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Investigating the effect of furnace material and feedstock composition on coke formation in steam cracking reactions

Aim

The aim of this work is to gain fundamental understanding of coke formation under typical industrial reactor conditions.

Justification

Light olefins such as ethylene and propylene are the most important basic chemicals for the petrochemical industry. The dominant process to manufacture them is the thermal cracking in the presence of steam. Coke deposition on the inner wall of the tubular cracking reactors is the main drawback of this process. The resulting coke layer reduces the cross-sectional area of the tubular reactors, causing a continuous increasing pressure drop. Thus, bi-molecular reactions gain ground, leading to lower olefin selectivity. In addition, the resistance to heat transfer from the furnace to the feed is increased. All the above lead to higher tube metal temperatures and eventually, to process shutdown in order to decoke the reactors. This negatively affects the desirable production and the economics of the process.

The reactor material is one of the most important factors affecting the deposition of coke. However, only a limited number of studies have been carried out evaluating the effect of metal surface technologies, including the use of low-coking alloys and coatings. On the other hand, for feedstocks heavier than ethane, fundamental understanding of the relation between the materials' composition/state and coke formation is limited to non-existing. Ideally a model could be developed that predicts the coking rates (initial and asymptotic coking rate) for different materials and coatings, taking into account feedstock composition as well as the operating conditions and the surface composition. This will help to optimize the run length of steam crackers and maximize its profit.

Program

Experimental thermogravimetric investigation of coke formation on desired samples of coated/uncoated metal to evaluate:

- The desired material composition, coating and surface morphology (roughness)
- Coking tendency of different feedstocks

The coated or uncoated metals will be examined using:

- Physical analysis of the coke (SEM) to understand the structure of the coke.
- Chemical analysis of the coke (EDX) to explore the structural analysis of the material after coking.

With the above information a comparison will be done that describes the coking rate taking into account process conditions, and reactor material composition for different feedstock compositions.