CL-200843 Received: November 24, 2020 | Accepted: January 12, 2021 | Web Released: January 20, 2021

Vol. 50 Commemorative Highlight Review

Ammonia Combustion Catalysts

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Abstract

Recent developments for ammonia (NH_3) combustion catalysts are covered in this highlight review. NH_3 has been proposed as a renewable and carbon-free energy source. However, use of NH_3 fuel poses the problems of high ignition temperature and nitrogen oxide (N_2O/NO_x) production. In order to overcome these issues, a novel catalytic combustion system was probed, and high performance catalysts were developed. This review introduces their research with including related studies.

Keywords: Carbon-free energy | Copper oxides | Nitrogen oxides

Introduction

The demands to realise a low-CO_2-emission society and address global warming are commonplace in developed countries. Recently, NH_3 has come to be regarded as a carbon-free energy source as well as fuel, because of its high energy density and negligible thermal NO_x emissions.[1–17] For example, an NH_3-fuelled micro gas turbine showed potential as the basis for an NH_3-fired power plant at the Fukushima Renewable Energy Institute in Japan, as well as an NH_3-fuelled industrial furnace.[2–7] Compared with fossil fuels, however, NH_3 has the following problems: (1) high ignition temperature, (2) low combustion rate, and (3) N_2O/NO_x production as a result of combustion. In order to overcome these issues, a novel NH_3 combustion system needs to be developed. One possible route is catalytic combustion. The catalytic combustion is regarded as a promising approach to decreasing emissions from hydrocarbon (HC)-based fuels, and it was actively studied in the 1980s for use in gas turbines, boilers and so on.[18,19] This combustion system has a lot of advantages over conventional noncatalytic combustion, as NO_x emissions are diminished as a result of the low operating temperatures and high efficiency can be achieved.

Chakraborty *et al.* noted the potential of NH_3 fuel and reported a bottom-up approach to the design of a novel and high performance binary core-shell Ru–Cu nanoparticle catalyst for the combustion of NH_3 to N_2.[20] In addition, RenCat (a start-up company in Denmark) has been commercialising technology for the decomposition of NH_3 into H_2 for use in fuel cells (Figure 1).[15] NH_3 combustion (i) is exothermic, but NH_3 decomposition or cracking (ii) is an endothermic reaction. Therefore, in the system detailed in Figure 1, NH_3 decomposition is expected to be promoted by the heat produced by NH_3 combustion.

NH_3 combustion: $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$
$\Delta H^\circ = -317\,\mathrm{kJ \cdot (mol\text{-}NH_3)^{-1}}$ (i)

NH_3 decomposition: $4NH_3 \rightarrow 2N_2 + 6H_2$
$\Delta H^\circ = 46\,\mathrm{kJ \cdot (mol\text{-}NH_3)^{-1}}$ (ii)