

Coke, friend or foe? The case study of the oxidative dehydrogenation of ethylbenzene to styrene

Ignacio Melián-Cabrera

Chemical Reaction Engineering, ITM, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands

Coke is often regarded as a negative by-product that leads to catalyst deactivation by fouling. There are however some examples where the deposited coke is the actual catalytic site. This is the case of the oxidative dehydrogenation of ethylbenzene to styrene.

Styrene is industrially produced by direct dehydrogenation of ethylbenzene in steam at 580-630 °C. The process suffers from high energy consumption due to low conversion per pass (equilibrium limited) and the high temperatures required for the endothermic reaction. Oxidative dehydrogenation can address these drawbacks, but it is not commercialized yet due to the limited catalyst stability and the lower selectivity to styrene that is ~90% (CO/CO₂, main by-products), while the commercial steam-based process has a selectivity >95% and marketable side products, such as benzene and toluene. For the O₂-assisted dehydrogenation it is accepted that the coke produced at the early stage of the reaction is the actual active/selective catalytic site. However, if coking is severe it produces a steady catalyst decay, and finally a flow obstruction in the catalyst bed. Hence, balancing the coke formation is the key issue.

In this presentation, I will show you relevant aspects of the industrial styrene process and recently obtained results about the thermal activation of a silica-stabilized γ -alumina. Such a relatively simple protocol impacts positively on the conversion, selectivity and coke rate deposition.