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Layered double hydroxides: Novel nanocatalysts for combustion of gaseous toluene from polluted air

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ABSTRACT

The catalytic performance of Ni-Al, Mg-Al, and Co-Ni LDHs as novel nanocatalysts was evaluated in the oxidation of toluene. The samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier transform infrared spectroscopy (FTIR). The XRD and FTIR approved the structure and functional groups of the LDH, respectively. Also, the presence of cations with different oxidation state confirmed by XRD. According to this result, Mars Van Krevelen (MVK) mechanism was suggested for the combustion of toluene over the LDH nanocatalysts. The SEM results indicated that the nanostructure and layered morphology of the catalysts. All LDHs exhibited catalytic activity for toluene oxidation. T_{80} (temperature for 80% conversion for toluene) for Co-Ni, Ni-Al and Mg-Al LDH catalysts were 225, 277 and 350 °C, respectively. So, the Co-Ni LDH showed the highest activity. Furthermore, Ni-Al LDH exhibited the highest thermal stability. So, we concluded that Ni-Al LDH is a superior catalyst for toluene oxidation in the studied series.

***Keywords**: Air pollution, Toluene, Nanocatalyst, Layered double hydroxides, Catalytic oxidation.*

1. Introduction

Large compounds that have the primary role in air pollutions are Volatile Organic Compounds (VOCs). These compounds are the most abundant air pollutants, as a result of industrial activities in the chemical, petrochemical, and related industries. The compounds are not only harmful to the environment but human health even at low concentrations. These days, job contact with volatile organic compounds has become more important. The studies have shown that contact with VOCs has various effects, such as inflammation of the eyes, effects on the nervous system, liver toxicity, and cancers [1-3]. The most common volatile organic compounds in industrial environments are toluene, benzene, Xylene, and ethylbenzene [4]. Toluene, as a representative of VOCs, is commonly used in many industries and environments that deal with paint and painting. The toluene odour threshold is in the range of 3-5.1 ppm, which is hardly detectable by humans in this concentration range.

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It is dangerous for jobs that are at risk of long-term exposure, and it has a lot of health effects on the central nervous system [5]. There are a lot of ways for controlling Volatile organic compounds such as Adsorption, thermal and catalytic oxidation, photocatalytic oxidation, and plasma. In the meantime, catalytic or thermal oxidation is a method used by some researchers to remove volatile organic compounds [6-8]. In the catalytic processes, the catalyst plays the main role and determines the selectivity toward the products. Numerous papers have been reporting the application of different catalysts in the combustion of VOCs [1-10].

The hydrotalcite-like materials or layered double hydroxides (LDHs) have numerous applications such as ionic conductors, ion exchangers, adsorbents, catalysts, supports, pharmaceuticals and so on [9]. The general chemical formula of materials can be written as $[M^{2+}_{1-x}M^{3+}_{x}(OH)_2](A^{n-})_{x/n}\cdot mH_2O$. In the formula, M^{2+} and M^{3+} are divalent and trivalent cations occupying the center of $M(OH)_6$ octahedral units, and A^{n-} is a compensation anion [10].

Numerous cation pairs and interlayer anions have been used in LDHs [11]. However, LDHs replacing the Mg^{2+}