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EXPLORING THE OPTIONS FOR THE IMPROVEMENT OF H2S ADSORPTION ON SLUDGE DERIVED ADSORBENTS: BUILDING THE COMPOSITE WITH POROUS CARBONS

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Introduction

The removal of hydrogen sulfide (H_2S) from gas streams has been an active area of research for decades [1]. Among different method, the H_2S separation through adsorption is considered as one of the most efficient and cost-effective way [2]. Many materials have been tested as adsorbents and, among them, catalytic activated carbons were found as providing a very high adsorption capacity at ambient conditions removing up to about 60 wt.% of sulfur from moist air streams [3]. Their capability is governed not only by their developed surface area (SSA) and porosity but also by surface chemistry. In the last years increasing efforts have been devoted towards the possibility of using sludges as a source of efficient H_2S reactive adsorbents. Nevertheless, owing to a low porosity and SSA of these materials [4] the deposition of sulfur as an oxidation product was limited. For those reasons, we have directed our attention toward the development of efficient sewage sludge-based desulfurization adsorbents analysing the effect of the pyrolysis temperature on the properties of the composite consisting of the catalytic components of sludge and porosity of activated carbon.

Materials and Methods

NCB-4X8 coconut shell-based carbon supplied by Nichem Co. (USA) and dewatered biosolid/sewage sludge from New York City's Wards Island Waste Treatment Plant were used to synthetize composites. The sludge (based on the dry mass) and carbon were mixed in a ratio 9:1 and 7:3 and carbonized in a nitrogen atmosphere at 600, 800 or 950°C. Their textural, morphological and chemical properties were investigated by nitrogen adsorption isotherms at -196°C, by x-ray diffraction, by scanning electron microscopy, by energy dispersive x-ray and thermogravimetric analysis. To determine the performance of our samples as H_2S adsorbents a home-designed breakthrough test was used [4]. The names of the samples are BXCY-TTT where X and Y express the content or biosolid/sludge and carbon, respectively, and TTT-carbonization temperature.

Results and Discussion

The obtained sludge-derived materials significantly differ in the breakthrough time depending on the synthesis temperatures. In particular, the longest breakthrough time was measured for B-950, followed by that for B9C1-950 and then for B7C3-950 and for the C carbon sample. The addition of the carbon phase to the synthetize samples leads to a complex changes in the behavior of composites as H_2S adsorbents. While for the materials obtained at 600 and 800 °C the measured capacity was higher than for the only sludge-derived adsorbents, for the samples obtained at 950 °C,

a decrease in the performance compared to the physical mixture was found. The obtained trends suggest that each phase treated at 950°C lost its performance to some extent or the carbon/sludge phase affected negatively the other phase. The high temperature treatment in fact accelerated these undesired effects. On the contrary, in the samples obtained at 600 and 800°C the addition of 10% of the carbon phase improved the performance reaching almost 300% for the sample obtained at 800°C. The adsorption capacity did not improve any with an increase the amount of carbon phase up to 30%. To better understand the trends and the effects of surface features on the observed behavior, the porosity and chemistry of the initial and spent samples were analyzed. While in the case of samples obtained at 600°C and 950°C building the composites decreased the SSA compared to those for the hypothetical physical mixtures, for the samples treated at 800°C the values of SSA measured are similar to those hypothetical ones. Thus, the marked increase in the H_2S adsorption for the composites in the case of the latter series of samples should be linked to the presence of a synergistic effect, arisen upon the composite formation.

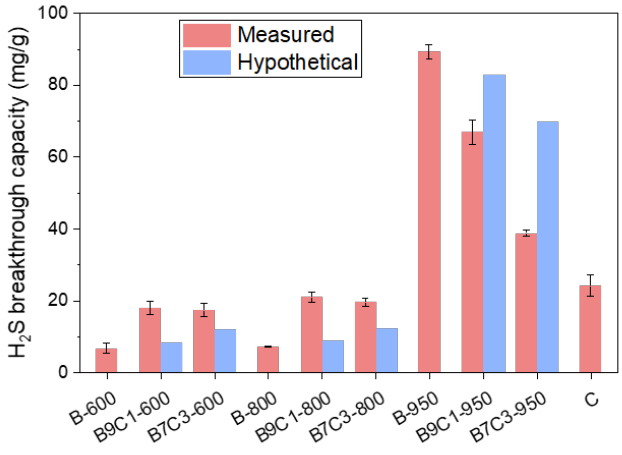

Figure 1. The comparison of the measured and hypothetical H_2S breakthrough capacity (assuming the physical mixture of the components).

Conclusions

The results showed that in the process of the H_2S removal from gas streams, the high volume of pores, although important, is a secondary parameter and it will not advance the adsorption process if the sufficient access to the catalytic centers is not provided. An interesting temperature dependent effect of the addition of carbon phase was found. For the composites pyrolyzed at 600 and 800°C the synergistic effect on the increased the H_2S adsorption was found capacity due to the increase in the porosity and availability/accessibility of catalytic centers to H_2S. On the contrary, the composites obtained at 950°C showed a decrease in the performance compared to the only sludge-based adsorbents owing to the detrimental effect of temperature on the sample's texture and chemistry.

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