Enhancing the catalytic properties of Mo/ZSM-5 catalysts for methane dehydroaromatization by ex situ formation of metal carbides

Abstract: Finding new uses for methane as a fuel and chemical feedstock in the manufacturing industry is of increasing interest since methane is the main constituent of natural gas, of which vast natural reserves are being exploited. Large quantities of this natural resource are being flared due to lack of infrastructure and high transportation costs. Among the different direct processing reactions that exist to convert methane to value-added products, there has been a growing interest in the heterogeneous catalytic conversion of methane to a mixture of benzene and hydrogen, by the non-oxidative methane aromatization reaction ($6 \text{CH}_4(g) \rightarrow \text{C}_6\text{H}_6(g) + 9\text{H}_2(g)$), which happens in one step. Our group is carrying out a fundamental and systematic study of this catalytic process with the goal to answer some fundamental questions, which can mitigate the technological challenges of this process.

Zeolite-supported molybdenum catalysts have so far been the most widely studied catalysts for the methane aromatization reaction, however, they do not fulfill the conversion and stability requirements for commercialization. It is agreed that Mo carbide species, originated by exposure of the Mo oxide species to the reactant methane, are responsible for methane activation, however, the nature and amount of carbide phases formed in the induction period of the reaction are not controlled. Our group has recently discovered the importance of the conditions at which the zeolite-supported molybdenum carbides are formed on the catalyst stability. We have tested different preparation conditions and contrasted the structure of the fresh and spent catalysts to explain the difference in catalytic behavior. Our results have resulted in obtaining Mo/ZSM-5 catalysts that maintain remarkably stable benzene yields over long periods of time in reaction.

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