Revue Science des Matériaux, Laboratoire LARHYSS N°08, Mai 2016 pp. 08-17

Effect of combustibles on the structural properties of $LaFeO_3$ synthesized by auto-combustion

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Abstract

Lanthanum ferrite, $LaFeO_3$, is a perovskite type material with an orthorhombic structure that was synthesized by auto-combustion of different fuels from where we have obtained the structure (in the presence of amine group no further calcination was needed). This perovskite structure was confirmed by : XRD, Infra-red spectroscopy (IR), UV-visible spectroscpy and laser particle size.

Key Words : $LaFeO_3$, perovskite, auto-combustion, XRD, IR, UV-visible and laser particle size.

1. INTRODUCTION

Perovskite oxides consiste of large families among the structures of oxide compounds, and several perovskite-related structures are currently recognized. Typical structures consist of large-sized 12-coordinated cations at the A site and small-sized 6-coordinated cations at the B site [1-2].

Perovskites induces a great interest because of a variety of properties presented in these materials according to the choice of the elements A and B [3] : conducting (insulating, superconducting, ionic conduction, electronic conducting) piezoferroelectricity, ferromagnetism and magnetoresistivity, catalysis at high temperature [4].

One of most common perovskite oxides [5-6], $LaFeO_3$ nanoparticles exhibited good photocatalytic properties such as water decomposition and dye degradation under visible light irradiation [7-8].

The perovskite oxides are usually synthesized by a variety of methods including the reaction in the solid state [9], co-precipitation technique [10-11], polymerized complex method [12], combustion synthesis [13], spray drying, the cryochemic method (freeze-drying), and the sol-gel (using in particular the amorphous citrate complexes) [9].

2. MATERIALS AND METHODS

The method of preparation used for this study is an auto-combustion process in aqueous method proposed for the first time in 1990 by Chick in the synthesis of chromites and manganites powders, which is called Glycine Nitrate Process (GNP) [14].
The precursors are generally used to synthesize the compound $LaFeO_3$: Lanthanum nitrates $La(NO_3)_3.6H_2O$ and Iron nitrates $Fe(NO_3)_3.9H_2O$ as oxidizers, citric acid and glycine as fuels, which are dissolved in distilled water and also using ammonia with citric acid to adjust the pH to 7 for preparing three samples :

Sample 1 : $LaFeO_3$ prepared by citric acid as a fuel.

Sample 2 : $LaFeO_3$ prepared by citric acid as a fuel by adding ammonia to adjust the pH to 7.

Sample 3 : $LaFeO_3$ prepared by glycine as a fuel.

The solutions are then mixed at a room temperature in the stoichiometric proportions. The mixture is heated between 50 to 60 minutes until obtaining combustion and cinders. The resulting products are submitted to grinding until we had a fine powder and it requires the calcination only with sample 1 prepared by citric acid.

3. RESULTS AND DISCUSSIONS

The figures (1, 2, 3 and 4) shows the 3 samples after combustion and grinding :

Fig. 1- Sample 1 : Cinders obtained.

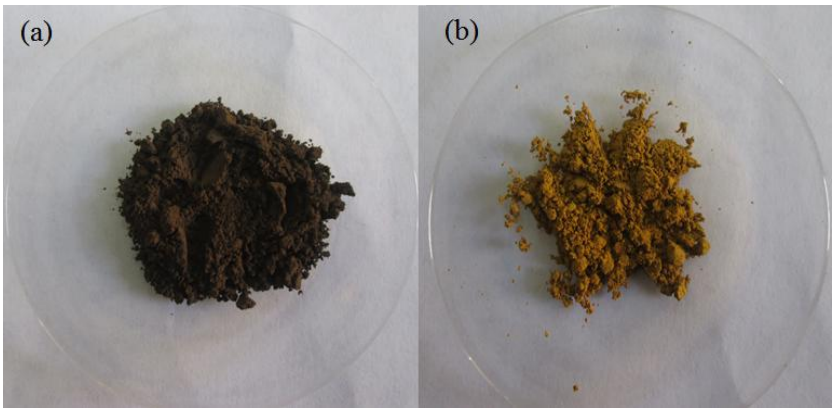

Fig. 2- Sample 1 : (a) : brown powder before calcination, (b) : yellow powder after calcination.

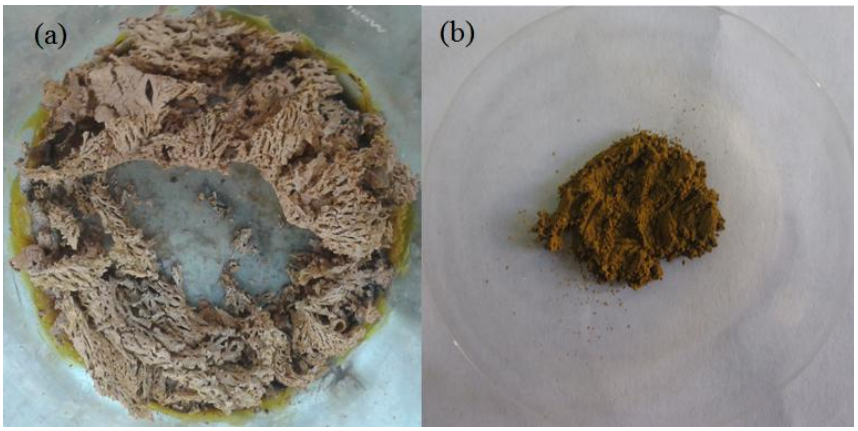

Fig. 3- Sample 2 : (a) : cinders obtained, (b) : yellow powder obtained without calcination.

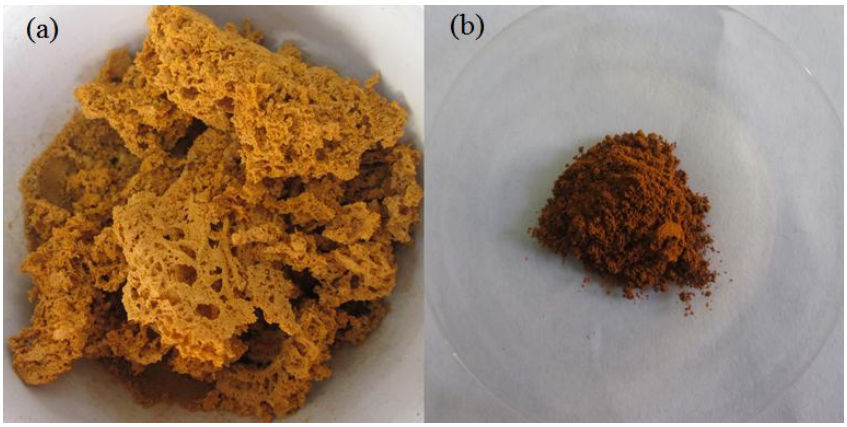

Fig. 4- Sample 3 : (a) : Cinders obtained, (b) : orange powder obtained without calcination.

3.1. X-ray diffraction

The XRD measurements (Fig. 5) shows that the perovskite oxide $LaFeO_3$ is a product with an orthorhombic structure and Pnma space group with paramaters of : a = 5.566 Å , b = 7.854 Å and c = 5.553 Å ($\alpha = \beta = \gamma = 90$ °). The diffraction data are in a good agreement with ASTM card of LaFeO3 from software X'pert highscore (ASTM no: 00-037-1493).

3.2. Infra-red spectroscopy

It is seen for the three samples (Fig. 6,7) an intense band at 560 cm^{-1} attributed to vibrations of the Fe-O band in the perovskite $LaFeO_3$. The presence of this band confirmed the formation of the perovskite phase in those three samples.

3.3. UV-visible spectroscopy

In the above spectra of the three samples (Fig. 8,9) we can see that the maximum wavelength is : λ_{max} = 326 nm.

This wavelength (λ_{max} = 326 nm) indicates that the $LaFeO_3$ compound prepared by the auto-combustion method is a photocatalytic material type according to the work published in [15]. The difference in the values of the wavelengths refers to the experimental conditions.

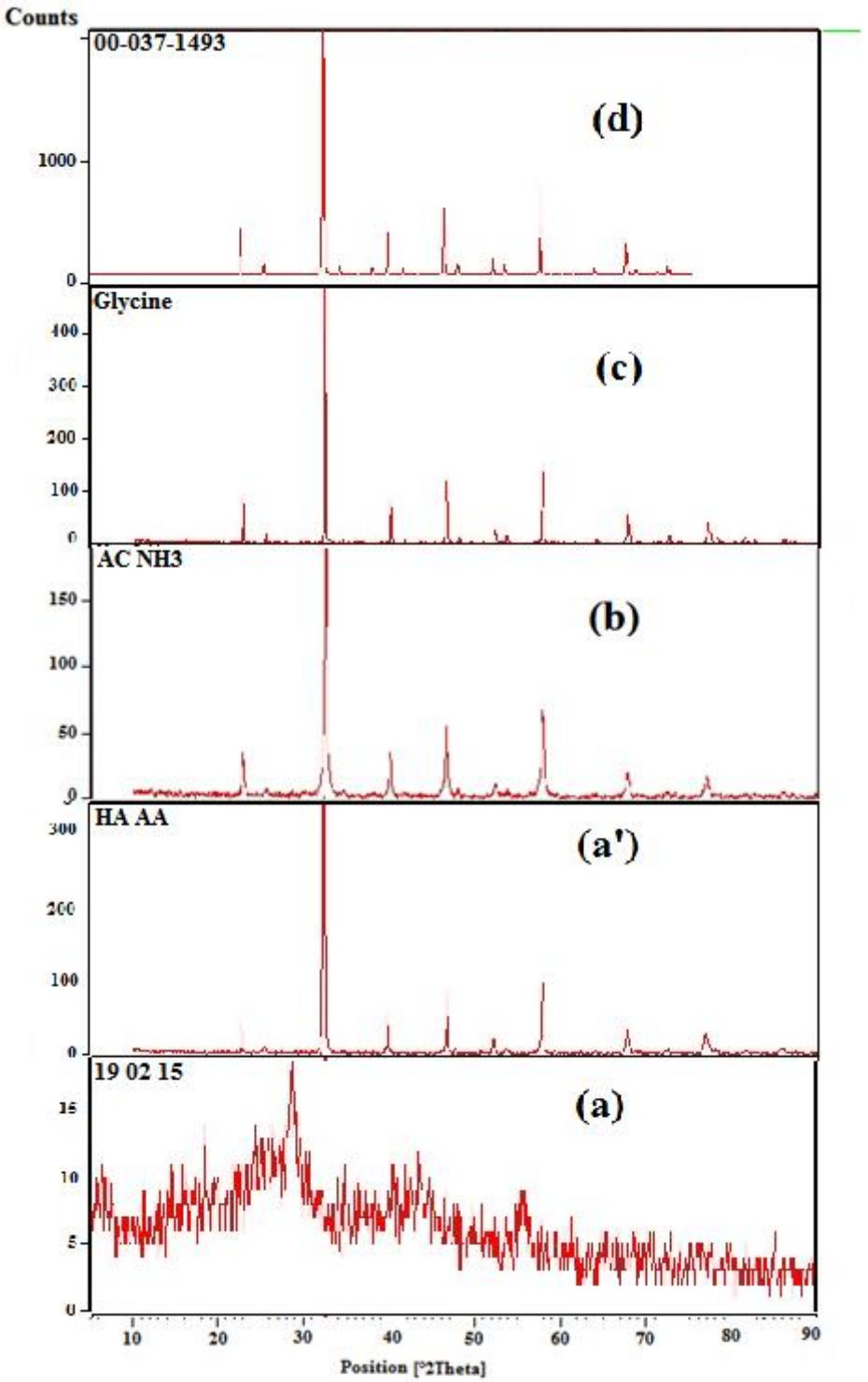

Fig. 5- diffractograms : 1st sample : (a) before calcination, (a') after calcination, (b) : 2nd sample, (c) : 3rd sample and (d) : ASTM card.

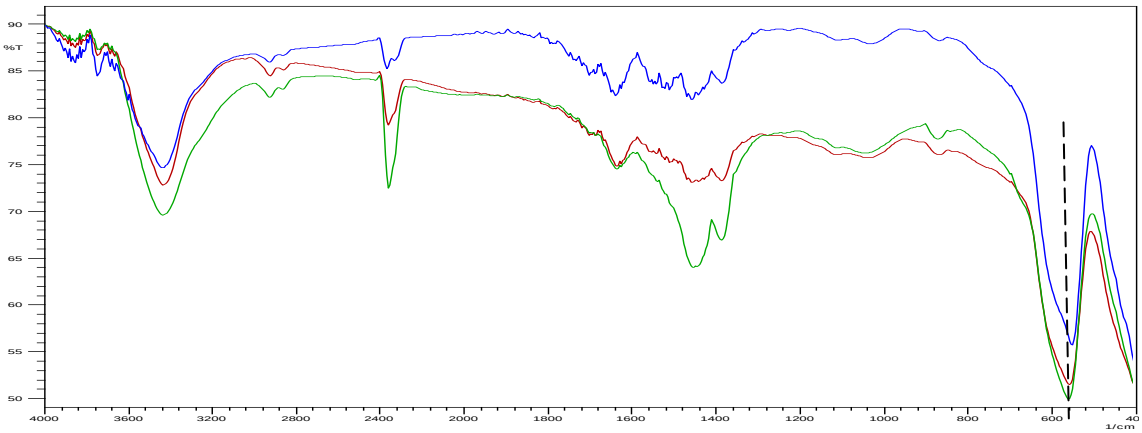

Fig. 6- Infrared spectra of the three samples.

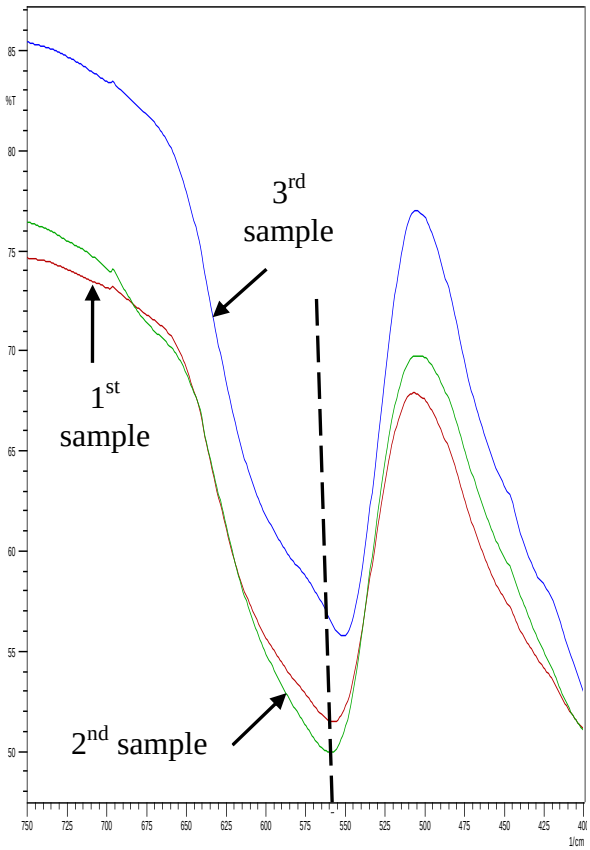

Fig. 7- The Fe -O band of 3 samples .

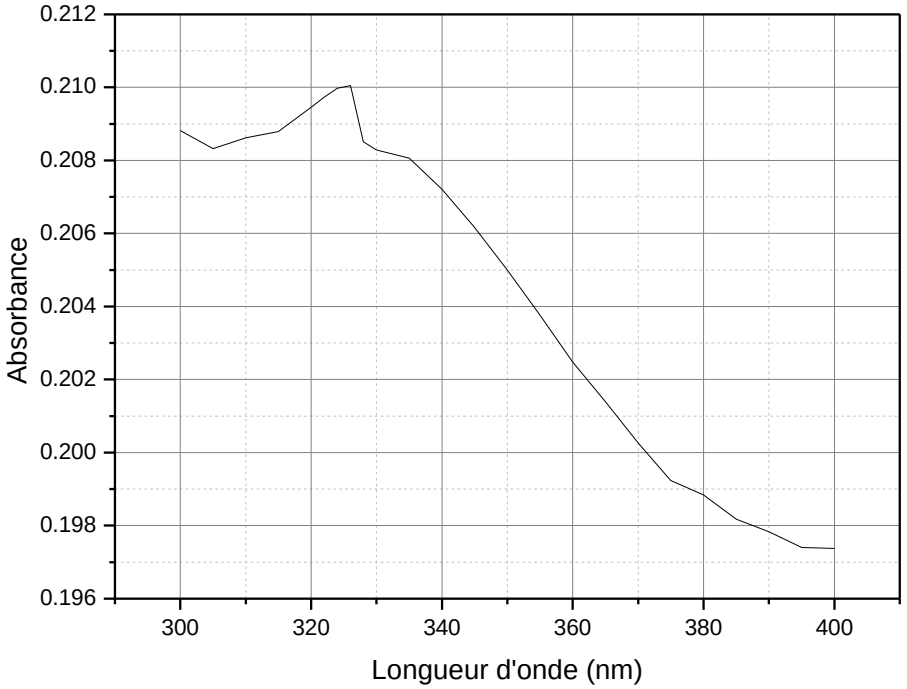

Fig. 8- UV-visible spectrum of the 1st sample before calcination.

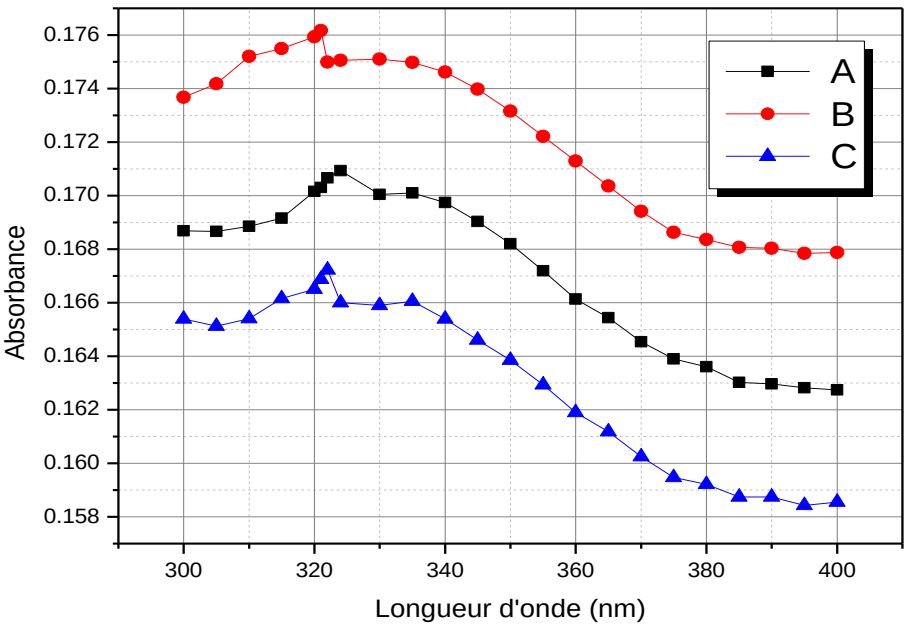

Fig. 9- UV-visible spectrum of : A : 1st sample after calcination,
B : 2nd sample, C : 3rd sample.

3.4. Laser particle size

The figure and table below show the particle size distribution for the three samples :

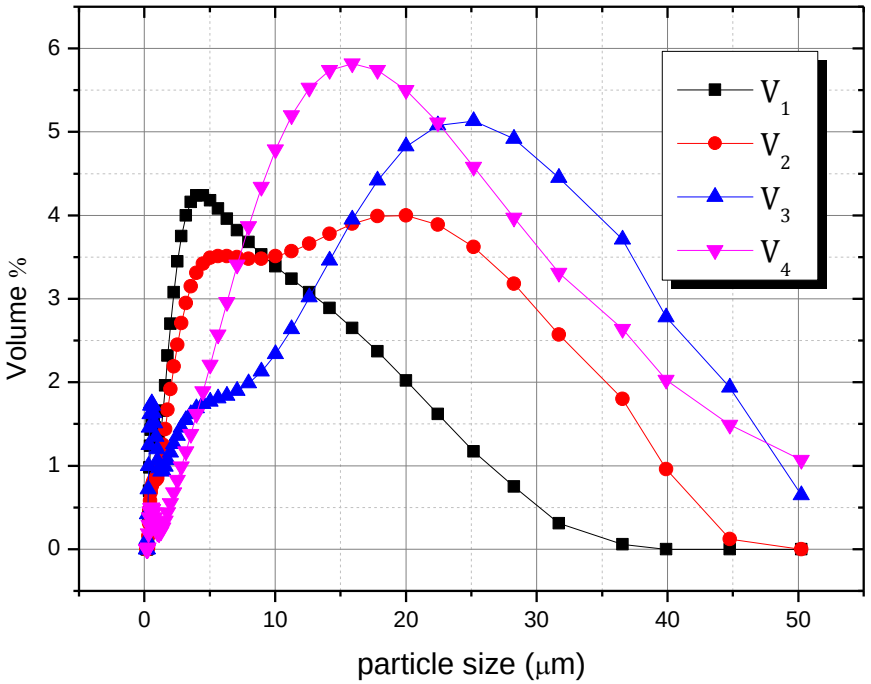

Fig. 10- Particle size distribution of : V_1 : 1st sample after calcination, V_2 : 1st sample before calcination, V_3 : 2nd sample, V_4 : 3rd sample.

Table 1 : Particle size distribution value of the three samples.

Samples	Volume distribution (%)	Particle sizes (µm)
1st sample before calcination	3.51	7.096
	4	22.44
1st sample after calcination	1.58	0.632
	4.24	4.74 5.024
2nd sample	1.75	0.564
	5.13	28.25
3rd sample	0.50	0.564
	5.82	17.825

4. CONCLUSION

The objective of this work was studying the synthesis of the mixed oxide $LaFeO_3$ perovskite by auto-combustion method to reach a structural powder by different fuels without calcination.

The synthesis of the material prepared in this work by auto-combustion method is considered as an exothermic reaction of redox where nitrates are oxidants and the carboxyl group is the reducing agent , but the amine group is the complexing agent of the transition metal so it is the responsible of $LaFeO_3$ oxide formation without calcination in a short period of time.

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