Review on Dye Removal from its Aqueous solution by using Nanoparticle as Adsorbent

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ABSTRACT - In this study, the collection of different types of nanoparticle as adsorbent to remove different dyes from the aqueous solution. Dyes are complex organic compounds which are used by various industries to colour their products. These dyes are purge from various industrial sources such as textile, cosmetic. paper, leather, rubber and printing industries. Waste water effluents contain dyes which may cause potential hazards to the environment.

Several methods are available for dye removal and some of them are well established in industrial scale. Reduction followed by chemical precipitation, adsorption, electro-kinetic remediation, membrane separation processes and bioremediation are some of the removal techniques. Each method is associated with both advantages and disadvantages. Currently, the use of nanosorbents for the aqueous dye removal is popular among researchers. The activated carbon is prepared by using waste materials in our surroundings. In this collection of adsorbent we should know which is the best adsorbent for a particular dye in economic aspect.

The aim of the work is to review the removal of dyes from aqueous solution by using nanoparticles.

Keywords : Adsorption, Dyes, Nanoparticles.

I. INTRODUCTION

Environmental pollution due to industrial effluent is a major concern because of its toxicity and threats for human beings. The environmental pollution control is one of the prime concerns of the society in today's context. Most of the dyes used for industrial purposes are highly toxic to aquatic life.[1]

Adsorption is an affordable and effective technique for the removal of dyes and colored pollutants from wastewater.[2]Removal of hazardous, carcinogenic compounds from industrial wastewater is one of the growing needs in the present time. Many dyes and pigments are toxic in nature, with carcinogenic and mutagenic effects.[3] Activated carbon is the most widely used adsorbent for the removal of color from textile effluents. It is so because it has a high capacity for organic matter, but its use is limited due to its high cost.[4]

Nanotechnology has been suggested as a strong candidate in resolving current problems in water treatment.[5]

In general, removing color and other toxic materials from waste water can be done via namely chemical, biological and physical methods. Chemical methods use coagulation,flocculation, electro-floatation to remove colour.Biological treatment utilizes fungi, bacteria (or) other biomass and is widely accepted due to its economical advantage. Physical methods often applied are membrane filtration and adsorption techniques.

Therefore, adsorption may be employed for the treatment of color removal from dye waste.[6,7]

The major aim of this review is to provide a summary of recent information concerning the use of low-cost materials as adsorbents.

This study reveals that nano particles as adsorbent in dye removal. Find the examples of nano particles in Table -1.

Table-1

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S.No	Adsorbent (Source of Activated Carbon)	Adsorbate (Dye)	Reference
1.	**Magnetic Carbon nano tubes**	**Azodyes**	Fei Yu, Junhong chen, Lu Chen, Jmig Huai, Wenyi Gong, Zhiwex Yuvan, Jrihe Wang, Magnetic carbon nano tubes synthesis by fentonis reagent method and their potential application for removal of azo dye from aqueous 000solution, Jie Ma., Journal of colloid and interface science **378 (2012**) 175-183.
2.	**Corchorus olitorius –L leaves**	**Rhodamine – B**	S Subasri, S Arivoli, V. Marimuthu and N. Mani., Equilibrium, Kinetic and Thermodynamic study on Rhodaurine – B removal from aqueous solution using activated corchorus., Journal of Plant, Animal and Environmental Science volume **3 (2014**) 208-218
3.	**Stishovite clay – TiO2 nano composite**	**Methylviolet**	Venkateswaran Vinayagam, Priya Thangaraju., Equilibrium and kinetics of Adsorption of Cationic dyes by STISHOVITE clay – TiO2 Nano composite, IJMER. Vol.2, Issue.6, Nov- Dec **(2012)** 3989 – 3995.
4.	**Cetyltri methylammonium Bromide – coated magnetite nano particles**	**Reactive black 5(RBBA) Reactive red 198(RRR) Reactive blue 21(RTB)**	M.Faraji, Y.Yamini, E. Tdhmasebi., A. Salem and F. Nourmohammadian., Cetyltrimethye ammonium Bromide – Coated Magnetite nano particles as Highly Efficient Adsorbent for Rapid Removal of Reactive Dyes from the textile companies waste waters, J. Iron. Chem. Soc., Vol. 7, Suppl., July 2010, S130- S144.
5.	**Calcium Oxide Nano particle**	**Coralene Dark Red 2B**	Madhusudhana .N., Yogendra.K., Mahadevan, K.M., Decolorization of Coralene Dark Red 2B azo. dye using calcium oxide nano particle as an adsorbent., Int. J.Res.Chem.Environ.vol. 2 April **2012** (21-25).
6.	**Magnetic Zeolite/iron oxide Nano composite**	**Reactive Orange 16 (R016) Indigo Carmine (IC)**	Fungaro D.A., Yamaura. M., and Carvalho. T.E.M., Adsorption of anionic dyes from aqueous solution on zeolite from fly – ash iron oxide magnetic nanocomposite Eur.Chem.Bull.**2013, 2(8), 524-529**.
7.	**MnO_2 Nano Particle**	**Malachite green**	Pradeep Kumar .B.M., Shivaprasad K.H., Raweendra R.S., Hari Krishna R., Sriram Karikat, Nagbhushana B.M., preparation of MnO2 nanoparticles for the adsorption of environmentally hazardous malachite green dye., IJAIEM volume 3., Dec **2014 (102-106**).
8.	**Iron oxide Magnetic nano particle**	**Cr (VI)**	Nirmala Ilankoon, use of iron oxide magnetic nano sorbents for Cr(V1) removal from aqueous solution : Journal of Engineering Resesarch and Applications Vol.4, Oct **2014 (55-63**).
9.	**Stishovite – TiO2 Nano composite and Stishovite clay-A**	**Malachitegreen**	V.Venkateswaran, V.T.Priya, P.Balasubramaniyam Removal of Malachite Green by Stishovite – T:O2 Nanocomposite and Stishovite Clay – A., Chem Sci Trans., **2013** 2(3) **771-780**.
10.	**Magnetite - covered Bentonite Nano composite**	**Methylene Blue**	F.S. Hashem, Removal of Methylene Blue by Magnetite – Covered Bentonite Nano Composite Eur.Chem.Bull. **2013**, 2(8), **524-529.**
11.	**Poly aniline – Fe_2O_3 magnetic Nano Composite**	**Carcinogenic acid Violet 19 dye**	Manohar R.Patil., V.S.Shrivastava, Adsorption removal of carcinogenic acid Violet 19 dye from aqueous solution by polyaniline – Fe_2O_3 magnetic nanocomposite, J.Mater. Environ.Sci.6(1) (**2015**) 11-21.
12.	**Tri – metal oxide nano composite (zn- Mn – Fe- Nano oxide metal)**	**Reactive yellow – 15**	Kamila Banu N., Santhi . T., Development of Tri –metal oxide Nano Composite Adsorbents for the removal of Reactive yellow – 15 from aqueous solution I.J.S.N., Vol. 4(3) **2013 (381-389**).
13.	**Gum Arabic – Coated Magnetic Nano particle**	**Methyle Blue**	Eman Alzahrani Gum Arabic – Coated Magnetic Nano particles for Methyle Blue Removal., International Journal of Innovative Research in Science, Engineering and Technology, Vol.3, Aug **2014 (15118-15129**).
14.	**Carbon Nano tube**	**Rhodamine B**	Sandeep Kumar, Gaurav Bhanjana, Kavita Jangra, Neeraj Dilbaghi, Ahmad Umar., Utilization of Carbon Nano tubes for the Removal of Rhodamine B dye from Aqueous solutions., J. Nanosci.Nanotechnol. **2013**, Vol .13 (**1-7**).
15.	**Gold Nano Particle**	**Congo Red**	Ghaedi M., Ramazami S., Roosta M., Gold nano particle loaded activated carbon as novel adsorbent for the removal of congo red, Indian Journal of Science and Technology, Vol.4 Oct 2011 (**1208-1217**)

Removal of Dyes by various Nanocarbon as Adsorbents:

I. Removal of azo dye using Magnetic Carbon Nanotubes

Magnetic CNT's were synthesized by a Fenton's reagent method without the addition of any cations.Iron oxide nanoparticles were uniformly dispersed on carbon nanotubes without any pretreatment such as defect activation by strong acids or covalent fictionalization processes. The novel Magnetic CNT's were used as adsorbents to remove MO from aqueous solutions with good adsorption capacity. A new photo catalytic regeneration technology was introduced based on the high loading of nanoscale iron oxide. This paper provides a green integrated method including adsorption enrichment and photo catalysis degradation for MO removal.

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II.Removal of Rhodamine-B using Corchorus Olitorius-l Leaves

The composite adsorbent exhibited effectiveness in the removal of Rh-B dye from aqueous solution. The removal efficiency was controlled by solution P^H,adsorbent concentration, contact time and initial ion concentration. Adsorption data fitted well with the Langmuir and Freundlich models.However,Langmuir isotherm display the better fitting model than Freundlich isotherm because of the higher correlation coefficient that the former exhibited, thus indicating to the applicability of monolayer coverage of the Langmuir dye on the surface of adsorbent. Using Corchorus olitorius-l to produce activated nanocarbons potentially provide a less expensive raw material,a highly effective adsorbent as well as production of activated nanocarbon processed from renewable resources instead of non-renewable ones.

III.Removal of cationic dyes using STISHOVITE clay –TiO_2 Nanocomposite

The present investigation showed that Stishovite –TiO_2 nanocomposite can be used as adsorbent for dye removal of methyl violet. The amount of dye adsorbed varied with initial dye concentration, adsorbent dose,Ph and temperature. Removal of methyl violet by nanocomposite obeyed both Langmuir and Freundlich isotherms. The adsorption process followed Pseudo second order kinetics. This has been further supported by Elkovich chemisorptive kinetic model. Desorption studies reveals that no satisfactory desorption taking place confirming chemisorptive nature of adsorption. Evaluation of thermodynamic parameters showed the process as endothermic and spontaneous.

III.Removal of Reactive black 5,Reactive red 198 and Reactive blue 21 using cetyl tri methyl ammonium bromide-coated Magnetite Nanoparticles

In the present study, Fe_3O_4 NPs were synthesized by using the reactor and then the CTAB-coated Fe_3O_4NPs were used as adsorbent for removal of the reactive dyes from waste water samples. Kinetic study showed that kinetic data were well fitted with Pseudo second order model which can confirm by a chemisorptions mechanism. Also, experimental adsorption data at equilibrium state were fitted by Langmuir model. Also, Fe_3O_4 NPs as adsorbent can be easily synthesized and regenerated. Due to very high surface areas, short diffusion route and magnetically-assisted separability of the CTAB-coated Fe_3O_4 NPs high adsorption capacities can obtain in a very short time. The reported data should be useful for the design and fabrication of an economically viable treatment process using batch or stirred tank reactors for dye adsorption and for diluting industrial effluents.

V.Removal of Coralene Dark 2B azo dye using calcium oxide Nanoparticle

A novel CNT-GAC composite was successfully produced which was easier to handle compared to pure nanomaterial alone. Experimental results on adsorption conditions indicated that coper,Nickel and lead ions have highest adsorption capacity at Ph 5,while the maximum adsorbent dosage was 1g/l for copper and lead ions recording a sorption capacity of 1.013 and 0.853mg/g respectively and 2g/l for Nickel recording 0.07mg/g.Langmuir isotherm adsorption model having higher R_2 value of 0.93,0.89 and 0.99 for copper,Nickel and lead ions respectively, described the adsorption process better than Freundlich model for the three metals. This novel material opens new door for various usage of the nanomaterials in different fields of application in the chemical, petro chemical industries and wastewater treatment plants, though more work is needed for the mass production of the material at reduced cost.

VI.Removal of Reactive Orange 16(RO16) and Indigo Carmine(IC) using Magnetic zeolite/iron oxide nanocomposite

From the results of this study zeolite from fly ash/iron oxide nanocomposite was investigated for the removal of Reactive Orange(RO16) AND Indigo Carmine(IC) from aqueous solutions. Adsorption processes for the two anionic dyes were found to follow the Pseudo-second-order kinetics rate expression.Freundlich isotherm described the equilibrium data of IC On zeolite better than Langmuir isotherm, while Langmuir isotherm fitted better to the equilibrium data of RO16.Thermodynamic parameters were calculated and indicated that each of these adsorption processes was spontaneous and endothermic in nature. If magnetic zeolite/iron oxide nanocomposite is used as the adsorbent for dyes, magnetic separation will be applied and the clear solution could be easily decanted off or removal by pipette.Furthermore,supporting of magnetite nanoparticles on zeolitic material from coal fly ashes during the process prevents the coaggregation of the iron oxide nanoparticles and is of help for their storage and pelltization.

VII.Removal of Malachite green dye using MnO_2 nanoparticles

MnO_2 nanoparticles were successfully prepared the simple solution combustion synthesis method and its adsorption capacity for Malachite green was investigated. The result showed that the parameters like effect of Ph and contact time will play a very important role on the adsorption.

VIII.Removal of Cr(VI) using iron oxide magnetic nanoparticle

This review article covers the recent studies done for the aqueous hexavalent chromium removal using iron oxide magnetic nanosorbents.Majority of the experimental results

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claimed that, the optimum Ph value for chromium adsorption on to iron oxide nanoparticles are within the range of 2-3.This review article revealed that, in majority of cases, the adsorption isotherms are well fitted with Langmuir and/or Freundlich models and kinetics are in accordance to pseudo second order kinetic model.

IX.Removal of Malachite Green using Stishovite-TiO_2 nanocomposite and Stishovite clay-A

The present investigation showed that Stishovite TiO_2 nanocomposite and Stishovite clay can be used as adsorbent for removal of malachite green. The amount of dye adsorbed varied with initial dye concentration, adsorbent dose,ph and temperature. Removal of dye by both nanocomposite and clay was found to obey both Langmuir and Freundlich adsorption models.The adsorption process followed Pseudo second order kinetics. This has been further supported by Elkovich chemisorptive kinetic model. Desorption studies reveal that no satisfactory desorption taking place confirming chemisorptive nature of adsorption. Evaluation of thermodynamic parameters showed the process to be endothermic and spontaneous.Intra particle diffusion play a major role. The study reveals that Stishovite-TiO_2 nanocomposite is more efficient than the natural Stishovite clay in removing the malachite green.

X.Removal of Methylene Blue using Magnetite-covered Bentonite nanocomposite

This study reveals that introduction of Fe_3O_4 magnetic nanoparticles into the surface of bentonite generates a porous surface with high surface area which is suitable for adsorption of basic dyes like methylene blue. The results of batch experiments for removal of MB showed that the adsorption capacity increased with increasing the contact time and the initial ph of MB solutions with maximum adsorption capacity at ph 7.However the adsorption capacity with increasing mass of the adsorbent.Kinectic data of adsorption are well fitted by the Pseudo second order kinetic model with a good agreement with the intra-particle diffusion model. The equilibrium experimental data fits perfectly the Langmuir isotherm which implies the monolayer formation on the surface of the modified bentonite.The maximum adsorption capacity was 1600 mg/g.

XI.Removal of carcinogenic acid violet 19(acid fuchsine)dye using Polyaniline-Fe_2O_3(PANI-Fe_2O_3)magnetic nanocomposite

This result indicates that adsorptive removal of acid violet 19 dye by using adsorbent dose(PANI- Fe_2O_3) is successfully applied. The adsorption rate increased significantly by increasing amount of adsorption dose, while with an increasing dye concentration adsorption rate decreases. Basic ph condition is found, which significantly affect the dye adsorption efficiency of acid violet 19 dye is 98.5% and after elution the concentration of dye is 20mg/lt.The present study shoes that conducting PANI-Fe_2O_3 can be used adsorbent for the removal of acid violet 19 dye from aqueous solution. The amount of adsorbed dye is found from 1.7 to 7.7(mg/g) increased with an increase contact time and increase in initial dye concentration with an increasing adsorbent dose. The rate of adsorption if found to confirm the Pseudo second order kinetics with good correlation with R2 values. It is found that Elkovich model has good correlation with R2 values, which indicates chemisorptions. Adsorption isotherms are described by Langmuir and Freundlich isotherm models.Freundlich isotherm model is found to fit with experimental data due to higher Yn and Kf values.

XII.Removal of Reactive yellow-15 using Tri-metal-oxide nanocomposite(Zn-Mn-Fe-Nano oxide metal)

Optimization, Parametric studies, adsorption isotherm and kinetic studies were done, and following conclusions were obtained: using Batch mode method, the optimum parameter conditions of 100ppm initial RY-15 concentration,2.0g adsorbent dose and a Ph of 4 were determined to yield a maximum RY-15 removal of 56.52%.The percentage removal of RY-15 was observed to increase with decreasing initial dye concentration and ph,and increasing adsorbent dose. The Langmuir isotherm best described the equilibrium data with R2=0.9981,which signifies that a homogeneous adsorption takes place between Reactive yellow-15 and Zn-Mn-Fe-nano metal oxide composite(Zn-Mn-Fe NMOC) adsorption system due to its high R2=0.9601.In addition, the theoretical qe(2.079 mg/g) generated by the Pseudo second order equation is in good agreement with the experimental qe value(13098 mg/g).This implies that the rate-limiting step is a chemisorptions process. This indicates that the rate-determining step is a combination of pore diffusion and chemisorptions.Conclusively,Zn-Mn-Fe-nano metal oxide composite adsorbent is an effective adsorbent in the removal of RY-15 dye from aqueous solution, where process parameters such as solution ph,initial dye concentration and adsorbent dose significantly affects the 56.52% of RY-15 removal.

XIII.Removal of Methylene Blue using Gum Arabic(GA)-coated Magnetic Nanoparticles(MNPs)

In this study, magnetic nanoparticles were coated with GA and characterized by BET,TEM,SEM,EDAX,XRD and FTIR.Determination of the effectiveness of MB adsorption from aqueous solution on to fabricated MNPs and GA-MNPs was investigated .Results indicated that the GA-Coated magnetic nanoparticles showed high efficiency in removing MB in aqueous solution and the adsorption isotherm of GA at the surface of bare magnetite followed a Langmuir model. The removal efficiency increased with increasing temperature, which means the adsorption process is endothermic in nature. The results of this study open the possibility for using GA-MNPs in applications involving

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the removal of dyes from aqueous solution and for waste water treatement

XIV.Removal of Rhodamine B dye using carbon Nanotubes

The present work describes removal efficiency of multiwalled carbon nanotubes as adsorbent for cationic dye Rhodamine B.The CNTs were synthesized using CVD and further explored for removal of cationic dye. The parameters such as contact time,Ph and dye concentration were examined. The equilibrium adsorption of Rhodamine B is best fitted in the Langmuir and Tempkin isotherms. Pseudo-second-order kinetic model was applied to identify the dynamics of the adsorption process.

XV.Removal of Congo red using Gold Nanoparticle Activated carbon (Au-NP-AC)

The Gold nanoparticle loaded activated carbon is identified to be an effective adsorbent for the removal of CR from aqueous solutions. It was observed that batch sorption using Au-NP-AC was dependent on parameters such as initial concentration of dye,time,pH,dose of adsorbent and type of dye. The equilibrium and kinetic studies were made for the adsorption of dyes from aqueous solutions on to CR.Adsorption parameters for the Langmuir,Freundlich and Tempkin isotherms were determined and the equilibrium data were best described by the Langmuir model. The process is endothermic in nature and its kinetics can be successfully fitted to Pseudo-second-order kinetic model. The results of the intraparticle diffusion model suggested that intraparticle diffusion was not the only rate controlling step.

II. CONCLUSION

This review shows that there are various adsorbent available to remove dye from aqueous media using adsorption method. The effect of different parameters like contact time, adsorbent dosage, initial concentration of dye,ph and temperature on the adsorption rate differs using these adsorbents.The adsorption capacity was dependent on the type of adsorbent and adsorbate used.Although the rate of adsorption depends upon the affinity of adsorbent towards the adsorbate,the adsorbents showed a good adsorption rate for majority of commonly used dyes and have been found to be quite effective in dye removal. From this review one can easily find the best adsorbent used for particular dyes.

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