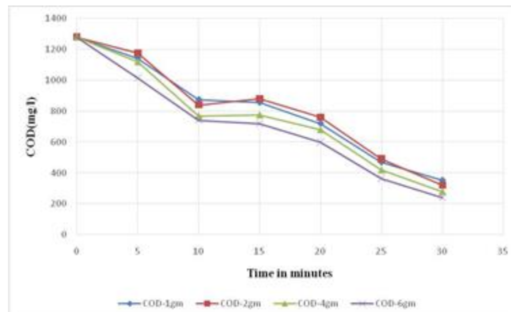

Fig. 8. Variation of COD as a function of time for textile effluent (Sample 2) for different weight fractions of magnetite nanoparticles

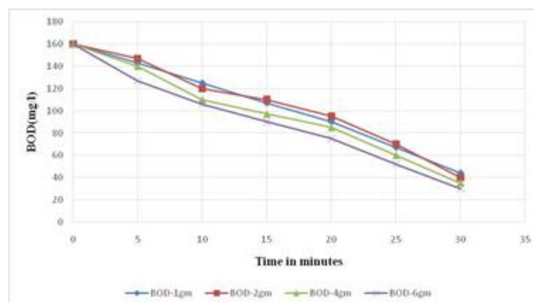

Fig. 9. Variation of COD as a function of time for textile effluent (Sample 2) for different weight fractions of magnetite nanoparticles

From the graphs above, it is evident that on increasing the weight fraction of nanoparticles in treatment has improved the removal of COD and BOD from textile effluents. It is found that the removal was very high on using 6 gram nanoparticles in treatment.

From the graphs plotted we can infer that on increasing the weight fraction of nanoparticles in treating the textile wash water, dye bath and textile effluents, the COD and BOD got reduced significantly. It is also observed that the maximum removal of COD and BOD took place on adding 6 grams of nanoparticles with each effluent.

Nano engineered materials such as nano-adsorbents, Nano metals, nano-membranes, and photo catalysts, offer the potential for novel water technologies that can be easily adapted to customer-specific applications. Most of them are compatible with existing treatment technologies and can be integrated simply in conventional modules. One of the most important advantages of nanomaterials when compared with conventional water technologies is their ability to integrate various properties, resulting in multifunctional systems such as nano-composite membranes that enable both particle retention and elimination of contaminants. Further, nanomaterials enable higher process efficiency due to their unique characteristics, such as a high reaction rate.

5. Conclusions

From this experimental work, the magnetite nanoparticles have been synthesized at lab scale by chemical precipitation method. The characterization studies are conducted to know the characteristics of synthesized particles. The Scanning Electron Microscope Images and X-Ray Diffraction studies show that characteristics of synthesized nanoparticles are matching with the standards.

The synthesized nanoparticles are applied for treating various industrials. Treatment is carried out on a batch process. For different weight fractions of the nanoparticles, the changes in C.O.D (Chemical Oxygen Demand) and B.O.D (Biological Oxygen Demand) levels of effluents are noted down. Further the graphs are plotted, showing variations in the level of BOD and COD for different effluents as a function of time at different weights of magnetite.

The plots show that on increasing the amount (weight) of nanoparticles in treatment, it resulted in a higher degree of COD and BOD removal from the textile wash water and dye bath and textile effluents. It is also evident that maximum removal of COD and BOD effected on using 6 grams of magnetite nanoparticles for treating the effluents.

According to the PCB norms the BOD should be 30 mg/l or below for potable water and BOD ranging from 40 to 100 mg/l can be used for irrigation and industrial as well as domestic uses. The COD level prescribe by PCB should be less than 250 mg/l for potable water. Water having COD ranging from 250 to 400 mg/l can be used for industrial as well as other domestic purposes where pure water is not required.

Finally, the obtained results (after removing pollutants) were compared with the PCB norms. The treated water showed BOD ranging from 30 to 100 mg/l and COD ranging from 250 to 500 mg/l (within permissible levels). Hence the treated water could be used for some domestic or industrial purposes where pure water is not required.

References

[1] World Health Organization, Guidelines for Drinking Water Quality, 3rd Edition, Incorporating the first and second addenda, Vol. 1, Recommendations, Geneva, Swiss. http://www.who.int/water_sanitation_health/dwq/fulltext.pdf, (2008).
[2] P.L. Brezonik and W.A. Arnold, Water chemistry: Fifty years of change and progress, Environmental Science and Technology 46 (2012) 5650-5657.
[3] S. Chen, Y. Zou, Z. Yan, W. Shen, S. Shi, X. Zhang and H. Wang, Carboxymethylated bacterial cellulose for copper and lead ion removal, Journal of Hazardous Materials 161 (2009) 1355-1359.
[4] Y. Chen, B. Pan, H. Li, W. Zhang, L. Lv and J. Wu, Selective removal of Cu(II) ions by using cation-exchange resin-supported polyethyleneimine (PEI) nanoclusters, Environmental Science and Technology 44 (2010) 3508-3513.
[5] V. Ivanov, J.H. Tay, S.T.L. Tay and H.L. Jiang, Removal of micro particles by microbial granules used for aerobic waste water treatment, Water Science and Technology 50 (2004) 147-154.
[6] J. Schulte and J. Dutta, Nanotechnology in environmental protection and pollution, Science and Technology of Advanced Materials 6 (2005).
[7] M. Auffan, H.J. Shipley, S. Yean, A.T. Kan, M. Tomson, J. Rose and J.Y. Bottero, Nanomaterials as adsorbents, in: M.R. Wiesner, J.Y. Bottero (Eds), Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill, New York (2007) 371-392.
[8] U. Schwertmann, R. M. Cornell, Iron Oxides in the Laboratory: Preparation and Characterization," VCH Publishers, Inc., New York (1991).
[9] Z. Sun, F. Su, W. Forsling, P. Samskog, Surface Characteristics of Magnetite in Aqueous Suspension, Journal of Colloid and Interface Science, 197 (1998)151 -159.
[10] R. M. Cornell, U. Schwertmann, The Iron Oxides, Structure, Properties, Reactions, Occurrences and Uses, Wiley-VCH, 2nd Edition, 2003
[11] S. Laurent, D. Forge, M. Port, A. Roch, C. Robic, L. Vander Elst and R.N. Muller, Magnetic iron oxide nanoparticles: Synthesis, stabilization, vectorization, physico-chemical characterizations and biological applications, Chemical Reviews 108 (2008) 2064-2110.