Introduction

Biodiesel refers to a vegetable oil, or animal fat based diesel fuel, consisting of long-chain alkyl (methyl, propyl or ethyl) esters.

There are three basic routes to ester production from oils and fats:

1. Base catalyzed oil transesterification with alcohol.
2. Direct acid catalyzed oil esterification with methanol.
3. Conversion of the oil to fatty acids, then to alkyl esters with acid catalysis.

Today, the majority of the alkyl esters are produced with a base catalyzed reaction.

Fat or oil is reacted with alcohol, like methanol, in the presence of a catalyst to produce glycerol (also known as glycerin) and the methyl esters for biodiesel. Excess methanol is charged to assist in quick conversion and then it is recovered for reuse. The catalyst is usually sodium or potassium hydroxide, which is premixed with the methanol.

Typical final methyl ester products are: rape methyl ester (RME) from rapeseed, palm methyl ester (PME) from palm oil, soy methyl esters (SME) from soybean, and fatty acid methyl ester (FAME) from a mix of vegetable and animal products. These products have different refractive indexes.

Application

Base catalyzed production of biodiesel is generally carried out through the following stages.

Mixing of Alcohol and Catalyst

Sodium hydroxide (caustic soda) or potassium hydroxide (potash) are typical catalysts. These are dissolved in alcohol using standard agitator or mixer.

Reaction

The alcohol/catalyst mix is then charged into a closed reaction vessel, which oil or fat is introduced to. This is a totally closed system to prevent alcohol loss into the atmosphere. The reaction mix is kept just above
the alcohol boiling point (around 71 °C or 160 °F) to speed up the reaction. Recommended reaction time varies from 1 to 8 hours and in some systems the reaction is at ambient temperature. An excess of alcohol is normally present to ensure the conversion of the entire feedstock to esters.

It is important to monitor the amount of water and free fatty acids present in the oil or fat feedstock. If the free fatty acid level or water level is excessive, it may cause problems with soap formation and glycerol by-product separation downstream.

Separation

Once the reaction is complete, there are two major products: glycerol and biodiesel. Each contains a substantial amount of excess methanol left over from the reaction. The reacted mixture, if required, is neutralized at this stage. The glycerol is much denser than the biodiesel and the two can be easily separated in a settling tank. A centrifuge is sometimes used to accelerate the separation.

Alcohol Removal

Once the glycerol and biodiesel have been separated, the excess alcohol in each is removed by a flash evaporation process or through distillation. In some systems, the alcohol is removed and the mixture neutralized before the glycerol and esters have been separated.

In both cases, the alcohol is recovered and is reused. It is important to ensure no water accumulates in the recovered alcohol stream.

Glycerol Neutralization

The glycerol by-product contains unused catalyst and soaps, which when neutralized with an acid, leave crude glycerol. In some cases, the salt formed during this process is recovered to be used as fertilizer.

Though in most cases, the salt is left in the glycerol. Water and alcohol are removed to produce a crude glycerol of 80-88 % purity. In more sophisticated operations, the glycerin is distilled to a purity of 99 % or higher, which is suitable to be used in cosmetics and pharmaceuticals.

Methyl Ester Wash

Once separated from the glycerol, the biodiesel may be purified by washing with warm water, which removes the residual catalyst and soaps. Once dried, it is stored and ready for distribution. In some processes this step is unnecessary. This is normally the end of the production process, resulting in a clear amber-yellow liquid with a viscosity similar to petrodiesel. In some systems, the biodiesel goes through an additional distillation to remove small amounts of color bodies in order to produce colorless biodiesel.

Product Quality and Registration

Prior to distribution as a commercial fuel, the finished biodiesel must be analyzed using sophisticated analytical equipment to ensure that it meets ASTM specifications.

Instrumentation and installation

Vaisala K-PATENTS® Process Refractometer PR-43-GP monitors the concentration of ester and glycerol at various stages in biodiesel production. The continuous and accurate measurement from the refractometer helps to increase efficiency and to obtain the desired product concentration. The refractometer can be used for preparing the alcohol base catalyst mixture, detecting the interface between glycerol and ester or glycerol and fatty acids in the settling tanks, and for automatic control of evaporation.

Because the refractive index value is different for each type of ester (RME, SME, FAME, PME), the refractometer can also be used to monitor the final product and to ensure it flows into the correct tank. Moreover, the final concentration measurement by the refractometer can be used as a reliable measure of quality control.

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Process Refractometer PR-43-GP</td>
<td>A general industrial refractometer for pipes and vessel installations. The PR-43-GP can be installed with 2, 3 and 4 inch flange and 3 inch Sandvik L coupling process connections and a variety of flow cells for pipe sizes of 1 inch and larger.</td>
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<tr>
<td>User Interface</td>
<td>Selectable multichannel MI, compact CI or a web-based WI user interface options allow the user to select the most preferred way to access and use the refractometer measurement and diagnostics data.</td>
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<tr>
<td>Measurement range</td>
<td>Refractive Index (nD) 1.3200 – 1.5300, corresponding to 0-100 Brix.</td>
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