Bifunctional zeolite catalysts for one-step synthesis of biorenewable chemicals

S. L. Zacho

DTU Chemistry, Technical University of Denmark

INTRODUCTION

Acetone is an important solvent and intermediate that is produced from oil. Fortunately, acetone can also be produced by fermentation of biomass and with the on-going developments in biomass processing it seems likely that bio-acetone may become an important platform molecule for the production of chemicals from renewable resources.
An important bulk chemical derived from acetone is methyl isobutyl ketone (MIBK). Traditionally, MIBK is produced in a three step process involving the base-catalyzed aldol condensation of acetone to diacetone alcohol, an acid-catalyzed dehydration to mesityl oxide and a metal-catalyzed hydrogenation to MIBK, see Figure 1.

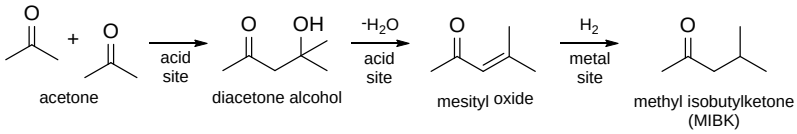

Figure 1: One-step process for production of MIBK from acetone.

Here, I present my investigations of zeolite encapsulated metal nanoparticles and their activity and selectivity as bi-functional catalysts for the direct production of MIBK from acetone. The zeolite facilitates the acid catalyzed aldol condensation, while the Pd metal nanoparticles catalyze the following hydrogenation.

RESULTS AND DISCUSSION

In order to study the effect of morphology and the close proximity between the acid and metal active sites, the Pd metal nanoparticles were supported on a conventional ZSM-5 zeolite as well as on a carbon-templated mesoporous and a recrystallized ZSM-5 zeolite. Figure 2 show how the recrystallization result in the formation of intra-particles voids and mesopores that provides ideal conditions for the formation small and disperse metal nanoparticles.

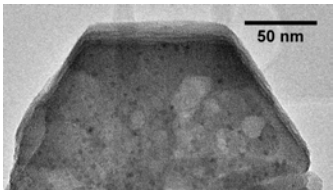

Figure 2: TEM image of metal nanoparticles encapsulated in recrystallized zeolite ZSM-5.

CONCLUSION

In conclusion, I have investigated different zeolite supported Pd metal nanoparticles as bi-functional catalysts for the direct production of MIBK from acetone. Furthermore, I have developed a new and simple method to encapsulate Pd nanoparticles in zeolites. The method is simple, effective and scalable and I therefore hope that impregnation of recrystallized zeolites may become a useful tool in the development of new and efficient bi-functional catalytic systems.