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HYDROTHERMAL SYNTHESIS AND PROPERTIES OF PEROVSKITE $LaMnO_3$ NANOPARTICLES

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Abstract

In this study focuses the hydrothermal synthesis and properties of perovskite Lanthanum manganite nanoparticles ($LaMnO_3$ NPs). The prepared sample was subjected to powder XRD, HRSEM, EDAX and FTIR analysis. The Powder XRD result confirms the formation of crystalline $LaMnO_3$ NPs. The average crystallite size of $LaMnO_3$ NPs is found to be 35 nm. The mixed spherical and polygon morphology of $LaMnO_3$ NPs was observed from the HRSEM images. The EDAX spectrum confirms the presence of Lanthanum, Manganese and Oxygen elements in the prepared sample. FTIR analysis confirms the presence of octahedron MnO_6 is assigned to stretching vibration of perovskite $LaMnO_3$ NPs.

Keywords: Perovskite, Lanthanum manganite, Crystallite size, Stretching vibrations.

1. Introduction

Nanomaterials has gained much attention due to variety of applications such as biofuel production, waste-water treatment, electronics, disease diagnostics, therapeutic purposes, photocatalysis, energy, environments, solar cells, sensors and storage devices [1]. Metal oxide nanoparticles are interesting and attracts the researchers due to their physiochemical properties. Metal Oxide nanoparticles play a major role in the field of Physics, chemistry and biomedical due to their high absorption capability, thermally stability and biocompatibility [2-5]. Perovskite metal oxides have been globally explored and applied in many fields for the past few decades due to their structures, redox behaviour, ionic and electronic conductivity, thermal stability, magnetic properties [6-11]. Perovskite material manifest considerable interest due to their numerous properties in photochromic, storage of images, decontaminate, switching, wave signal processing devices [12-17]. Among Perovskite materials Lanthanum-based Perovskite have attained great attention due to its stability, flexibility and extraordinary catalytic properties. In the present work, $LaMnO_3$ perovskite is synthesized by Hydrothermal method and studied its properties by powder XRD, HRSEM, EDAX and FTIR analysis.

2. Experimental method

2.1 Synthesis of $LaMnO_3$

The following chemicals Lanthanum Nitrate hexahydrate ($La(NO_3)_3.6H_2O$), Manganese (II) chloride tetrahydrate, ($MnCl_2.4H_2O$), Sodium hydroxide (NaOH) and Acetone with 99.99% purity are used for the synthesis of $LaMnO_3$ perovskite material. $LaMnO_3$ was prepared by adding stoichiometric ratio of Lanthanum nitrate $La(NO_3)_3.6H_2O$ and Manganese (II) chloride tetrahydrate ($MnCl_2.4H_2O$) was dissolved in distilled water. The mixture was stirred for 15 minutes. 2 M of NaOH is prepared and added as a reducing agent into the mixed solution to attain the pH value around 5. The solution formed was dried at 80˚C and the mixture is ground well for 30 minutes in mortar crystal. After obtaining the uniform powder, it was calcinated at 1000˚C for 4 hours. After calcination, the obtained powder was taken out from the furnace and again ground well and kept in a sample container. The solutions are prepared by using the de-ionized water.

2.2. Characterization

Characterization of nanomaterials is necessary to study their various properties. It describes the various methods of synthesis and characterization of nanomaterials. The phase structure of the $LaMnO_3$ is identified by X-ray diffraction (XRD). The high resolution of Scanning Electron Microscope (HRSEM) is employed to study the surface morphology of the sample. The elemental composition of the prepared sample is analyzed by EDAX. The molecular vibrations of the prepared perovskite $LaMnO_3$ NPs is iden-

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tified by using FTIR analysis.

3. Results and Discussion

3.1 Powder XRD analysis

The powder XRD pattern of perovskite $LaMnO_3$ NPs is shown in fig.1. The reflection of $LaMnO_3$ is observed at 22.92˚,32.86˚,39.95˚, 46.62˚, 58.48˚ and 68.54˚ correspond to planes (100), (110), (111), (200), (211) and (220) respectively. The peaks of the sample are categorized in the rhombohedral structure using the standard JCPDS card No # 53-0058. From the observed full width half maxima of the peaks, the crystallite size of the prepared sample is calculated using Sherrer formula (Table 1). The average crystallite size and the dislocation density of the perovskite $LaMnO_3$ NPs is found to be 35 nm.

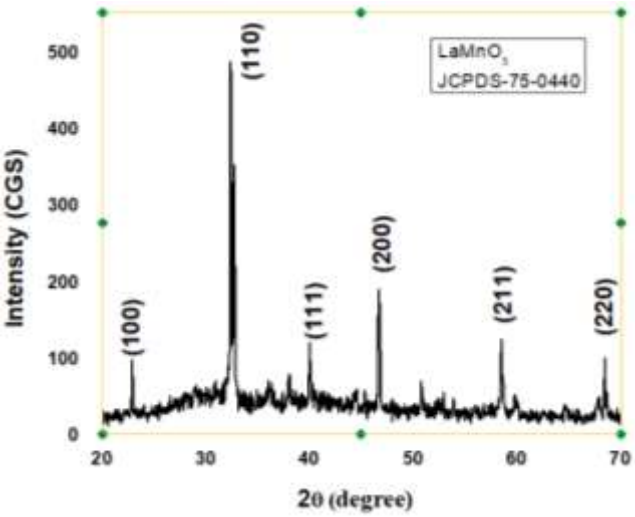

Fig.1 Powder XRD pattern of perovskite $LaMnO_3$ NPs

Table 1. Powder XRD data of perovskite $LaMnO_3$ NPs

Reflection	2θ(degree)	β(radian)	D(nm)	δ (nm^{-2})
(100)	32.43˚	0.34442	25.09	0.003406
(110)	40.03˚	0.27918	31.63	0.000428
(111)	46.70˚	0.18482	48.90	0.000523
(200)	58.51˚	0.14819	64.17	0.000831
(220)	68.54˚	0.1536	58.43	0.000662

3.2 HRSEM analysis

HRSEM images of perovskite $LaMnO_3$ NPs shown in Fig. 2. HRSEM images clearly reveal that the particles are spherical and polygon morphology. This mixed morphology of the prepared perovskite $LaMnO_3$ NPs are similar to the earlier reports [18]. The average particle size of perovskite $LaMnO_3$ is found to be 80 nm.

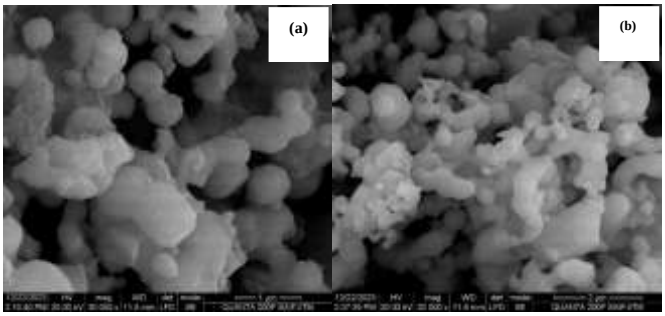

Fig. 2 HRSEM images of perovskite $LaMnO_3$ NPs

3.3 EDAX Analysis

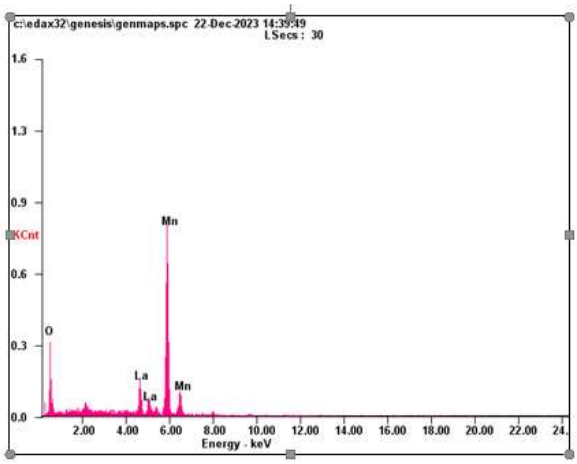

Fig. 3 EDAX spectrum of perovskite $LaMnO_3$ NPs

The elemental composition of perovskite $LaMnO_3$ NPs is depicted in fig. 3. The EDAX spectrum clearly shows the presence of required amounts of Lanthanum, Mangnese and Oxygen elements in the prepared perovskite $LaMnO_3$ NPs and there is no impurity peaks are observed.

3.4 FTIR Analysis

Fig. 4 shows the FTIR spectrum of perovskite $LaMnO_3$ NPs. The absorption bands are situated around 524, 956,

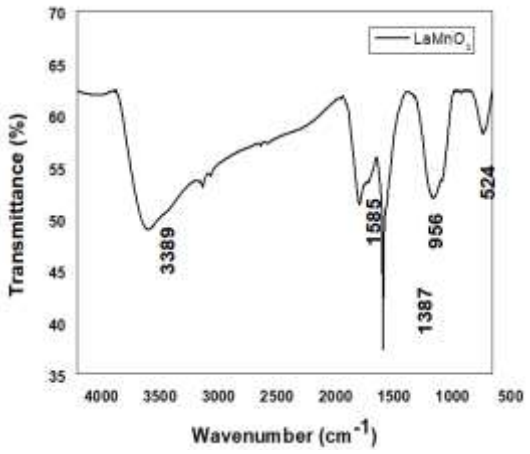

Fig. 4 FTIR spectrum of perovskite $LaMnO_3$ NPs

1387, 1585, 3389 cm^{-1}. The absorption band at 524 cm^{-1} corresponds to the stretching mode related with octahedron MnO_6 assigned to a vibration of the ABO_3 perovskites. The peaks at 3389 cm^{-1}, 1585 cm^{-1} and 1387 cm^{-1} are corresponds to O-H and La(OH) bonds [19].

4. Conclusion

The perovskite $LaMnO_3$ NPs are prepared by the hydrothermal method. The structural, morphological, elemental and vibrational properties of the perovskite $LaMnO_3$ NPs are studied by PXRD, HRSEM, EDAX and FTIR analysis. The powder XRD analysis confirms the formation of perovskite $LaMnO_3$ sample. The average crystallite size and dislocation density of the prepared perovskite $LaMnO_3$ NPs are estimated using Sherrer formula. The mixed spherical and polygon morphology of the prepared $LaMnO_3$ NPs are observed from the HRSEM images. EDAX analysis confirms the presence of La, Mn, O elements in the prepared perovskite $LaMnO_3$ NPs.

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