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Dearomatization of normal paraffin by adsorption process using synthesized NaX zeolite

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Abstract: Linear alkyl benzenes (LABs) are the main materials for detergent production. The presence of aromatic compounds in this material can decrease the quality of the final product and enhance the deactivation rate of catalysts. In this research we used zeolite NaX for de-aromatization of the recycled paraffin from the alkylation unit of an LAB production complex. The effect of different parameters on the removal efficiency of adsorbent was studied and optimized. To study the re-usability of the adsorbent, the breakthrough curves were obtained by using a fixed bed column filled with the adsorbent. The results indicated that the adsorbent capacity remained unchanged after three regeneration cycles. The Langmuir and Freundlich adsorption models were applied to describe the equilibrium isotherms. It was concluded that the Langmuir model agreed well with the experimental data. The calculated thermodynamic parameters of the adsorption showed that the adsorption process was spontaneous and exothermic. The reaction rate was estimated by the pseudo-second order kinetic model.

Key words: Dearomatization, LAB, zeolite, adsorption, separation

1 Introduction

Linear alkylbenzene made from C_{10}-C_{13} linear olefins are widely used as the active ingredients of many household detergents (Almeida et al, 1994). According to Universal Oil Products (UOP) design, a linear alkylbenzene plant consists of pre-fraction, hydro-treating, extraction, dehydrogenation and alkylation units (Kocal et al, 2001). In the dehydrogenation unit, side reactions such as dehydrocyclization, aromatization, cracking and isomerization take place and lead to formation of some non-linear by-products. By additional alkylation reactions, these by-products can be further converted to new aromatic compounds like alkylated benzenes, poly alkylbenzenes, naphthalenes and biphenyls (Kocal, 1994; Kocal and Korous, 1994). Accumulation of these aromatic by-products on the surface of a catalyst will result in several problems such as enhancement in the deactivation rate of the catalyst, and reduction in dehydrogenation, alkylation selectivity and sulfonatability of the synthesized LAB. Under these circumstances, facile electron transition in the conjugated double bonds of polyaromatics by-products colors the produced sulfonated alkyl benzene (Goncalvez et al, 2009). Adsorption separation as an effective method for removal of pollutants can be considered as a candidate for purification of LAB from aromatic compounds (Yang, 1973). Different activated carbons have been studied for adsorption of phenanthrene as a model aromatic compound (Murillo et al, 2004). Susu (2000) developed a mathematical model to predict the effluent concentration and breakthrough profiles of aromatic compounds in kerosene deodorization by using commercial clays. Zeolite-based molecular sieves are commonly used as adsorbent in commercial separation processes. Zeolite pore size as a governing parameter determines the extent of aromatic compound entrapment. In fact, interaction between π-electrons of aromatic rings and cations held within pores of the absorbent can be considered as a driving force behind this separation process. Therefore, formation of more intense electrostatic interaction between cations of zeolite and adsorbate can significantly enhance the efficiency of the separation process. In addition, adsorption capacity can be enhanced by electrostatic interactions between the sorbent and the cations held within the pores of the adsorbent (Breck, 1974). Adsorptive separation of aromatics from kerosene cut by using NaX has been reported (Dorogochinskii et al, 2004). In a recent study, adsorption of liquid aromatic/alkane mixture on NaY zeolite has been investigated (Fathizadeh and Nikazar, 2009). Many patents relevant to the separation of aromatic by-products in the linear alkylbenzene process for either improving the quality of linear alkylbenzene or for economic benefit have been registered (Plee, 1998, Al-Zaid et al, 1989).

2 Material and methods

2.1 Synthesis and characterization of NaX zeolite

To prepare spherical type NaX zeolite, aluminum and

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