



# Solidification of Fat and Oil at Room Temperature using Hydrogenation Process

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## DESCRIPTION

Hydrogenation of fats and oils and their oil chemical derivatives (fatty acids, fatty acid esters, and fatty nitriles) has proven to be a very useful and versatile method for modifying these raw materials. This chapter discusses hydrogenation of carbon-carbon double bonds. Hydrogenation or the addition of hydrogen throughout the double bond allows the processor to change its properties by removing the double bond. Therefore, selectivity is another aspect used in fat modification by hydrogenation. The addition reaction of hydrogen to the olefin double bond was discovered by the French chemist and Nobel Prize-winning Paul Sabatier at the end of the 19<sup>th</sup> century. He found that the reaction could be carried out under relatively mild conditions in the presence of certain metals such as nickel, cobalt and platinum. He believed that this was only possible when using "volatile" organic compounds as substrates. In the second half of the 19<sup>th</sup> century, there was a growing demand for cheap hard fats in much of Europe and later in the United States (followed by other countries). These fats were needed for the production of margarine and the replacement of butter, but there was a major shortage. German chemist Wilhelm Norman successfully hydrogenated oleic acid into stearic acid with finely divided nickel, thereby refuting Sabatier's restrictions on "volatile" organic compounds. As a result, Norman has obtained several patents covering the hydrogenation of unsaturated fatty acids and their glycerides. Since about 1909, hydrogenation of triglycerides has become an increasingly popular process in Western Europe and the United States. It was soon used by many companies around the world as a relatively inexpensive and versatile source of stable fats and oils using locally available liquid ingredients.

### Hydrogenation purpose

Hydrogenation usually serves one or more of the following purposes:

**Converting liquid oil into solid fat:** If the proper concentration of solid fat is expensive or unavailable, hydrogenation may

provide a way to produce the desired fat in combination with other processes such as trans-esterification.

**Change the consistency of fat:** The melting point of hydrogenated fat can be controlled by the degree of hydrogenation. Vegetable oils most often contain the *cis* isomers of fatty acid. Hydrogenation also converts some *cis* isomers to *trans* isomers, giving triglycerides different melting properties.

**Expand the availability of edible fats and oils:** Whale oil and subsequent fish oil are "many fish" and cannot be eaten. By hydrogenating these oils, delicious raw materials were made.

### Requirements for hydrogenation

**Raw materials:** The catalyst used for hydrogenation is sensitive to various impurities that may be present in the oil. These impurities can reversibly reduce the activity of the catalyst or permanently contaminate the catalyst. If the catalyst is contaminated, the changes are irreversible and must be replaced with a new catalyst. This means that the oil needs to be refined to low levels of residual contaminants that reduce catalyst consumption to economically reasonable levels. In general, a more thorough purification choice should be weighed against higher costs as it results in lower catalyst consumption and more predictable catalyst performance. The content of individual impurities varies depending on the type of oil.

**Hydrogen:** Hydrogen is available from a variety of sources. Hydrogen in cylinders, pipeline supply from major gas producers, electrolysis, gas reforming, etc. The designer of a hydrogenation plant needs to know the quality of hydrogen. Therefore, the quality of hydrogen has little effect. Hydrogen may contain three groups of impurities that can affect hydrogenation: inert substances, inhibitors, and toxicants.

**Inerts:** Inert are other gasses than hydrogen, such as methane, water or nitrogen which lower the partial pressure of the hydrogen, thus reducing the rate of the hydrogenation. This is particularly problematic in batch hydrogenation because as the hydrogen is being consumed during the hydrogenation, the inerts accumulate in the headspace of the reactor. As the total

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pressure is usually kept constant, the partial pressure of the hydrogen will therefore decrease.

**The catalyst:** In the hydrogenation of fats and oils the catalysts used industrially are the so called supported nickel catalysts, whereby the nickel metal is mounted on an inert support material.

In the past, other catalysts have also been used, e.g. Niformal, Raney-type nickel, nickel-copper and copper-chrome. In addition, the use of precious metal catalysts has been explored.

Niformal and Raneytype catalysts must be activated *in situ*. They were in common use in the 1940s and 1950s, when easy to handle, reduced-assisted ni-catalysts became popular. The currently supported ni-catalyst types have significantly better performance than the Niformal and Raney types.