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RESEARCH ARTICLE

A Simple Study on the Photocatalytic Efficiency of Copper Magnesium Ferrite

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ABSTRACT:
Nanostructured Materials have great scope in research due to their broad range of applications. Here in this study we have prepared copper doped magnesium ferrite ($CuMgFe_2O_4$)through Solution Combustion technique at very low temperature. The synthesized samples were analyzed by powder X-ray Diffraction (XRD) and Scanning Electron Microscope(SEM). The flake like morphology of $CuMgFe_2O_4$ catalyst could be clearly identified from the SEM images. The efficiency of $CuMgFe_2O_4$catalyst over Congo Red dye degradation under sunlight were studied and were found to be better than commercial photocatalyst. To further improve the degradation efficiency of the catalyst various parameters was optimized such as H_2O_2, pH and Catalyst weight. From our studies we confirm that the $CuMgFe_2O_4$ catalyst could be a promising material for practical application.

KEYWORDS: Photocatalyst, Solution combustion Technique, Visible light, SEM, Magnesium Ferrite.

INTRODUCTION:
In common industries are looking for the refabrication of utilized water, as the huge amount of investment over steady fresh water is creating problem for developing industries. Under these circumstances purification of contaminated water had also become tedious work[1]. When looking for materials with economic mode two major shortcomings were observed, very low efficiency under visible light irradiation and reusability mechanism. Henceforth development of effective photocatalyst is still under broad research race. Recent studies have provoked iron oxides Fe_3O_4 and γ-Fe_2O_3 to be a promising fentoncatalyst[2,3]due to its overwhelming abilities such as low conductivity range, thermal stability and reusability. Still ferrite has a major disadvantage that a very high rate of electron hole pair recombination affecting the efficiency of photocatalyst[4]. To overcome this drawbacktransition elements like Cr, Mn, Co, Ni and Cu etc.,[5]were replaced for Fe into the crystal lattice proved which had effectively improve efficiency of the ferrite based heterogeneous fenton catalysts. But still the property of ferrite can be controlled by synthesis method such as hydrothermal, co-precipitation, sol-gel and combustion methods[6].In this study we have synthesized the Cu doped Magnesium ferrite $CuMgFe_2O_4$ bysolution combustion method to study its photocatalytic efficiency againtcongo red dye[7,8].

MATERIALS AND METHOD:
Analytical grade iron nitrat**e** [$Fe(NO_3)_3{\bullet}9H_2O$], magnesium nitrate [$Mg(NO_3)_2{\bullet}6H_2O$], cobalt nitrate [$Cu(NO_3)_2{\bullet}3H_2O$], Citric Acid, H_2O_2 and Congo Red Dye were purchased from Merck and used as such without any purification.

Synthesis method of $CuMgFe_2O_4$:
The $CuMgFe_2O_4$ were prepared by solution combustion method using citric acid as combustion fuel. Iron nitrate [$Fe(NO_3)_3{\bullet}9H_2O$], magnesium nitrate $Mg(NO_3)_2{\bullet}6H_2O$] and cobalt nitrate [$Cu(NO_3)_2{\bullet}3H_2O$] solutions were prepared separately and mixed in definite stoichiometric proportions. To this stoichiometric solution citric acid were added and stirred for about 5 min to attain

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homogenous solution. The resultant solution was kept in muffle furnace for 5 min at 450°C and allowed to attain room temperature.The obtained product were crushed into powder and used for further analysis[9].

Photodegradation Experiment:
The degradation efficiency of the above synthesized catalyst was examined using congo red dye under direct sunlight. In each study, 0.03mg of $CuMgFe_2O_4$ catalyst was added into 50ml of congo red dye solution with concentration of 0.2g/L. The resultant mixture was kept in dark room to attain adsorption equilibrium between dye and the photocatalyst for about 30min, and then the solution was illuminated by natural sunlight. The color removal of dye were monitored from 2ml sample collected from reaction mixtures at regular periods[10,11]. The suspended catalyst was removed by centrifugation. The supernatant solution were analysed using Shimadzu UV-3600 Model at λmax=499 nm[12].

RESULT AND DISCUSSION:

XRD pattern of MNF catalyst:
XRD technique is used identify the crystal phase of the synthesized sample13. Figure 1 IllustratesXRD pattern of the prepared $CuMgFe_2O_4$catalyst. The crystalline peaks at 29.96° and 35.27° are corresponding to reflection planes (220) and (311) of Fe_2O_4JCPDS card no 65-3107. The peaks at 36.81°, 42.83° and 62.13° are indexed to (111), (200) and (220) planes of MgO[14]. Also the peaks at 48.43°, 56.96° and 60.04° were attributed to (202), (202) and (113) planes of CuO. From the peaks observed we are able to confer that the synthesized material has spinel ferrite strucuture.

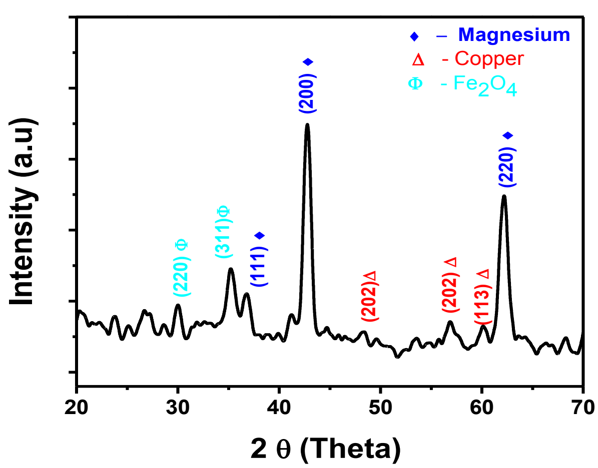

Figure 1 XRD of synthesized $Cu/MgFe_2O_4$

SEM image of NMF photocatalyst:
The surface morphology of the catalyst was determined by Scanning Electron Microscope (SEM)[15,16] and the images were illustrated in Figure 2(a,b). The SEM images show clear resemblance of flake like morphology. Figure 2a shows agglomeration of many small particles which is due to the magnetic dipole-dipole interaction[17]. Figure 2b shows HRSEM image at high magnification inferring clear homogeneous flake surfaces.

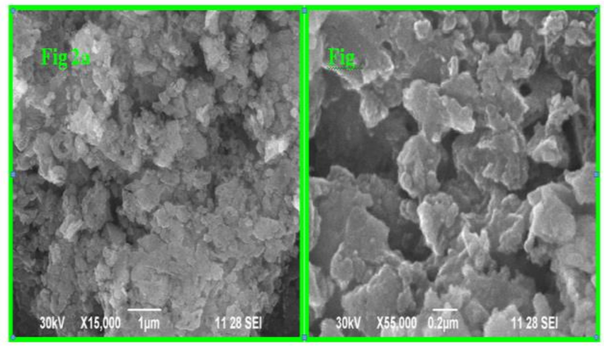

Figure 2 SEM image of synthesized $CuMgFe_2O_4$

Comparative study of Photocatalyst:
The catalytic activity of the catalyst is examined by the degradation of congo red dye under ambient conditions and results are illustrated in Figure 3. From the experiments results we could find that degradation of CR dye is almost negligible under sunlight alone. Also without catalyst, from results we can observe that CR is very stable in presence of sun light. It is also proved that a slight degradation was obtained with TiO_2 and $MgFe_2O_4$ alone. After inclusion of Cu into the $MgFe_2O_4$ the degradation efficiency is achieved to maximum. This result shows that the Cu could act as charge carrier and improve the catalytic efficiency[18,19].

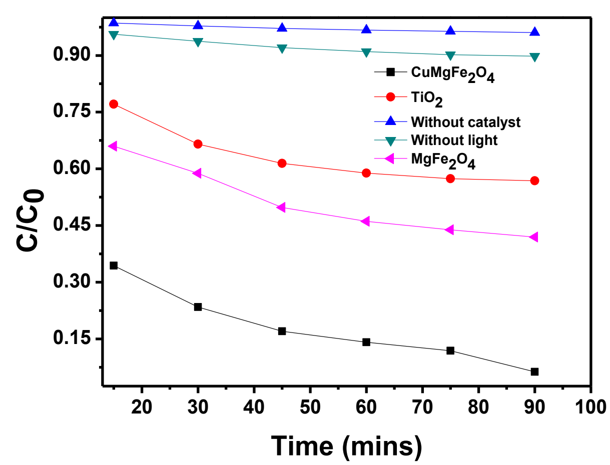

Figure 3 Catalytic activity of $CuMgFe_2O_4$

Effect of H_2O_2:
The photocatalytic efficiency of the photocatalyst is significantly affected by the H_2O_2concentration[20]. Photocatalytic degradation experiments were carried out to optimize the H_2O_2 concentration by varying the H_2O_2(1-4 ml/L) at constant pH (4), catalyst weight (30mg/L) and within the irradiation time of 90min and

the results are shown in Figure 4 From the experiment we infer that initially the degradation efficiency is increased; however above certain concentration of H_2O_2 there is an decrease in degradation rate. This is due to the reason that presence of excessive amount of H_2O_2 may react with hydroxyl radicals leading to formation of oxyhydroxy radicals which is less reactive than hydroxyl radicals [21].

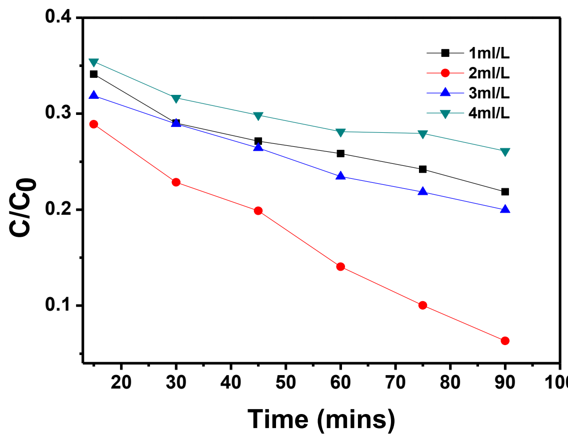

Figure 4 Effect of H_2O_2 Concentration over Congo Red dye

Effect of pH:

Figure 5 illustrates the influence of pH on the degradation of CR using synthesized photocatalyst and results confirm that pH has significant role in degradation. The experiments were carried out at pH between 1 and 10. The degradation efficiency is very low at pH =1due to the dissolubility of ferrite materials.

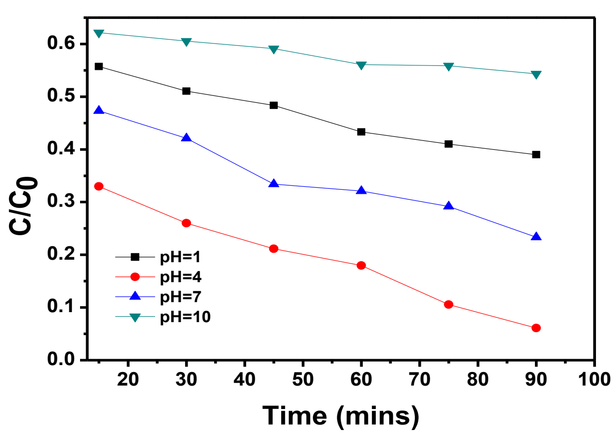

Figure 5 Effect of pH on degradation studies

By increasing the pH from 1 to 4 we achieved a maximum degradation for the synthesized materials. At pH 7 and above the degradation efficiency is reduced because of formation$Fe(OH)_2^+$ and $Fe(OH)^{2+}$ions on the surface of the catalyst[22,23].

Effect of catalyst weight:

The degradation efficiency of the catalyst is increased when the catalyst weight is increased from 0.020g/L to 0.030g/L, due to the formation of more active radicals the degradation efficiency is enhanced and the results are presented in Figure 6. The decomposition rate of H_2O_2 is high when more active site present in the sample which increase the degradation of congo red dye. Above 0.030g/L the degradation efficiency is slightly decreased because of aggolomeration of catalyst reduced the active radials and inhibit the light penetration into the solution. Therefore, 0.030 g/L of the catalyst was used as the optimal dosage for the subsequent experiments[24,25].

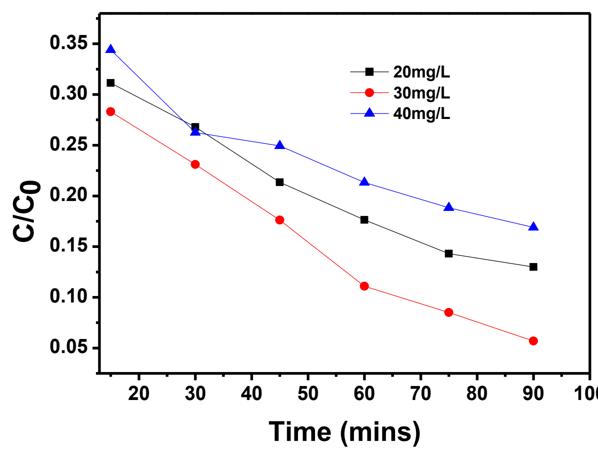

Figure 6 Study of catalyst concentration

CONCLUSION:

A new $CuMgFe_2O_4$ was synthesized by solution–combustion method. The synthesized catalyst was characterized by different techniques. XRD results reveals that the prepared catalyst having spinel structure in nature revealing the presence of Mg, Fe and Co in the catalyst. $CuMgFe_2O_4$ is found to be more efficient than commercial catalysts for degradation of CR under sun light. The optimum pH and catalyst loading for efficient removal of dye are found to be 4 and 2 g L^{-1}, respectively. Hence when compared to other catalyst $CuMgFe_2O_4$ was foundto be better and efficient in terms of method of preparation, photocatalytic activity and reusability so it can be considered as potential candidate in industrial application point of view.

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