Catalytic properties of Fe and Mn modified lanthanum hexaaluminates for catalytic combustion of methane

REN Xiaoguang, ZHENG Jiandong, SONG Yongji, LIU ping
Department of Chemical Engineering, Beijing Institute of Petrochemical Technology, Beijing 102617

Abstract

A series of Fe and Mn modified lanthanum hexaaluminates, $LaFeMn_xAl_{11-x}O_{19}$ (x=0, 0.5, 1,2,3, 4, 5) as new catalysts for combustion of methane, were prepared by sol-gel method and calcination at high temperature. Iron and manganese ions were used as active component to replace part of aluminum ions in the hexaaluminate lattices. The structure and properties of these samples were characterized by XRD, BET, TG, DTA and XPS. The series of hexaaluminates exhibited significantly catalytic activity and stability at high temperature respectively. The $LaFeMnAl_{10}O_{19}$ catalyst possesses a larger surface area and shows a good activity in methane combustion.

Keywords*:* Sol-gel method; Hexaaluminate; Catalytic combustion; methane

1. Introduction

In recent years, many researchers think the catalytic combustion is a promising technology for energy production because it produces very low amounts of CO and unburned hydrocarbons. The thermal formation of NO_x is also practically suppressed due to the low operating temperatures. Methane is the main component of natural gas, which has a large available reserves all over the world. Meanwhile methane is stable and therefore easy to be transported and stored. This leads methane to be a good candidate of fuel in most of the research on catalytic combustion.

2. Experimental

The LaFeMnxAl11-xO19 samples (x=0, 0.5, 1, 2, 3, 4, 5) were prepared by sol-gel method. The crystal structure of the calcined samples was determined by X-ray powder diffraction (XRD). The specific surface area were measured on a AUTOSORB-I-MP Series Instrument using N_2 adsorption at liquid N_2 temperature. The binding energy and chemical composition of surface elements of the catalysts were measured by Sigma Probe X-ray photoelectron spectroscopy (XPS) using Al K_α radiation. TG and DTA are carried out on a BÄHR- STA503 thermal analyzer at heating rate of 10 ℃/min. The reaction of methane combustion was carried out in a conventional flow system under atmospheric pressure. Catalyst (300 mg) (20–40 mesh) was loaded in a quartz reactor (i.d. 8mm), with quartz beads packed at both ends of the catalyst bed.

3. Conclusions

We have explored the effect of Fe^{3+} and Mn^{2+} on the catalytic activity of lanthanum hexaaluminate toward methane combustion. The catalysts were prepared through sol–gel method, followed by calcination at 1200℃, and homogeneous and mono-phased catalysts were produced. The addition of the Mn^{2+} ions to $LaFeAl_{11}O_{19}$ improves the performance of the catalyst by increasing its thermal stability at high temperature without suppressing its catalytic activity. The adjustment of Fe /Al / Mn ratio via the sol–gel method is found to be able to give hexaaluminate with higher surface area. Catalytic activity is strongly enhanced by manganese incorporation which is due to surface cations accessible to reactants. $LaFeMn_xAl_{11-x}O_{19}$ catalysts have comparable activity associated with exceptional strong thermal resistance.