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# Catalytic removal of toluene over three-dimensionally ordered macroporous $Eu_{1-x}Sr_xFeO_3$

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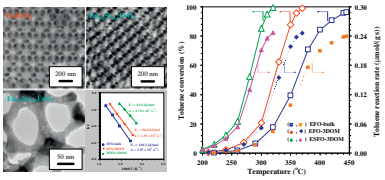
## HIGHLIGHTS

- 3DOM $Eu_{1-x}Sr_xFeO_3$ are prepared by the PMMA-templating method.
- 3DOM $Eu_{1-x}Sr_xFeO_3$ are high in surface area and $O_{ads}$ content and good in reducibility.
- 3DOM $Eu_{0.6}Sr_{0.4}FeO_3$ performs well in the combustion of toluene.
- Catalytic activity is governed by $O_{ads}$ concentration and reducibility.

## GRAPHICAL ABSTRACT

3DOM $Eu_{1-x}Sr_xFeO_3$ ($x = 0$, 0.4) with high surface areas are fabricated using the citric acid-assisted PMMA-templating method. It is found that large surface area, high oxygen adspecies concentration, and good low-temperature reducibility as well as high-quality 3DOM structure are responsible for the good catalytic performance of 3DOM $Eu_{0.6}Sr_{0.4}FeO_3$.



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## ABSTRACT

Three-dimensionally ordered macroporous (3DOM) perovskite-type oxides $EuFeO_3$ (EFO-3DOM) and $Eu_{0.6}Sr_{0.4}FeO_3$ (ESFO-3DOM) were prepared by the citric acid-assisted polymethyl methacrylate-templating method. The physicochemical properties of the materials were characterized by means of numerous techniques. Catalytic activities of these porous samples were evaluated for the combustion of toluene. It is shown that the EFO-3DOM and ESFO-3DOM catalysts were of high-quality 3DOM architecture and single-phase orthorhombic crystal structure with a surface area of 16–31 $m^2/g$. The sequence in surface oxygen species concentration and low-temperature reducibility decreased in terms of ESFO-3DOM > EFO-3DOM > EFO-bulk, in good agreement with the order in catalytic activity. The ESFO-3DOM catalyst exhibited the best performance, giving the $T_{10\%}$, $T_{50\%}$, and $T_{90\%}$ of 233, 278, and 305 °C at a space velocity of 20,000 mL/(g h), respectively. Apparent activation energies of the ESFO-3DOM, EFO-3DOM, and EFO-bulk catalysts were ca. 82, 96, and 104 kJ/mol, respectively. The excellent catalytic activity of ESFO-3DOM might be associated with its higher surface area and surface oxygen species concentration and better low-temperature reducibility as well as high-quality 3DOM structure.



## 1. Introduction

Perovskite-type oxides ($ABO_3$) show higher chemical, thermal, and structural stability than single oxides. Due to the low cost, anti-poisoning capacity, and high thermal stability, $ABO_3$ has been generally believed to be a potential alternative to noble metals for the combustion of soot and volatile organic compounds (VOCs) [1–5]. Among the various perovskite catalysts, $LaMO_3$ (M = Mn, Co, Cr, Fe, and Ni) show good catalytic activities for the oxidation of hydrocarbons, carbon monoxide, and carbon particulates [2]. Via the partial substitution of A- and B-site ions in $ABO_3$ by foreign ions (e.g. $La_{1-x}Sr_xFeO_3$ [6] and $La_{0.9}K_{0.1}Co_{1-x}Fe_xO_{3-\delta}$ [4]), it is feasible to tailor-make the dimensions of the unit cell [7] and the covalency of the B–O bond, thus modifying the catalytic property of such a material. It has been generally accepted that catalytic activity of an $ABO_3$ is associated with factors, such as oxygen nonstoichiometry, reducibility, surface area, and pore structure [8]. The partial substitution of A-site ions with heterovalent ions can produce structural defects (e.g., oxygen vacancies) and stabilize

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