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Research paper

Properties of modified crude clay by iron and copper nanoparticles as potential hydrogen sulfide adsorption

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ABSTRACT

The present work aimed at modifying original kaolin with iron and copper chlorides in order to introduce active centers for hydrogen sulfide (H_2S) adsorption. In the first modification, interlayer sodium cations were exchanged with two metals. In the second one, iron oxide (FeOx) was introduced to the clay surface. Kaolin and modified kaolin were analyzed using ICP, X-ray diffraction (XRD), Infrared Ray, Fluorescence-X, BET surface area analysis and SEM. The modified clay samples were tested as hydrogen sulfide adsorbents. Iron-doped and copper-doped samples showed a significant improvement in the capacity for H_2S removal, despite a noticeable decrease in microporosity compared to the initial pillared clay. The smallest capacity was obtained for the clay modified with FeOx. Variations in adsorption capacity are likely due to differences in the chemistry of metals species, degree of their dispersion on the surface, and accessibility of small pores for H_2S molecule. Results suggest that on the surface of metal-modified clay, hydrogen sulfide reacts with Cu^{2+} and Fe^{+3} ions to form sulfides or can be catalytically oxidized to SO_2 on iron (hydro) oxides. Subsequent oxidation may lead to sulfate formation.

1. Introduction

Hydrogen sulfide (H_2S) is one of the most common compounds that can be found in petrochemical plants, coal gasification plants, and waste water treatment plants (Stepova et al., 2009). H_2S is a major air pollutant when it is emitted into the atmosphere because it is not only a malodorous but also a corrosive gas as well as a source of acidic rains.

There are several available technologies for the treatment of H_2S, but with conditions of low concentrations and high flow rates from livestock housing. Adsorption with inorganic material (clay) (Krishna et al., 2001; Jiang and Zeng, 2003; Nguyen-Thanh and Bandosz, 2006; Bouras et al., 2007; Sánchez-Martín et al., 2008) is considered as one of the most appropriate waste gas treatment technologies: it is regarded to be cost-efficient and does not produce toxic by-products during the treatment.

Filtration relies on physical processes such as absorption and adsorption for the supply of odorants to be degraded (Chen and Hoff, 2009); therefore, adsorbents with good physical properties can increase the filtering efficiency. Adsorbents such as compost, soil, and perlite have relatively low adsorption capacities for waste gases, which reduce the efficiency of filters (Dorado et al., 2010). Other adsorbents such as activated carbon with high adsorption capacity lose some of their capacity when they are humidified (Devinny et al., 1999). They are also associated with high cost compared to other adsorbents (Dorado et al., 2010).

Low mass transfer of H_2S, as a result of the high air–water partition, has been identified as a major challenge to efficiently remove H_2S using filtration (Feilberg et al., 2010). A packing material with a high adsorption capacity may enhance the mass transfer process and therefore the removal efficiency of H_2S in filters.

Modified clay with metals was traditionally used as a construction and hydroponic material, but has recently been used as a filtration packing material for treating odors (Fogarty and Curran, 2008; Feilberg et al., 2010). It has a high specific surface area, excellent mechanical properties, and higher H_2S removal efficiencies of compared to other materials (Feilberg et al., 2010).

Montmorillonite, which is composed of several metal oxides (Brigatti et al., 2006), is predicted to contribute to the degradation of H_2S and Methanethiol during adsorption (Lahav et al., 2004; Tamai et al., 2011). The objective of this paper was to describe the

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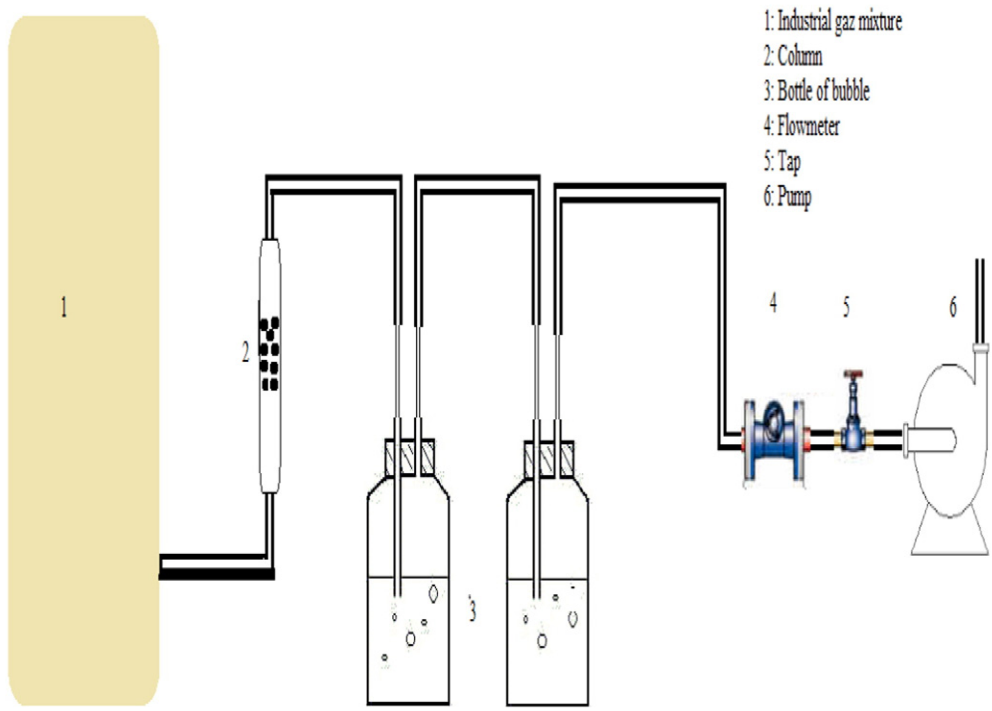

Fig. 1. Experimental set-up for H_2S adsorption tests.

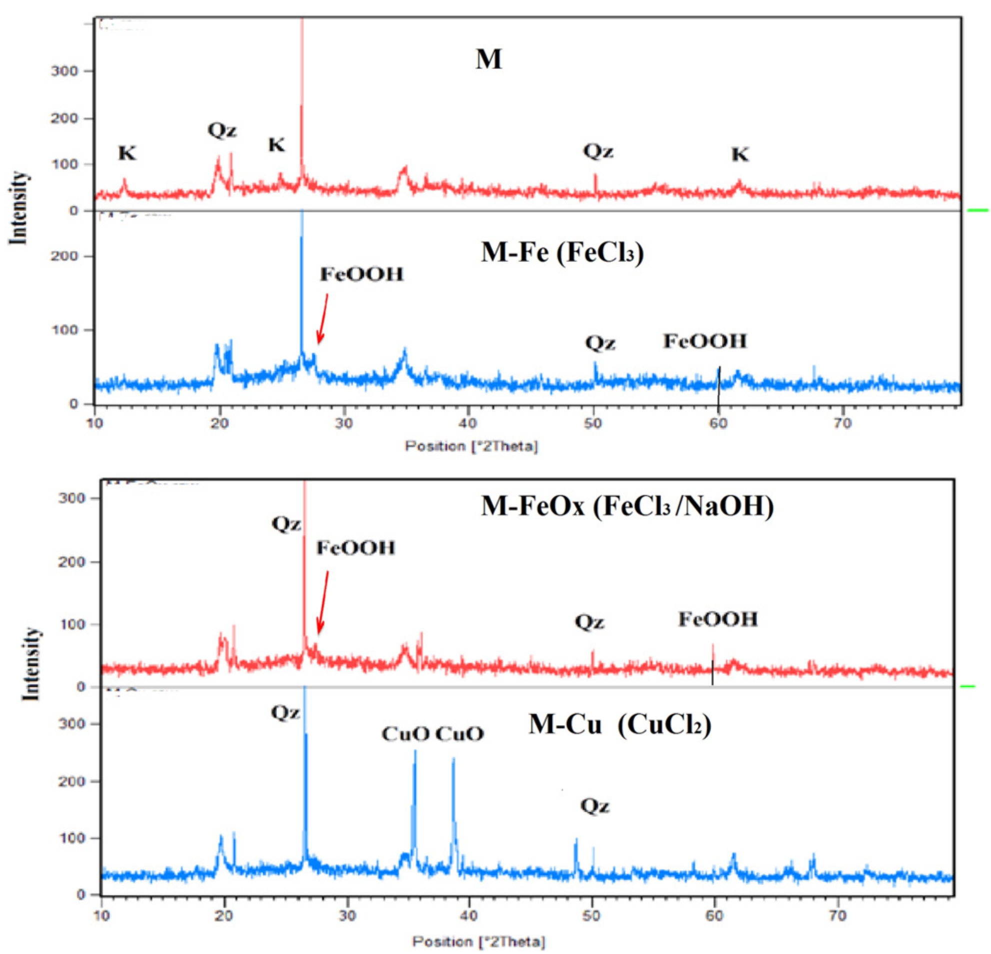

Fig. 2. XRD patterns of clay and modified clay.