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The effects of excess manganese in nano-size lanthanum manganite perovskite on enhancement of trichloroethylene oxidation activity

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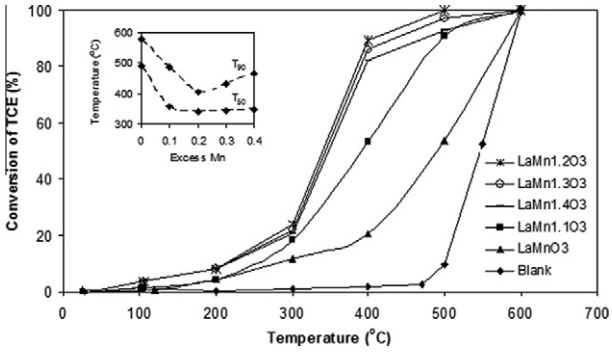
HIGHLIGHTS

- Excess Mn, up to Mn/La ratio of 1.2, enhances TCE oxidation activity of $LaMn_{1+x}O_{3+\delta}$.
- Compared to $LaMnO_3$, T_{50} and T_{90} of TCE oxidation on $LaMn_{1.2}O_{3+\delta}$ severely decrease.
- Water vapor enhances the TCE oxidation activity on the $LaMn_{1+x}O_{3+\delta}$ perovskites.

GRAPHICAL ABSTRACT



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ABSTRACT

The effects of excess manganese in $LaMn_{1+x}O_{3+\delta}$ perovskite on enhancement of trichloroethylene (TCE) oxidation, as a chlorinated volatile organic compound (CVOC), in air are studied. Various $LaMn_{1+x}O_{3+\delta}$ (x = 0.0–0.4) nanocatalysts were synthesized by a microwave-assisted "gel combustion" method and calcined at 600 °C in air. XRD patterns of the samples confirm formation of perovskite structure and SEM micrographs exhibit spongy agglomerated nanoparticles with a wide size distribution and presence of large pores in their structure. TEM micrographs show the presence of 12–30 nm nanoparticles of possibly highly dispersed amorphous and/or fine crystallites of MnO_x, which are not detectable in XRD patterns. TPR results indicate that the oxygen overstoichiometry of $LaMn_{1+x}O_{3+\delta}$ catalysts increases with excess Mn. Enhancement of BET surface area of the catalyst samples as much as 2.5-fold and the maximum TCE oxidation activity are observed for the $LaMn_{1.2}O_{3+\delta}$ catalyst. As compared to $LaMnO_{3+\delta}$, T_{50} and T_{90} of TCE oxidation on $LaMn_{1.2}O_{3+\delta}$ are decreased by 150 and 174 °C, respectively. Loss of BET surface areas of the catalysts after exposure to reaction conditions may be responsible for the observed initial deactivation. XPS spectra show the formation of LaOCl during the initial deactivation. Simple zero-order kinetics expression with respect to TCE, provides fairly good fits for the evolution of the TCE conversion on $LaMn_{1+x}O_{3+\delta}$ catalysts.

1. Introduction

Volatile organic compounds (VOCs) are the major components in air pollutants, and are directly (toxic or malodorous nature) or indirectly (ozone precursors) harmful to human health [1]. Halogenated and more specially chlorinated VOCs (CVOCs) are widely used in industry as solvents, dry cleaners, degreasing media, chemical intermediates in the production of plastics, synthetic resins or pharmaceuticals [2]. Further, incineration of municipal and medical wastes is also a source of CVOCs. About 16% worldwide pollutants, 1.5 million tonnes, emitted into atmosphere are CVOCs [3,4].

Trichloroethylene (TCE) is probably the most common CVOC, since it is used in many industries, such as electronic, dry-cleaning and metal surfaces and adhesives [5]. The presence of a double

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