SAPO-34 Catalyst Description

The reaction of methanol to olefins provides many different products. The goal to achieve for this MTO process is to maximize the production of lighter olefins: ethylene and propylene. Several paths have been followed to increase selectivity to light olefins in the transformation of methanol into hydrocarbon. Due to the limiting nature of its chemistry, a catalyst is needed to assist the desired reactions. To help this happen, the SAPO-34 catalyst is used in the reactor. The nature of SAPO-34 is to favor smaller products to form, while hindering the formation of larger product chains. SAPO-34 has an isomorphous structure to that of chabazite (zeolite group). It is a tridimensional structure consisting of channels (spaces between 8 atoms of oxygen), with a maximum diameter of 4.4 Å and a minimum diameter of 3.1 Å. It consists of intersections between channels, which give way to cavities of 10 Å maximum diameter and 6.7 Å minimum diameter. Those dimensions are ideal for the formation and selectivity of desired products, while hindering larger and undesired products for the MTO process. The preparation of SAPO-34 (whose composition is $H_{0.09}(Si_{0.08}Al_{0.51}P_{0.4})O_2$) is carried out following the expired patent of Union Carbide.

By performing its duty in the reactor, the catalyst is also very susceptible to the formation of coke; which deactivates the catalyst if left unmonitored. SAPO-34 permits one to obtain 90% selectivity to light olefins in the 623-748 K operating range, even though deactivation by coke is very high. In order to control this formation of coke buildup, this process uses a fluidized bed reactor with a circulating catalyst regeneration unit. The catalyst travels through the reactor at the desired rate and into the regeneration chamber which will remove the coke buildup by burning the coke with air at 823 K for a desired time (2 hours for complete regeneration of catalyst at this temperature). In this process the goal is to stay in the range of around 5% coke formation on the catalyst. When operating in reaction-regeneration cycles, it has been proven that the catalyst completely recovers its activity. The stability of SAPO-34 (including hydrothermal stability) gives this catalyst possibilities even for the more severe reaction conditions. For example, the stability of SAPO-34 allows for cooling after regenerating before re-entering the reactor, which helps neutralize the exothermic effect of the reaction in the reactor.

From literature it is found that for SAPO -34 the chemical formula used is:

$$H_{0.09}(Si_{0.08}Al_{0.51}P_{0.4})O_2 \qquad [2]$$

***NOTE: *Other competing catalysts include ZSM-5, which is another zeolite type catalyst. SAPO-34 is the industry standard for this process, with both higher stability and better selectivity.*

References used for this description:

1. https://www.sciencedirect.com/science/article/pii/S0016236100001824

2. https://pubs.acs.org/doi/pdf/10.1021/ie990188z