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Single and combined effects of Bottom Cracking (BCA) and Propylene Booster (PBA) separate particles additives addition to a Fluid Catalytic Cracking (FCC) catalyst on the FCC product distribution and quality

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A B S T R A C T

In the present work, we have investigated how the single and combined addition of commercial separate particle additives, such as Bottom Cracking additive (BCA) and Propylene Booster additive (ZSM-5 based-PBA), to a FCC USY catalyst can influence the product distribution and quality during FCC processing. Due to the relatively low catalytic activity of the BCA additive, the increasing single addition of BCA implies a higher ratio of thermal to catalytic cracking, leading in particular to higher dry-gases and coke selectivities and a lower gasoline pool quality. The Bottom Cracking ability of the BCA additive is feed dependent and starts to be representative for high addition levels of about 50–60 wt%, allowing the increase of the LCO pool selectivity and quality. The single and low addition level (i.e. 10 wt%) of ZSM-5 based additive allows to drastically improve the light alkenes selectivity at the expense of the gasoline selectivity, improving, due to concentration effects, the quality of the FCC gasoline pool, but generally limiting the LCO selectivity and quality while the coke selectivity is little increased. The combined use of both additives looks like an interesting upgrading strategy considering that it is possible to keep a high catalytic activity, to fully take advantage of the beneficial effects of the ZSM-5 and BCA additives, and to mitigate at the same time the increase of the coke and dry gases selectivities.

1. Introduction

Light alkenes and, in particular, propylene are traditional building blocks for the chemical and petrochemical industries [1,2]. The main process for propylene production is today the steam cracking, in which the propylene is not the main product (i.e. ethylene) but an important by-product. Nevertheless, the $C_{2=}/C_{3=}$ ratio in steam cracking process cannot be tuned over a wide range to supply more propylene, and as today propylene worldwide demand grows faster than the ethylene one, other propylene sources are needed to fill the gap between propylene demand and supply [3]. Alternative routes for direct production of propylene, such as propane dehydrogenation [4], methanol-to-olefins [5] and olefin conversion, including metathesis and olefin cracking processes [6], are available. However, even if each one of these routes can offer competitive economics, it is not expected that these technologies will be able to completely make up the shortfall of propylene supply.

The second largest source of propylene is from Fluid Catalytic Cracking (FCC) process, and FCC units are expected to play a fundamental role for propylene production [7]. Conventional propylene yields achieved in FCC units are 4–7 wt%. However, adapted FCC processes, such as Deep Catalytic Cracking (DCC) and PetroFCC processes may be able to increase the propylene yield up to 15–20 wt% [8]. Another possibility to increase the FCC propylene production, as proposed by various authors [9–14], is to recycle to the FCC unit the high sulfur and olefin content light naphtha from catalytic cracking. On the other hand, it is well known that using optimized conditions (i.e. high severity) and shape-selective catalyst additives (i.e. Propylene Booster additives – PBA), it is possible to directly improve the yield of propylene and other light olefins in the conventional FCC process, at the expense mainly of gasoline and distillate products [15,16]. Taking them together, these modifications can result in propylene yield up to 8–12 wt%.

Propylene Booster additives are zeolitic materials based on ZSM-5 zeolite ($Na_n \cdot Al_nSi_{96n} \cdot O_{192} \cdot 16H_2O$ with $0 < n < 27$) which gives, thanks to its intermediate pore size distribution, a preferential cracking selectivity to light olefins (C_2–C_5) in general and to propylene in particular at the expenses mainly of linear and low octane compounds of the gasoline pool. ZSM-5 based additives were commercially introduced into the FCC process in the 1980s to improve gasoline octane numbers. Nevertheless, today, the additive is principally used with the purpose of increasing C_3–C_5 olefins yields.

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