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The impact of catalyst and reaction conditions on demanding hydrogenation applications

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The success of demanding fats and oils hydrogenation applications is reliant on selecting the right catalyst and reaction conditions; temperature plays a key role. Evonik's MONCAT[®] catalysts have been developed specifically for these processes.

The hydrogenation of castor oil, monomer acids and dimer acids with Evonik's MONCAT[®] catalysts

When it comes to demanding fats and oils hydrogenation applications, the selection of the right catalyst and reaction conditions are decisive for technical and financial success.

Although these applications have little in common at first glance, they are united by the key role temperature plays – looking at castor oil, too high a temperature and the product is ruined, while with dimer and monomer acids, too low a temperature and hydrogenation is not achievable.

The hydrogenation of castor oil with MONCAT® 2021

Castor oil is a special triglyceride (TG); more than 89% of the fatty acid chains are ricinoleic acid, with a hydroxyl group on the 12th carbon. Polar in nature, these hydroxyl groups give castor oil its unique properties – including higher density; compatibility with resins, polymers and waxes; and viscosity that withstands temperature changes.

Although typical TG hydrogenations are robust processes with temperatures up to 200 °C and pressures less than 5 bar, reaction temperatures above 150°C in castor oil tend to remove the hydroxy groups completely – converting it to a standard fat or oil. Another unwanted reaction above 150°C is the dehydrogenation of the hydroxyl group to the corresponding ketone.

The preferred hydrogenation catalyst for this reaction is one that provides selective high activity at low temperatures with fast filtration, such as Evonik's widely used MONCAT® 2021 catalyst.

Hydrogenated castor oil is then usually saponified to preserve the hydroxy groups and processed to mostly 12-HSA for multiple applications, including lubricants and cosmetics.

Dimer and monomer acid hydrogenation with MONCAT® 1991

On the other side of speciality applications is the hydrogenation of dimer acids, where higher temperatures are required for improved conversions. Unsaturated dimer and monomer acids are made from split free fatty acids (FFA) that undergo a range of reactions over solid acid catalysts at 230-250 °C and 5 to 10 bar.

For FFA hydrogenation, it is known nickel catalysts with smaller pores perform better than wider ones, due to the steric hindrance of nickel soap formation in these confined spaces. However, the bulky structures of unsaturated dimer acids may need improved kinetics to be hydrogenated on very durable catalysts.

With common FFA, hydrogenation is usually performed at 200 °C or lower, with hydrogenation pressures between 15-30 bars, to avoid unwanted side reactions and inhibit nickel soap formation, respectively.

Dimer acids, however, can be hydrogenated at temperatures up to 240 °C with MONCAT® 1991, due to their durability and ability to deliver very high yields under these conditions. An excellent free fatty acid hydrogenation catalyst, MONCAT® 1991 is also the preferred catalyst to produce saturated monomer and dimer acids.

Producing hydrogenated oleochemicals with special properties and sensitivities – 12-HSA, monomer acids, dimer acids – requires not only the right reaction conditions, but also catalysts with the right stability and activity at the required temperatures and pressures. Evonik’s MONCAT® catalysts are the spot-on choice for typical fats and oils hydrogenation applications, and for the more demanding ones seen here.

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