Mn0.5zn0.5fe2o4 nano-material: hydrothermal synthesis

Title: Hydrothermal synthesis and photocatalytic application of $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nano-material for degradation of Reactive Blue H5R dye

In the proposed research work $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nano material will be synthesized using hydrothermal technique for the degradation of reactive blue H5R dye. The chlorides of manganese, iron and zinc will be used for the synthesis of the $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nano material. Then synthesized material will be used in water treatment for the degradation of reactive blue H5R dye through photocatalysis using visible light. The examination of the size of the particles and structural properties of the synthesized material will be carried out by using X-ray diffraction (XRD) technique and the morphology of material will be evaluated by scanning electron microscopy (SEM). Particle or grain size of prepared samples of $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nano material will be computed using the Scherer's formula. The photo-catalytic behavior of $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nano material will be investigated by measuring the photo degradation rate of the dye. The stability of the nano-photo catalytic material will also be investigated by the repeated use of $Mn_{0.5}Zn_{0.5}Fe_2O_4$.

INTRODUCTION

Synthetic dyes and different chemicals used in textile industries play significant role in environmental pollution. Some of these industrial chemicals and synthetic dyes decompose aerobically and anaerobically resulting in the formation of carcinogenic compounds (Neill *et al.,* 1999). In the past few decades, there has been huge attention between scientists in increasing semiconductor photo-catalysts with great prospective for environmental protection applications like water disinfection (Ullah *et al.,* 2012; Shahid *et al* ., 2013).

Most of the ferrite materials are known to show exciting photocatalytic capabilities for hydrogen or oxygen generation from water upon irradiation with visible light. Such visible light absorption properties, and their proper band edge positions with respect to redox levels essential for water splitting, are desirable for a water splitting photocatalyst to work under sunlight (Dom *et al., 2014*).

Ferrite materials technology has now extended to a very progressive stage, in which the properties to a large extent are designed and controlled by engineers, to garb the particular function of the device. Because of their outstanding magneto-transport properties the mixed valence ferrites have involved huge scientific attention in the recent years (Ahmed and Bishay 2005). In the beginning works the ferrites were attained by soft chemistry and mechano-synthesis (Millot *et al.* , 2007).

Hydrothermal strategy is a promising synthetic method because of the low process temperature and very easy to manage the particle size. The hydrothermal procedure has several benefits over other growth methods such as the use of simple devices, catalyst-free growth, low cost, large area uniform production, environmental friendliness and less harmful (Aneesh *et al.,* 2007). Moreover, no post-heat behavior is needed for the created nanoparticles, which makes this method extremely suitable as heat treatment might result in particle collection. (Haw *et al.,* 2002)

OBJECTIVE

The objective of present research work is to produce $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nano-sized particles by hydrothermal technique specifically for catalysis of reactive blue H5R dye. The structural properties of synthesized nano-photocatalyst will be studied by using X-ray diffraction (XRD) and scanning electron microscopy (SEM). Photo-catalytic behavior of the $Mn_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles will be investigated by determining the photo degradation rate of the reactive blue H5R dye under visible light irradiation.

Review of Literature

Rath *et al* . (1999) synthesized $Mn_{0.65}Zn_{0.35}Fe_2O_4$ particles in nanosize (9–12nm) using metal chlorides via hydrothermal precipitation. The characterization was done with TEM, XRD, and VSM. The concentration of chloride ion and pH of precipitate played a vital role in retaining the preliminary stoichiometry of the solution of the nano-material. Whereas at low pH, incomplete precipitation of Mn was observed. Zn loss in the nano-particles at higher pH of precipitation was noted.

Bujoreanu *et al.* (2000) investigated the structure of manganese ferrite in powder form which was prepared by co-precipitation method using MnO_2 and $FeSO_4 . 7H_2O$. The powder material then was co-precipitated and aged at temperatures ranging from 55 to 59 ^oC, then washed and dried in the air at room temperature. By the addition 15% sodium hydroxide solution in the 2N cation solution the stoichiometric amounts of MnO_2, $FeSO_4 . 7H_2O$ and H_2SO_4 were precipitated

Kosak *et al.* (2004) prepared nanocrystalline MnZn-ferrite with different morphology through single water-in-oil micro-emulsion comprising of n-hexanol, surfactant CTAB and an mixed metal sulfates solution. The mixture was precipitate with sodium hydroxide solution and oxidized with hydrogen peroxide. The prepared nano materials were characterized by using X-ray diffraction (XRD), BET surface analyzer, magnetometry and transmission electron microscope (TEM).

Abdollahi *et al.* (2004) synthesized various compositions of manganese Mn doped ZnO. using precipitation method. XRD, TEM, SEM, EDX, BET techniques were used for characterization. The band gap measurement was done with UV-visible reflectance. XRD pattern showed no impurity peaks, indicating Mn-related secondary phases. The EDX showed the slightly lower amount of Mn doped on ZnO than the theoretical value and SEM showed that 1% Mn-doped ZnO well ordered morphology, homogeneous distribution of slightly lower particle size and low aggregation.

Vaidyanathan *et al.* (2004) compared $Mn_{0.9}Zn_{0.1}Fe_2O_4$ synhesized through double sintering method and chemical co precipitation method in order to find the magnetic properties. The precipitated ferrites showed altered magnetic properties like magnetization (M_s), coercive field (H_c) and Curie temperature (T_c). The particles were reduced in size as compared to co-precipitated nano-sized particles.

Arulmurugan *et al.* (2006) prepared by $Mn_{1-x}Zn_xFe_2O_4$ used for ferro-fluid preparation. TG-DTA, XRD, TEM, VSM and Mossbauer spectroscopy was used for description. The ultimate approximated cation contents decided with the initial degree of substitution. The particle size and curie temperature (T_c) reduced with the rise in zinc substitution. The particles with greater zinc concentration, showed ferrimagnetic and super paramagnetic behavior at room temperature.

Yimin *et al.* (2007) synthesized $Mn_{1-x}Zn_xFe_2O_4$ using metal sulfate in aqueous ammonia. The TEM, XRPD, VSM and TGA were appled to demonstrate the material properties. The classification of the nanoparticles was evaluated and discussed. The effects of the reacting components and preparation methods on the Curie temperature, the magnetization and the size distribution of Mn Zn ferrite nanoparticles.

Hejase *et al.* (2012) produced hyperthermia inducing agents manganese zinc iron magnetic nanoparticles. The structure was recongnized using scanning electron microscopy, X-ray diffraction, and a superconducting quantum interference device. The curie temperature, saturation magnetization, remnant magnetization, coercive field, and hysteresis were analyzed which showed that adapting the Mn contributed to the modification of properties of the magnetic complex.

Shahid *et al.* (2013) synthesized high effective $ZrFe_2O_5$ nanoparticles using co-precipitation method. By (EDX) the chemical composition of nano-materials were analyzed. (FE-SEM) was used to study the morphology. The structural properties of the produced material were appraised by XRD technique. By evaluating the degradation rate of TBO dye in aqueous solution the photo-catalytic action of $ZrFe_2O_5$ nano-particles was examined under visible light irradiation in the presence of $ZrFe_2O_5$ nano-particles. By increasing time of exposure under visible light irradiation a steady decrease in absorption peak was noticed. As after 140 min of contact to visible light the 92% degradation effectiveness was detected. Besides, $ZrFe_2O_5$ nano-photocatalyst could be recaptured and reprocessed purely. The rate of TOC elimination and TBO was decreased by only 10% and 5% respectively, afterward seven cycles of use, representing the more photo-stability of the synthesized nano-photo-catalyst material.