



Review

Advances in direct NO_x decomposition catalysts

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ABSTRACT

Direct decomposition of nitrogen oxides (NO_x), which are the main air pollutants responsible for photochemical smog and acid rain, into N₂ and O₂ (2NO → N₂ + O₂) offers the most ideal route for NO_x removal by catalysis. Direct decomposition of NO_x is versatile and economic because no reductants are required. However, the catalytic activities of conventional catalysts are insufficient, particularly in the presence of other gases such as O₂ and CO₂. In recent years, however, investigation of different catalyst structures and compositions has led to enhanced catalytic activity. In particular, significant advances have been made in improving the tolerance of the catalyst to coexisting gases. These direct NO decomposition catalysts have been designed with a view to maximizing the cavity space and number of oxide anion vacancies in the crystal lattice. In this review article, recent advances in the direct NO decomposition catalysts are summarized.

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1. Introduction

Nitrogen oxides (NO_x) are not only harmful to the human body but are also responsible for photochemical smog and acid rain when present in relatively large quantities. Emission sources of NO_x can be divided into mobile and fixed sources. Automobiles and maritime vessels are well known examples of mobile sources while the large-scale boilers used in factories are fixed sources. To remediate NO_x from automobile exhausts, the three-way catalyst (TWC) and NO_x storage reduction (NSR) catalyst are used, while to remove NO_x emitted from fixed sources, selective catalytic reduction (SCR) processes using ammonia, urea or hydrocarbons are typically used [1,2].

The TWC is an effective system for gasoline-engine vehicles, in which the oxygen concentration in the exhaust gas can be controlled, but is unsuitable for diesel engines because oxygen exists at high concentrations. For the NSR catalysts, NO_x gases are eliminated in a reductive atmosphere by supplying a large quantity of fuel to the engines to produce fuel-rich conditions, thereby reducing the gas mileage [3]. For fixed sources SCR methods employing ammonia are effective, having sufficient decomposition efficiency and a stable reaction process at high temperatures [4–11]. However, separate specialized equipment is needed to supply the ammonia and it is absolutely essential to ensure secure control systems because of the high toxicity and flammability of ammonia. Although SCR systems using an aqueous solution of urea have been practically applied in diesel-engine vehicles [12–16], an additional anti-icing system such as a heater is necessary in cold climates because the urea solution freezes at below –11 °C. Other SCR methods using hydrocarbons or hydrogen as a reducing agent have been proposed

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