Green Synthesis of Zinc based Nanoparticles for Thermal Industry based Applications

Govindaswamy Padmapriya, Pandian Paulraj, Ayyar Manikandan

Abstract: ***Spinel ZnAl2O4 nanoparticles were prepared effectively by simplistic, economical microwave heating method using Hibiscus rosa-sinensis extract as reducing agent. The samples were successfully characterized by XRD pattern, EDX spectra, FT-IR analysis, HR-SEM analysis, and VSM instrumentation techniques. XRD, EDX and FT-IR results demonstrated that the products contain a pure single-phase spinel structure lacking of other secondary phase impurities. SEM results confirmed the spherical shaped nanoparticle morphology of the sample. Magnetic characterization property was confirmed by VSM analysis. VSM hysteresis loop established the superparamegnetism of the sample and the magnetization (Ms) value of ZnAl2O4 is 0.023 emu/g.***

Keywords: Spinel ZnAl2O4; Nanocrystals; Hibiscus rosa-sinensis extract; Magnetic property.

I. INTRODUCTION

In recent times, spinel transition semiconductor oxide nanomaterials have been broadly studied [1], due to their sole opto-electrical, magnetic, catalytic/photocatalytic properties those of bulkiness materials [2, 3]. Commonly, spinel aluminates (A2+(Al3+)2O4: A2+ = Zn2+, Co2+, Cu2+) have develop into an significant materials, owing to their probable in different multidisciplinary areas [3-5]. Various spinel aluminates ZnAl2O4 has been investigated extensively [5]. Several techniques have been used to prepare the spinel type transition metal oxide semiconductor nanoparticles, for example solvo thermal, co-precipitation, solvothermal, sol-gel and hydrothermal methods [6-10] etc. But, the above said methods meet several inconveniences for instance required long time procedures, high temperature and high-energy overriding, costly and complicated equipments and multifaceted procedures [11-16].

Amongst the above conservative methods, easy and cost proficient routes to prepare spinel metal oxide semiconductor nanoparticles by exploitation of inexpensive, cheap, low cost, non-toxic and environmentally benevolent precursors are unmoving key issues. Therefore, the enlargement of superficial and ecological gentle route is severely essential [17-21]. In this present work, spinel ZnAl2O4 nanostructure was prepared. Currently, the plant extract-assisted microwave heating route has enthralled and extraordinary interest in fabricating useful nano materials [22]. Additionally, microwave irradiation method is a short time preparation route and no need the complex equipment, which making this route is very attractive. In recent times, the bio based synthetic route is much uncomplicated and provides pure and better yield materials with satisfactory possessions.

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II. EXPERIMENTAL METHOD AND TECHNIQUES

A. Materials

Aluminium nitrate, Zinc nitrate, and H. rosa-sinensis extract as the raw materials were used. Millipore water was used for this synthesis. H. rosa-sinensis extract was prepared from a 5 g piece of systematically washed leave was thinly cut then it was liquefied in 10 ml of distilled water at 30 min to get clear solution, Nitrates of Zinc, and aluminum were dissolved in the H. rosa-sinensis extract under stirring for 1 h and solid powders are formed, and then washed with water and ethanol and kept at 70 ºC for 1h. [1-12]

Formation of ZnAl2O4 nano-crystals were carry out using a Rigaku Ultima XRD (λ = 1.5418 Å). The corresponding metal-oxide group formation was analyzed by Perkin Elmer FT-IR spectra. Surface was achieved with a 6360 HR-SEM..

III. RESULTS AND DISCUSSION

Crystal nature, crystal formation, size and purity were established by powder X- XRD pattern. The XRD diffraction peaks may possibly index single-phase spinel cubic structure of $ZnAl_2O_4$.

Lattice parameter was designed using the given formula in Eq. (1):

$$\sin^2\theta = \frac{\lambda^2}{4}\left[\frac{4}{3}\left(\frac{h^2+hk+k^2}{a^2}\right)+\frac{l^2}{c^2}\right] \quad \text{---- (1)}$$

The lattice parameter of $ZnAl_2O_4$ sample is 8.332 Å [3].

The crystallite size calculated by given in Eq. (2):

$$L = \frac{0.89\lambda}{\beta\cos\theta} \quad (2)$$

The calculated crystallite size of spinel $ZnAl_2O_4$ sample is 15.25 nm. Nevertheless, the microwave irradiation process, the microwave-oven has produced microwaves energy at a power of 850 W and converted into thermal energy, which resulting the functional nano-sized $ZnAl_2O_4$ sample.

A wide-ranging vibration band at ~3420 cm^{-1} to 3250 cm^{-1} is connected with the OH vibration of water, representing superior amount

of exterior OH. In addition, two main wide M-O bands in the range of 400-950 cm^{-1} [3], which is spinel $ZnAl_2O_4$ sample.

The surface was analyzed by HR-SEM analysis and is exposed in Fig. 3. Fig. 3 is the SEM image of spinel $ZnAl_2O_4$ sample exhibit homogeneous sphere-like nanoparticles. The smaller agglomerations of the products are mainly due to the influence of microwaves for the homogeneous distribution of the samples, which makes agglomeration and also magnetic relations between the resources.

Sample was confirmed by EDX technique. The peaks of Al, Zn and O and the absence other secondary peak observation, confirmed the purity products.

The magnetic assets of the spinel $ZnAl_2O_4$ sample was analysed by VSM at field ranging upto ± 10 kOe is exposed in Fig. 4. VSM hysteresis (M-H) loop confirmed superparamagnetism. The saturation magnetization (M_s) value was obtained to be 0.023 emu/g. From the VSM results, it was inference the magnetic property of the products depending on their size, and shape of the nanopowders.

IV. CONCLUSIONS

Spinel $ZnAl_2O_4$ sample was synthesized successfully by a facile microwave heating route using *H. rosa-sinensis* extract. XRD, EDX and FT-IR results specified that the prepared spinel $ZnAl_2O_4$ sample have spinel structure with well crystalline product and also free from other phase impurities. The HR-SEM result revealed that spinel $ZnAl_2O_4$ sample contain nanoparticle-like morphology. The specific M_s values were obtained to be 0.023 emu/g for spinel $ZnAl_2O_4$ sample.

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