Implementation of Spinels ($NiAl_2O_4$, $CoAl_2O_4$ and Ni-Co_2O_4) as Emerging Catalysts for Upgrading of Extra Heavy Oil Including Hydrogen Production under Supercritical Water Conditions - Djimasbe Richard - Kazan Federal University

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Abstract

Spinel types catalysts were synthesized and employed in this work in order to consider its upgrading performance for extra heavy oil from the Taha oilfield (China) to produce light oil and mainly for gases production (methane and hydrogen). The results of synthesis and that of XRD patterns and SEM showed that the following spinel types denoted CoAl2O4 (2); NiAl2O4(3); and Ni-Co2O4 (4) with an average particle size around 59.13 nm, and the Ni and Co composition in catalysts is 9.29% and 4.68%, respectively. The results of the product distribution showed smaller yield of upgraded oil of 58.83 % and higher yield of coke of 33.64 % were obtained using only the supercritical water (SCW). However, using catalysts CoAl2O4 and NiAl2O4, the upgraded oil yields reach 63.34% and 61.07%, respectively. Therefore, the use of alloys of metals (Ni and Co) in form of spinel Ni-Co2O4, a higher yield of 67.26 % of upgraded oil was obtained with smaller yield of coke of 22%, while the greater yields 13.00% of gases is obtained in the sample (3). The viscosity of crude oil of 230000 Pa*s at 60 oC decreased to the smaller value of 54.8 mPa*s at 25 oC. So, high conversion of asphaltenes was also observed in the sample (4), hence the decreased from 39.04 % to 1.79%. Additionally, 8.07% of hydrogen and 43.61% of methane were obtained in the gaseous product. Therefore, the alloys of Ni-Co2O4 catalyst with high synergetic performances demonstrate its possible use for hydrogen and methane production on the industry's scale.

The definitions of heavy oil, extra-heavy oil, and tar sand bitumen are inadequate insofar as the definitions rely upon a single physical property to define a complex feedstock. This chapter presents viable options to the antiquated definitions of the heavy feedstocks (heavy oil, extra-heavy oil, and tar sand bitumen) as well as an introduction to the various aspects of heavy feedstock refining in order for the reader to place each feedstock in the correct context of properties, behavior, and refining needs.Thermal cracking (noncatalytic) processes offer attractive methods of conversion of heavy feedstocks because they enable low operating pressure, while involving high operating temperature, without requiring expensive catalysts. Currently, the most widely operated heavy feedstock conversion processes are visbreaking and delayed coking, and these processes are still attractive processes for refineries from an economic point of view.

The purpose of this chapter is to present descriptions of the thermal processes commencing in each section with the processes that are well known and followed by other processes that are available for the conversion of heavy feedstocks and to place them in the perspective of the future refinery. Typically, the feedstocks for catalytic cracking can be any one (or blends) of the following: (i) straight-run gas oil, (ii) vacuum gas oil, and (iii) heavy feedstocks. However, if blends of the above feedstocks are employed, compatibility of the constituents of the blends must be assured under read to conditions or excessive coke will be laid down on to the catalyst. In addition, there are several pretreatment options for the feedstocks for catalytic cracking units and these are: (i) deasphalting to prevent excessive coking on catalyst surfaces, (ii) demetallization, that is removal of nickel, vanadium, and iron to prevent catalyst deactivation, (iii) use of a short residence time as a means of preparing the feedstock, and (iv) hydrotreating or mild hydrocracking to prevent excessive coking in the fluid catalytic cracking unit. The purpose of this chapter is to present descriptions of the catalytic cracking thermal processes commencing in each section with the processes that are well known and followed by other processes that are available for the conversion of heavy feedstocks and to place them in the perspective of the future refinery.

A growing dependence on heavy feedstocks has emerged as a result of continuing decreasing availability of conventional crude oil. Refiners must, therefore, continue to remove substantial portions of sulfur from the lighter products so that the final products meet specifications. However, heavy feedstocks, heavy crude oil, and tar sand bitumen pose a particularly difficult problem in terms of the propensity of these feedstocks to form coke and to shorten catalyst life. Catalytic hydrotreating is also seeing increasing use prior to catalytic cracking to reduce sulfur and improve product yields, and to upgrade middle-distillate petroleum fractions into finished kerosene, diesel fuel, and heating fuel oils. This chapter introduces the reader to the concept of hydrotreating of heavy feedstocks, which requires considerably different catalysts and process flows, depending on the specific operation so that efficient hydroconversion through uniform distribution of liquid, hydrogen-rich gas, and catalyst across the reactor is assured.

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