

La-Ni-Co Perovskite Structure: Dry Reforming of Methane

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Abstract. LaNi_{0.2}Co_{0.8}O₃ perovskite oxide, as a catalyst, was prepared with the Pechini method. Brunauer-Emmett-Teller (BET) nitrogen adsorption technique, X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR) were conducted to characterize the perovskite sample. The results showed that a single perovskite phase was formed in the synthesized sample and the conversion of methane in dry reforming of methane reached 0.82.

Keywords: La-Ni-Co perovskite oxide, Characterization, dry reforming of methane

1. Introduction

Perovskite -type oxides of the general formula ABO₃ (A: alkali, alkali earth, rare earth and some large ions and B: some transition metals) are an important class of catalytic materials and have been widely studied for their application in heterogeneous catalysts [1-4]. Perovskite type catalysts have higher activity, comparable stability and lower cost than traditional catalysts based on noble metals in many reactions, but their low surface area is a disadvantage [5-6]. One of the most important of the reactions using perovskite oxides as a catalyst is dry reforming of Methane for the production of syngas (H₂+CO) which has attracted much attention from both environmental and industrial aspects [7-8]. Since the dry reforming of methane is a highly endothermic reaction, Eq. (1), it has to be performed at low pressure and high temperature to gain maximum conversions.



In this paper, LaNi_{0.2}Co_{0.8}O₃ perovskite oxide was prepared with the Pechini method. The synthesized sample was investigated by Brunauer-Emmett-Teller (BET) nitrogen adsorption technique, X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR). Finally the activity of the catalyst sample was evaluated in the dry reforming of methane (DRM) at a high temperature reactor.

2. Experimental

2.1. Catalyst preparation

LaNi_{0.2}Co_{0.8}O₃ perovskite sample was prepared with the Pechini method (Fig.1). La(NO₃)₃.6H₂O, Ni(NO₃)₂.6H₂O, and Co(NO₃)₂.6H₂O were used as the sources of Lanthanum, Nickel, and Cobalt respectively.

Heat treatment of the sample was as follows:

Drying: 90°C for 12 h

Calcination: 500°C for 5h and 800°C for 4h

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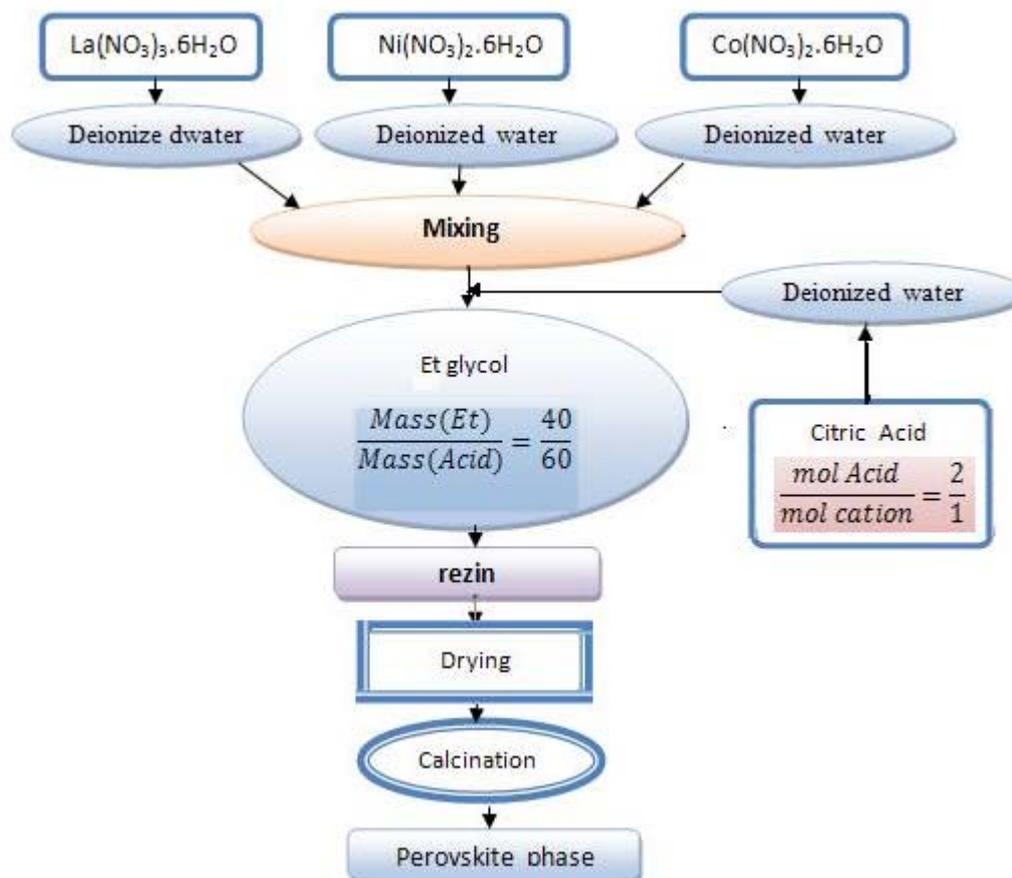


Fig. 1: Formation of perovskite phase by the Pechini method

2.2. Catalyst characterization

The specific surface areas of the samples (S_{BET}) were carried out in a Quantachrome Nova 2000 apparatus. Prior to the adsorption, the supports were outgassed at 300 °C for 3 h. X-ray diffraction (XRD) patterns were collected on a Philips PW1800 diffractometer using Cu $K\alpha$ radiation. FT-IR spectra were recorded on a Shimadzu FT-IR instrument (model IRsolution 8400S) by diluting with KBr in a pellet.

2.3. Catalyst evaluation

The catalyst performance in dry reforming of methane was evaluated in a fixed bed quartz tubular microreactor (9 mm o.d. and 6.6 mm i.d.), containing 0.2 g of the sample. The activity test was carried out at 800 °C, under atmospheric pressure with a feed composition of $\text{CH}_4:\text{CO}_2 = 1:1$ and a total flow of 50 mL min^{-1} . To activate the catalyst, it was previously reduced in situ under hydrogen flow (80 mL min^{-1}). A heat rate of $5 \text{ }^\circ\text{C min}^{-1}$ was used and the gaseous effluent was analyzed on line using a Varian model GC-380 gas chromatograph.

3. Results and discussions

The XRD pattern of $\text{LaNi}_{0.2}\text{Co}_{0.8}\text{O}_3$ perovskite sample is shown in Fig. 2. As indicated in this figure, the perovskite structure without any impurity has been formed. The perovskite structure could be indexed to a pseudo-cubic symmetry of the ABO_3 type. It can be concluded that the Pechini method was an effective method for preparing a single perfect perovskite oxide.

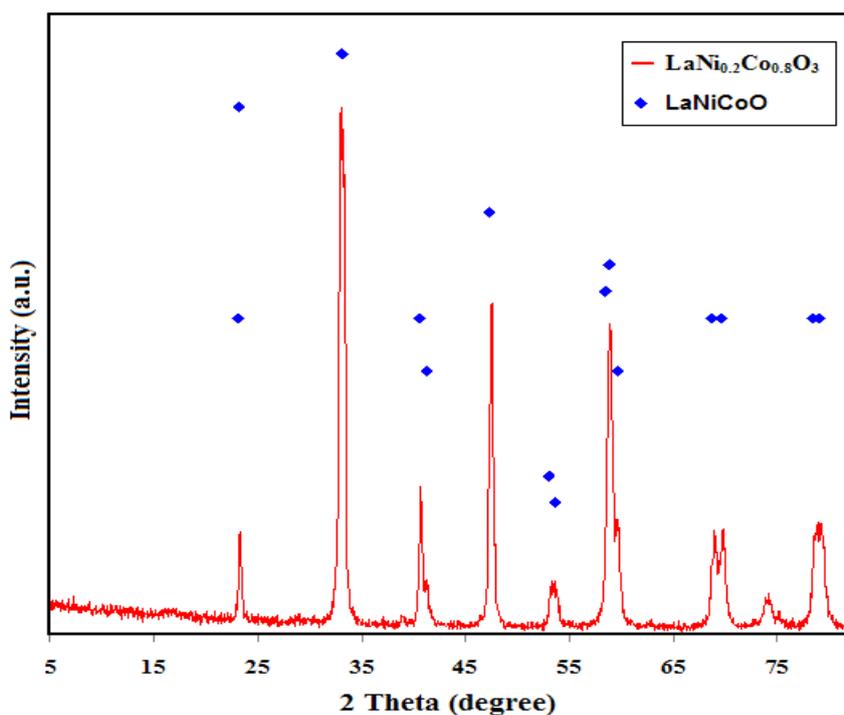


Fig. 2: XRD pattern of the catalyst sample

The FT-IR spectrum of the catalyst sample dried at 90°C is shown in Fig. 3. A broad band around 3400 cm^{-1} characteristic of a hydroxyl group can be observed in this figure. There were sharp absorption bands in the vicinity of 1740 and around 1187 cm^{-1} , which can be attributed to the monodentate ligand of a metal ion with carbonyl groups (COO^-) [9-10].

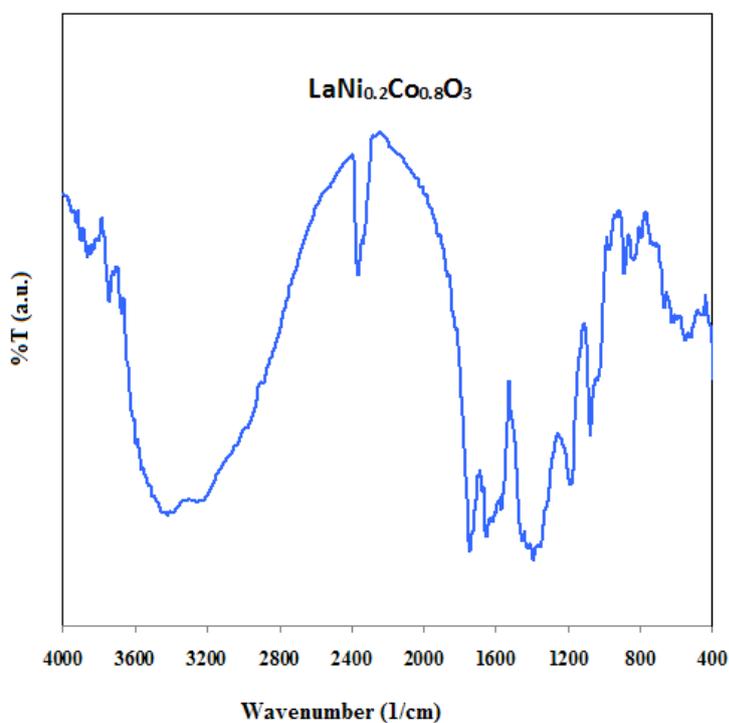


Fig. 3: FT-IR pattern of the catalyst perovskite sample

The specific surface area of the sample was $15.3 \text{ m}^2 \text{ g}^{-1}$. The conversion of the reactant was defined as the converted amount of methane per total amount of methane in the reactor feed, respectively, as shown in equation (2). The methane conversion of this sample in dry reforming of methane at $800 \text{ }^\circ\text{C}$ was 0.82.

$$X_{\text{CH}_4} = (F_{\text{CH}_4, \text{in}} - F_{\text{CH}_4, \text{out}}) / F_{\text{CH}_4, \text{in}} \quad (2)$$

4. References

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