Healthier fats and oils by Green Chemistry:

Triglycerides consist of one glycerol plus three fatty acids. Triglycerides that contain mostly unsaturated fatty acids are liquid at room temperature. Manufacturers partially hydrogenate these fatty acids to make them solids at room temperature. *Trans* fatty acids form during the hydrogenation process; they are found at high concentrations in a wide variety of processed foods. Unfortunately, consumption of *trans* fatty acids is also a strong risk factor for heart disease. To reduce *trans* fats in the American diet as much as possible, the FDA is requiring labeling of *trans* fats on all nutritional fact panels by January 1, 2006. In response, the U.S. food and ingredient industry has been investigating methods to reduce *trans* fats in food.

Of the available strategies, interesterification is the most effective way to decrease the *trans* fat content in foods without sacrificing the functionality of partially hydrogenated vegetable oils. During interesterification, triglycerides containing saturated fatty acids exchange one or two of their fatty acids with triglycerides containing unsaturated fatty acids, resulting in triglycerides that do not contain any *trans* fatty acids. Enzymatic interesterification processes have many benefits over chemical methods, but the high cost of the enzymatic process and poor enzyme stability had prevented its adoption in the bulk fat industry.

Enzymatic interesterification positively affects both environmental and human health. Environmental benefits include eliminating the use of several harsh chemicals, eliminating byproducts and waste streams (solid and water), and improving the use of edible oil resources. As one example, margarines and shortenings currently consume 10 billion pounds of hydrogenated soybean oil each year. Compared to partial hydrogenation, the ADM/Novozymes process has the potential to save 400 million pounds of soybean oil and eliminate 20 million pounds of sodium methoxide, 116 million pounds of soaps, 50 million pounds of bleaching clay, and 60 million gallons of water each year. The enzymatic process also contributes to improved public health by replacing partially hydrogenated oils with interesterified oils that contain no *trans* fatty acids and have increased polyunsaturated fatty acids.

Compared to other processes that are used for the same purpose, such as hydrogenation, interesterification generally preserves the original distribution of fatty acids in the product, and hence is expected to preserve its nutritional and health attributes. However, those other techniques may still be applied to the starting fats or to the products of IE, and the latter may be blended with other fats. Also, some of the new triglycerides produced by IE may be fractionated (separated) through controlled crystallization.

Interesterified fats are used in many industrial food products, including cookies, crackers, biscuits, cakes and icings, dairy fat replacers, pie crust, popcorn, flatbread and tortillas.

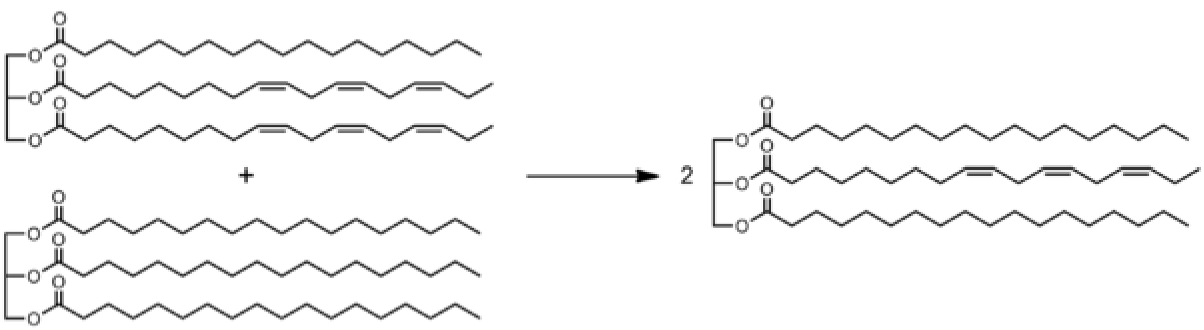

Figure: An example of interesterification between a triglyceride (top left) with two linolenic acid residues (LARs) and one stearic acid residue (SAR), and another triglyceride (bottom left) with three SARs, yielding two molecules with two SARs and one LAR each (right)

Enzymatic interesterification

Enzymatic interesterification (IE) uses an enzyme to break and reform the ester bonds. Enzymes most suitable for this process are esterase; lipase; acylase; those enzymes that facilitate acidolysis reactions, transesterification reactions, ester synthesis or ester interchange reactions; enzymes having phospholipase or protease activity, including thermostable and thermotolerant hydrolase activity; and polynucleotides.

Some enzymes will break and reform ester bonds only at positions 1 and 3 (sp1 and sp3) of the glycerol hub, leaving the acids in position 2 (sp2) fixed.

The most common industrial EIE process forces the liquid fat feedstock through a fixed-bed reactor, that typically contains an oil purification bed followed by an enzyme bed. The latter has the enzyme fixed on some inert granular substrate. The first bed removes impurities from the oil blend that could inactivate the enzyme or affect its performance. The enzyme activity decreases over time, so flow must be carefully monitored and adjusted over time to maintain conversion.

Two or more reactors maybe used in tandem, where the first reactor has the lowest enzyme activity and absorbs most of the impurities and harmful compounds. This sequencing protects the most active enzymes, which are in the last reactors.

EIE has been replacing CIE because it has fewer processing steps, can be carried out at lower temperatures, produces no by-products and has lower production costs.