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Effective decomposition of greenhouse gas SF6 via heavy-metal solid waste derived catalyst

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Abstract

Sulfur hexafluoride (SF6) is a refractory greenhouse gas. Catalytic decomposition of SF6 was seldom reported. In this work, we synthesized novel multi-metal containing catalysts from heavy-metal solid wastes, and applied them in green catalytic decomposition of SF6 for the first time. As a result, the waste-derived catalysts, which mainly contained Cr, Cu and Fe oxides, remarkably removed SF6 at a capacity of 1.10 mmol/g at 600oC. This active temperature was 100-200oC lower than that of phosphate catalyst, but much lower than 5000 K by electrical arc reported elsewhere. XRD analysis showed that the solid phase transformed from metal oxides (e.g. Fe2O3) to fluorides (e.g. FeF3) with the consumption of SiO2. At the same time, on-line FTIR analysis detected that the evolved gases were SO2 and SiF4, with no toxic SOF4, SO2F2 and SF4 being detected. These generated gases were readily captured by alkaline solution. According to the above results, the reaction between SF6 and SiO2 was catalyzed by CrCuFe oxides in solid waste derived material, resulting in the green reduction of SF6. Furthermore, stainless steel slag (SSS), another kind of multi-metal containing solid waste, also decomposed SF6 effectively at 600oC. By comparison, CaFeMgMn oxides in SSS catalyzed the reaction between SF6 and SiO2. Therefore, our works exhibited that heavy-metal solid waste was a kind of potential resource for the synthesis of high-value added catalyst.

An economic and facile method was urgently required for the degradation of SF6 to replace the high-energy excitation treatment. Both theoretical calculations and experimental observations were conducted to reveal the synergy of Cr/Fe/Si composites on a new technique of SF6 degradation through reacting silicon dioxide. Density functional theory (DFT) calculations show that strong adsorption of SF6 on Cr2O3, and then the fast F/O exchange between CrF3 and Fe2O3 (energy barrier was 1.45 eV) as well as FeF3 and SiO2 (energy barrier was 1.69 eV) enhanced mediated efficiency from SF6 to SiF4. The fluorine (F) migration between solid interfaces in Cr2O3&Fe2O3@SBA15 was responsible for efficient SF6 removal. The F migration route was composed of SF6 to CrF3, CrF3 to FeF3, and FeF3 to SiF4 with the lowest thermodynamic driving. Enhanced specific accumulative converted amount (SACA) of SF6 on Cr2O3&Fe2O3@SBA15 was achieved and the highest SACA was 13.98 mmol/g within 7 h, significantly higher than that on Fe2O3@SBA15 (5.74 mmol/g) and Cr2O3@SBA15 (2.71 mmol/g). Moreover, X-ray diffractometry and X-ray photoelectron spectroscopy were performed to support DFT calculations, including ion intensities detected using mass spectroscopy and composition analysis of the mediator during the reaction. Therefore, our work put forward a novel approach for economic and efficient SF6 decomposition through reacting with silicon dioxide under the mediation of Cr2O3&Fe2O3. This method was also potentially used in effective degradation of refractory non-metal halides.

The contribution of this chapter is to deepen and widen existing knowledge on municipal solid waste (MSW) management by analyzing different energy recovery routes for MSW. The main aspects related to the composition of waste are addressed, as well as the technological routes for thermochemical and biochemical energy usage. Within the thermochemical route, incineration is currently the most utilized technology for energy recovery of waste, with generation of electricity and heat and also a decrease in the volume of the produced waste. Gasification and pyrolysis are alternatives for the production of chemical products from wastes.

Diesel engines have high efficiency, durability, and reliability together with their low-operating cost. These important features make them the most preferred engines especially for heavy-duty vehicles. The interest in diesel engines has risen substantially day by day. In addition to the widespread use of these engines with many advantages, they play an important role in environmental pollution problems worldwide. Diesel engines are considered as one of the largest contributors to environmental pollution caused by exhaust emissions, and they are responsible for several health problems as well. Many policies have been imposed worldwide in recent years to reduce negative effects of diesel engine emissions on human health and environment. Many researches have been carried out on both diesel exhaust pollutant emissions and aftertreatment emission control technologies. In this paper, the emissions from diesel engines and their control systems are reviewed. The four main pollutant emissions from diesel engines (carbon monoxide-CO, hydrocarbons-HC, particulate matter-PM and nitrogen oxides-NOx) and control systems for these emissions (diesel oxidation catalyst,

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diesel particulate filter and selective catalytic reduction) are discussed. Each type of emissions and control systems is comprehensively examined. At the same time, the legal restrictions on exhaust-gas emissions around the world and the effects of exhaust-gas emissions on human health and environment are explained in this study.

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