Photo-thermocatalytic synergetic degradation of styrene on nano-perovskite $LaBO_3$ compounds (B= Cr, Mn, Fe, Co, Ni)

Taicheng An[a,*], Zhigui He[a,b], Jiangyao Chen[a,b], Guiying Li[a]
[a] *State Key Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China;*
[b] *Graduate School of Chinese Academy of Sciences, Beijing 100049, China*
**E-mail address: antc99@gig.ac.cn. Tel: +86-20-85291501*

Introduction

Perovskite oxides and related compounds have been attracting increasing research interest over the past decade because of their applications in pollution abatement and energy development originated from their potential photocatalytic, thermocatalytic and high thermal stability properties [1]. The perovskite oxides have a general formula ABO_3, where A is a rare-earth or alkaline earth cation and B is a transition metal cation [2]. The La-based perovskite oxides have drawn particular interest because their catalytic properties can be easily tuned by changing B metal cation [3]. Besides, photocatalytic activity, some La-based peroviskite oxides, like $LaNiO_3$, $LaMnO_3$ and $LaFeO_3$, also displayed a high thermocatalytic activity in VOCs combustion with a high thermal resistance. However, the shortcoming like low visible light photocatalytic activity and easily poisoning still remain, restrain their application seriously. Herein, to develop a series cost-effective superior catalyst for VOCs removal is a great challenge.

Due to the potential visible light responsive and thermocatalytic activity of La-based peroviskite oxides, thermal and photocatalysis could be ideally combined together. The probable synergetic effect may lead to efficient degradation of VOCs using newly-prepared nano-perovskite $LaBO_3$ compounds.

Materials and Methods

A series La-based nano-perovskite oxides (B= Cr, Mn, Fe, Co, Ni) were prepared using sol-gel assisted citrate method. The catalytic oxidation of styrene on the prepared nano-perovskite oxides at different temperature was tested on a closed cylindrical stainless steel gas-phase reactor. They were conducted at the initial concentration of styrene 40 ppmv, 50-240 °C and 300 W Xe lamp with the cooling exhaust fan. 500 mg $LaBO_3$ catalyst were coated on the glass fiber membrane, which were firmly fixed in 60 mm from Xe lamp on the top of reactor. A thermocouple was put on the surface of catalysts to measure its surface temperature. Styrene was removed by photocatalytic (PC), thermocatalytic (TC) and photo-thermocatalytic (PTC) oxidation, respectively.

Results and Discussion

Figure 1a shows XRD patterns of the prepared La-based oxides. The observed diffraction peaks can be indexed to those of perovskite type. **Figure 1b** shows that $LaMnO_3$ catalysts to be highly active for PTC oxidation of styrene, following by $LaNiO_3$, $LaFeO_3$, $LaCoO_3$, $LaCrO_3$ at 140 °C.

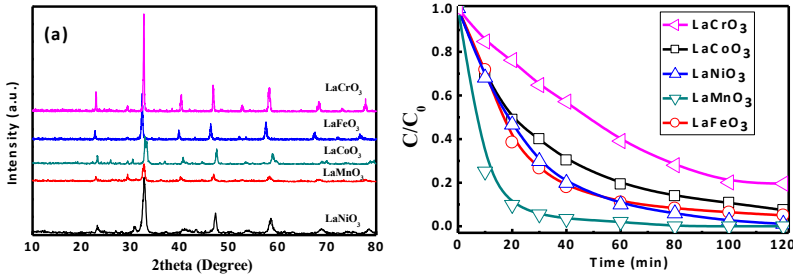

Figure 1. (a) XRD patterns and (b) time course of the styrene concentration on $LaBO_3$ (B= Cr, Mn, Fe, Co, Ni) catalyst under photo-thermocatalytic oxidation at 140 °C.

Figure 2a shows the styrene degradation under three oxidation systems. For PC, the styrene removal efficiency was the lowest, after 2 h irradiation, only 43.1% styrene was removed, while 92.8% styrene was removed by TC. Comparatively, when thermal and photocatalysis combined together, styrene could be completely removed within only 40 min. Because of synergetic effect of thermal and photocatalysis, the thermocatalytic temperature of $LaMnO_3$ could reduce by 120 °C in the same styrene remove efficiency as shown in **Figure 2b**.

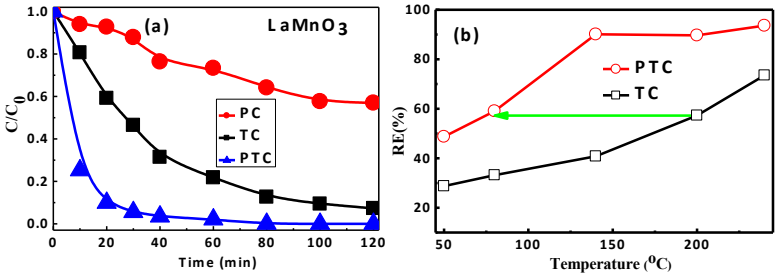

Figure 2. (a): The time course of the styrene concentration on $LaMnO_3$ catalyst under PC, TC at 140 °C and PTC oxidation; (b): Effect of temperature on styrene removal efficiency under TC and PTC oxidation.

Significance

The high cost and poor thermal durability for thermal catalysts and the low visible photocatalytic activity of perovskite compounds are the major barriers in their application. In our study, newly-prepared catalysts which have excellent photothermocatalytic synergetic effect could solve these problems experimentally.

Acknowledgements: Financially supported by Team Project from NSF of Guangdong Province, China (S2012030006604), and NSFC (41373102 and 41205088).

References

1 Ponce, S. Pena, M. Fierro, J. *Applied Catalysis B: Environmental* **2000,** *24,* 193.
2 Pena, M. Fierro, J. *Chemical Reviews* **2000,** *101*, 1981.
3 Kim, C.H. Qi, G. Dahlberg, K. Li, W. *Science* **2010,** *327*, 1624.