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Catalytic reduction of Methylene Blue dye molecules using Fe_3O_4@Ag Nanocomposites: A comparative study

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Abstract

Fe_3O_4 and Fe_3O_4@Ag nanoparticles were synthesized by coprecipitation method. andare characterized by FT-IR spectroscopy. Catalytic degradation of MB dye was studied by the UV-visible spectrophotometer and showed 70.5% degradation by the Ferrate nanoparticles than the Ag decorated ferrate nanoparticles.

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I.INTRODUCTION

Many elements are known which are plentiful in occurrence and extensively used on earth. Iron, in the form of various oxides, is one of these known elements which has potential for different applications. Various types of oxides of Fe like Fe_3O_4, β-Fe_2O_3, α-Fe_2O_3 and FeO are known to exist. These polymorphs of iron oxide exhibit remarkable chemical and physical properties which are favorable in wide range of applications. These magnetic nanoparticles of iron oxides have many uses such as recording material, magnetic resonance imaging, magnetic drug target, environment and catalysts [1].
Fe_3O_4known as magnetite is one of the oxides of iron which plays a major role in various areas of chemistry, material sciences, physics and medical sciences. Fe_3O_4 crystallizes in mixed oxidation state iron (Fe^{3+} and Fe^{2+}) inverse cubic spinel structure [2-4] . Fe_3O_4 can be used in magnetic resonance imaging, in drug delivery systems, as sorbent for heavy metal, as antibacterial agents, as catalyst, as electrochemical biosensors, as shielding material in electromagnetic interference and for energy harvesting[5-9] . It has been reported that separation between valence band of Fe(4s) and O(2p) in Fe_3O_4 is 4–6 eV (309-206 nm) .[10]
The photo catalytic activity of metal oxide, Fe3O4, can be further boosted up by doping it with metal atoms. In metal-metal oxide photo catalyst, the photo excited electron easily shifts to fermi level of doped metal atom via Schottky contact which prevents the de-excitation of electron and hence it improves the catalytic performance of metal oxide [11-13]. In the present study describe the catalytic reduction of methylene Blue dye molecules using $Fe_3O_4$and Fe_3O_4@Ag nanoparticles.

II.EXPERIMENTAL

Synthesis ofFe_3O_4nanoparticles

A solution was prepared by suspending 16.25 g $FeCl_3.6H_2O$ in 100 mL distilled water. Similarly, another solution was prepared by suspending 6.35 g $FeCl_2.4H_2O$ in 100 mL distilled water. Both solutions were mixed in a glass beaker. Then, NH_4OH was added dropwise to mixture formed by mixing of first two solutions of $FeCl_3.6H_2O$ and $FeCl_2.4H_2O$ under continuous stirring at 70 °C till pH 10. The resultant precipitate was filtered, washed, and dried.

Synthesis ofFe_3O_4@Ag Nanoparticles

To deposit silver on the magnetite particles, initially, 4 mM ethanolic silvering solution was prepared, then 3 mg Fe_3O_4 nanoparticles were dispersed in 30 mL of this solution in a polypropylene container by using an ultrasonic bath. The polypropylene container was used to avoid non-specific silvering of the reaction vessel. At the end, silver coating was achieved by adding butylamine as a weak reductant of $AgNO_3$ in ethanol [14].

III.RESULTS AND DISCUSSION

The synthesized Fe_3O_4 Nanoparticles are shown in Figure 1 and the Fe_3O_4@Ag was dispersed as solution.

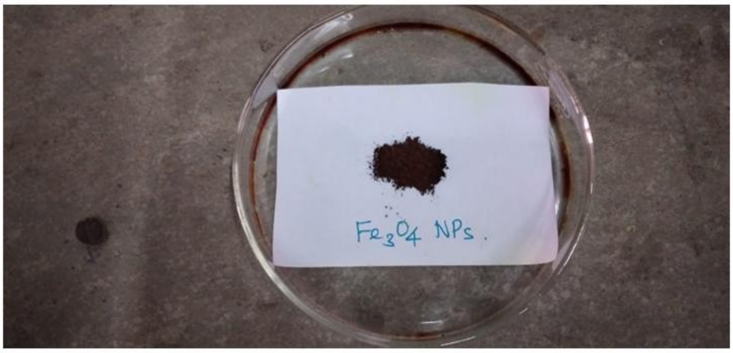

Figure 1.Fe_3O_4Nanoparticles.

FT-IR spectroscopy analysis of Fe_3O_4@Ag NPs

The FT-IR spectrim of the Fe_3O_4 @Ag NPsis shown as Figure 2. The obsorption peak at 720 cm^{-1}conforms the presence of Ferrate ion as Fe-O. The other obsorption peaks conforms the formation Fe_3O_4 @Ag NPs.

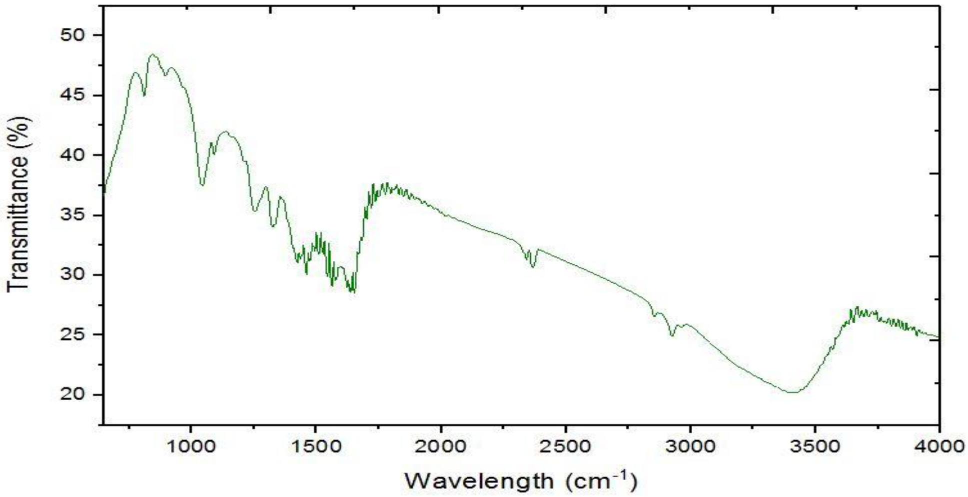

Figure 2. FT-IR spectrum of Fe_3O_4@Ag Nanoparticl

Catalytic reduction of Methylene blue dye

The catalytic reduction of the MB dye molecules as aqueous solution isshown in Figure 3.

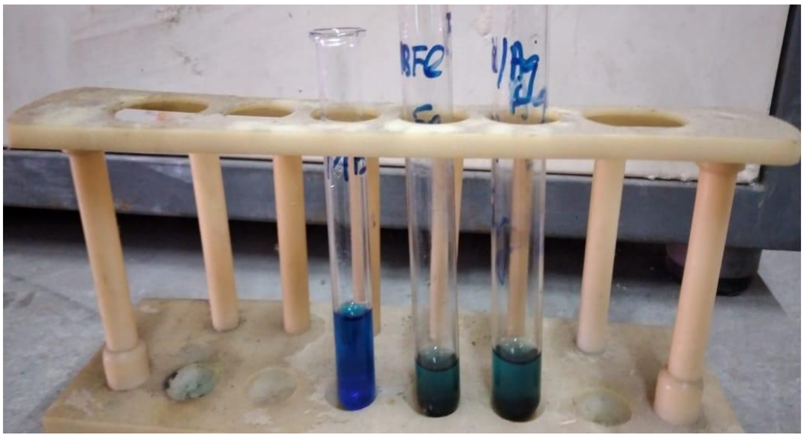

Figure 3. Catalytic reduction of MB dyes using Fe_3O_4 andFe_3O_4@Ag nanoparticles.

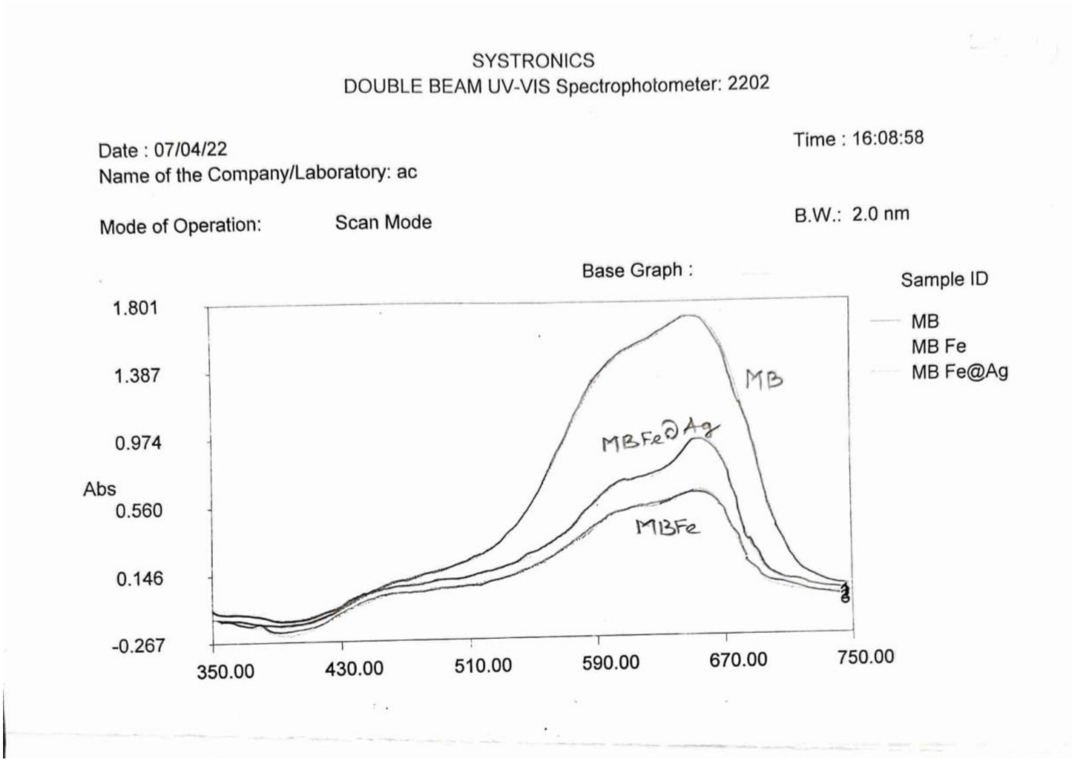

Figure 4. UV-visible spectrum of Catalytic reduction of MB dyes using Fe_3O_4 andFe_3O_4@Ag nanoparticles.

Catalytic reduction of MB dye molecules in aqueous solution usingFe_3O_4 andFe_3O_4@Ag nanoparticleswasdetermined by UV-visible spectrophotometer. About 50 mL of 50ppm of dye solution taken in a beaker and 50mg of nanoparticles (Fe_3O_4 andFe_3O_4@Ag) were added separately into the dye solution . After 30 mins the dye solution were taken for UV-visible absorption study. The absorbance of the dye solutions were recorded and are shown in Figure 4. The absorbance reveals that Fe_3O_4 reduces the dye molecules than that of Silver decorated Fe_3O_4 nanoparticles. The percentage of reduction of MB dyes by using Fe_3O_4 andFe_3O_4@Ag nanoparticles are 46.0 and 70.5 % respectively. Therefore the ferrate nanoparticles are better dye adsorbent towards MB dyes than the Ag decorated ferrate nanoparticles.

IV.CONCLUSIONS

Fe_3O_4 andFe_3O_4@Ag nanoparticles were synthesized by coprecipitation method. The synthesized nanoparticles were characterized by FT-IR spectroscopy. Absorption peaks conforms the formation of Ag decorated ferratenanoparticles. Catalytic degradation of MB dye was studied by the UV-visible spectrophotometer and showed 70.5% degradation by the Ferrate nanoparticles than the Ag decorated ferrate nanoparticles.

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