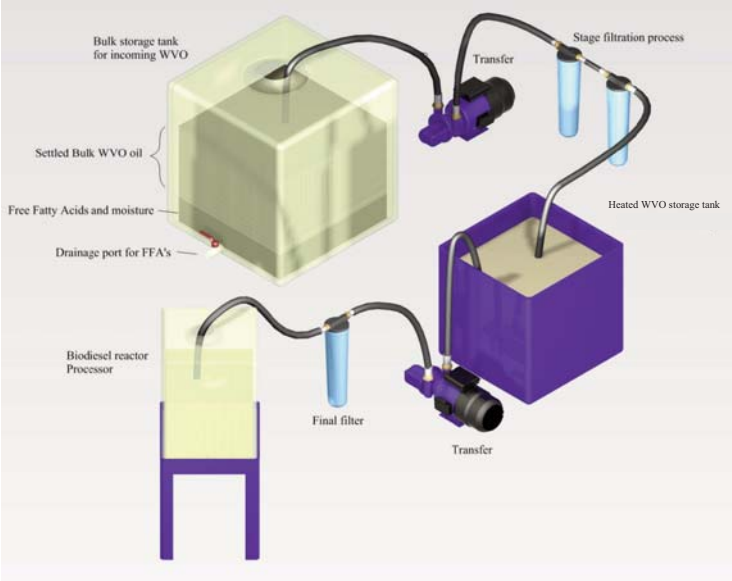
Production & Purification Overview

Feedstock filtration (WVO/RSO/SBO/Algae Oil)

Most biodiesel is made from waste vegetable oil (WVO) collected from catering and food production facilities, or from virgin feedstocks.



The schematic shows the importance of pre-treatment of base feed-stocks in a batch production system. Settling or alternative removal methods are required to ensure the base feedstock is suitable for use.

The Need for Effective Filtration & Pre Treatment

The WVO often contains high levels of Free Fatty Acids, moisture as well as solids, other impurities and contaminants. The solids can be filtered out using correct filtration procedures. The water must be removed by heating the oil to above 212°F (100°C) for an extended period to drive the water from the oil. Other drying methods are also acceptable.

Pre-treatment of WVO prior to the transesterification process is important. Free Fatty Acids (FFA), oil contaminants and moisture need to be effectively removed in order to ensure a clean, irreversible reaction.

WVO typically contains from 2-5% free fatty acids. If the free fatty acids are above this amount, it is very difficult to produce biodiesel without an acid esterification process. The free fatty acid number is determined by a titration process. A full description of this process is available on request.

A common problem with biodiesel producers is instead of a clear separation between the biodiesel and the glycerine after the reaction and settling process, they end up with a semi-solid, gelatinous mixture that cannot be purified and used as fuel. This is an indication that the oil contained excessive free fatty acids and/or water.

Raw vegetable oils that are produced by pressing oilseeds such as canola, mustard, soybeans or other virgin oils like sugar cane or algae can also be converted to biodiesel. The free fatty acid level of these raw oils is usually 0.5% or less, which is low enough not to pose a problem. However, the oil may contain gum compounds that can create sludge deposits in the processing equipment and can make it difficult to separate the glycerine at the end of the reaction.

Waste Vegetable Oil/ Virgin Oil Filtration

Choose from our range of filter cartridges (reusable or disposable) and a range of filter housings to suit all budgets and production levels. SchroederBiofuels can supply individual components as well as the complete the filtration systems. Skid mounted units are available in varying sizes. Rugged pump specifications allow for transfer of viscous liquids.

Choose from a range of high performance filtration elements in different materials and pore sizes: low cost polypropylene, nylon recleanable and mesh screen are available. Irrespective of your budget and production levels, SchroederBiofuels has a feedstock filtration solution to suit your operation.

Crude BioDiesel Purification

Having a good and complete reaction is not enough. The production residues and impurities left in the crude biodiesel after the reaction are dangerous to any combustion system and must be removed. Whether your method of Biodiesel purification is Wet or Dry, it is a step that must not be overlooked.

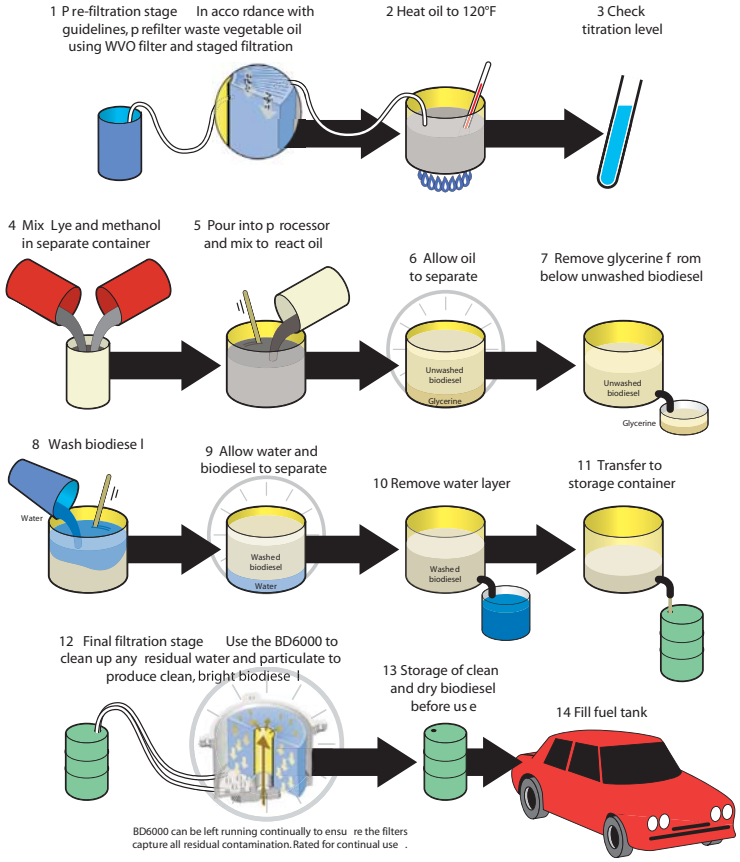
As mentioned earlier, after the reaction, separation of the gylerol and demethylating, the biodiesel still has high levels of soaps, aggressive pH, excess caustic and other impurities that must be removed via a wash process. Though Schroeder BioFuels does not endorse one wash method over another, our product portfolio supports the use of any wash method and has the perfect addition for your process to produce clean, pure traceable fuel confidently.

Wet Wash Purification

The longest standing method for purification is the wet or water wash method. It is a process where a certain percentage of water is added to the crude biodiesel and the water is let to settle. As the water passes through the fuel, it attaches to impurities. (An air wash or bubble wash is sometimes paired with this process to accelerate the water passing through the fuel.) Once settled, the contaminated water is drained off. This process is repeated until the water removed is clear in color. To assure the amount of water being removed meets standards, the addition of SchroederBiofuels' TestMate Water Sensor (TWS-C-E) allows you to monitor the amount of moisture in the biodiesel. Once all the water is removed, the remaining clean biodiesel is dried using a BD6000 or other demoisturizing unit and is ready for final quality check.

This purification method works very well; however, with tightening government standards it becomes difficult and costly to treat and dispose of the highly contaminated water. Other challenges may include the cost and effort to dry the emulsified (oil and water in suspension together) fuel once the purification is complete. All of these issues mentioned can vary based on your actual production method, experience and local laws.

The Wet Wash Process Explained*

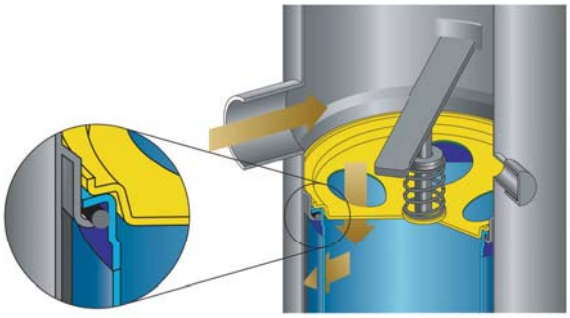


* The method shown is just for example. The actual method and variables can be changed based on your preferences and experience.

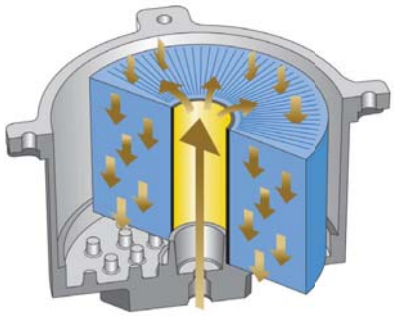
Crude BioDiesel Purification

Dry Wash Purification

Dry wash purification is a more recent addition to biodiesel purification. Current methods for dry washing the crude fuel include ion-exchange resins (like Amberlite or Purolite) and silicates (like Magnesol or TriSyl). Though both methods are dry, they are applied differently.



Dry Wash Cell Illustration



BD600 Polishing Unit Illustration

Ion Exchange Purification

An ion exchange resin is an insoluble matrix (or support structure) normally in the form of small (1-2 mm diameter) beads, usually white or yellowish, fabricated from an organic polymer substrate. The material has highly developed structure of pores on the surface of which are sites with easily trapped and released ions. The trapping of ions takes place only with simultaneous releasing of other ions; thus the process is called ion exchange. There are different types of ion exchange resin which are fabricated to selectively prefer one or several different types of ions.

Ion exchange resins are widely used in different separation, purification, and decontamination processes. The most common examples in the past have been water softening and water purification. Specialty ion exchange resins can be utilized to bind and remove trace impurities from a biodiesel process stream. After the bulk separation of the glycerin, the biodiesel stream is simply passed though a column of the dried ion exchange resin to bind and remove ionic salts (such as Na+ and Ca++0), trace catalysts, soaps, and glycerin. The dried resin also acts as a desiccant retaining and removing trace water from the biodiesel feed.

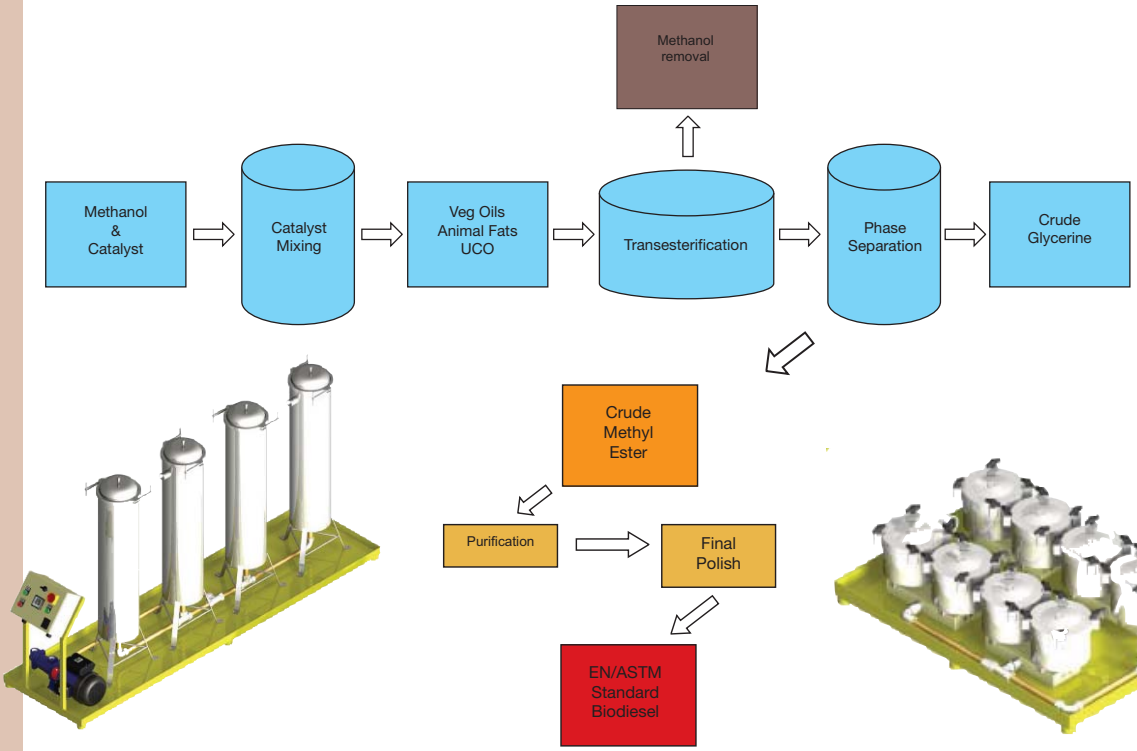
The efficiency and life of a resin to reduce and remove impurities from the biodiesel will depend upon how well bulk separation of the biodiesel and glycerin are made. A resin operation step should be viewed as a polishing process to remove trace materials in the 275-750ppm range, not as a replacement for optimizing the bulk separation.

Generally a lead-lag two column continuous feed system is recommended for most operations. In many cases, a third column should be considered in order to ensure continuous operations and reduce down time.

Challenges of this process include the possibility of blinding over the resin, and thereby disabling its capacity by passing a bad batch of fuel through it. Other concerns are that fine particles can pass downsteam into your final fuel, so final polishing and filtration is still required. Polishing can be accomplished via our BD-6000 line, MFD or any of our Schroeder filters outfitted with our Z (high efficiency) media or Schroeder meltblown elements. The adoption of a TCM, a laser particle monitor, can provide assurance that all final particles have been removed.

Crude BioDiesel Purification

The Dry Wash Process Using Eco2Pure



The Dry Wash Process Explained

The future of drywash technology

Overview

Eco_2Pure™ is a unique cellulose based, natural and sustainable composition of adsorbent technologies, specifically formulated for biodiesel purification from any feedstock.
Eco_2Pure's composition is designed to optimize purification efficiency and contamination removal, combined with increased flow enhancement characteristics.

Eco_2Pure is designed to be a filter-free wash process with no consumables in the wash stage and the lowest cost drywash biodiesel purification method in existence today. Each pound of Eco_2Pure is capable of purifying between 41-82 gals of biodiesel .(Each kilogram of Eco_2Pure™ is capable of purifying between 93-185 gallons of biodiesel*).

Eco_2Pure removes soaps, catalyst traces, residual methanol, moisture and other production residues from biodiesel, thereby assisting in the attainment of EN14214 & ASTM-D6751 quality standards.

Eco_2Pure outperforms existing Ion Exchange Resin (IOX) technologies in terms of fuel quality, purification speed as well as price, boasting the lowest purification costs on the market today*. At $0.03 cents per gallon**, Eco_2Pure can be used to replace or compliment your existing purification system while allowing for a reduction in overall purification costs.

Crude BioDiesel Purification

The frequency of re-bedding (replacing the spent media) will depend on the level of impurities in your biodiesel, the amount of biodiesel treated and the size of the Treatment Tower. So a single 110 lb (50 kg) Treatment Tower could only require re-bedding on average every 9,250 gallons. Loading is fast and simple and once Eco_2Pure is loaded, no other intervention is required. Once the Eco_2Pure is bedded in the Treatment Tower, it automatically purifies the biodiesel in a single passage of flow.

* Based on speed and price comparison of average resin prices on UK/USA mainland.
**Eco_2Pure™ life performance is determined by the initial starting quality of the crude biodiesel, base feed stocks, etc.

Eco_2Pure™ is available in tubs, drums or sacks for easy storage and transportation for the smaller producer and available in bulk quantity for larger producers. For details of a stocking distributor near you, please contact us for more details.

A representative will work with you to determine the optimum utilization for your plant and to select the precise amount of Eco_2Pure™ required, according to your process conditions.

The Importance of Final Polishing

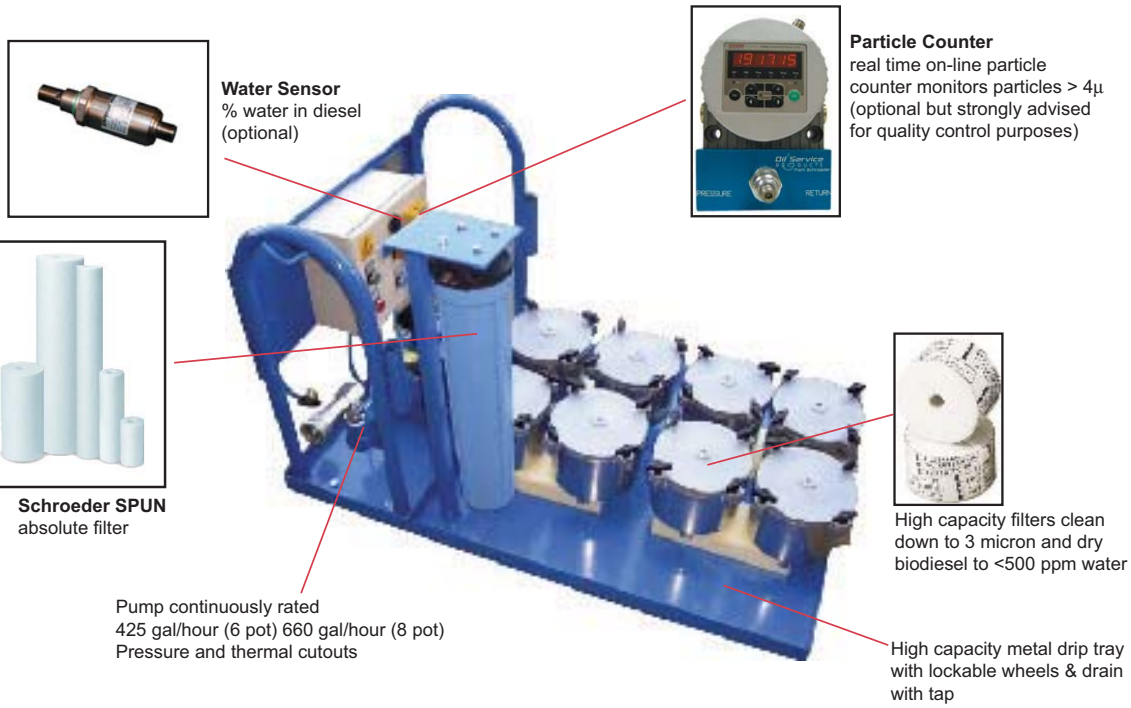
Irrespective of the wash process you choose for your production facility, final polishing of biodiesel is essential to ensure that fuel, once washed, is free of solid contaminants, moisture, production and wash residues. As the final step in the production process, it gives the producer total peace of mind that the fuel produced is clean and dry. Final polishing is a fundamental part of the overall production process and one that is far too frequently overlooked. It is also overlooked in dry wash purification using ion exchange resin as small particles can migrate downstream.

Final fuel quality and in-house quality control are key aspects in successful biodiesel production. Batch consistency and traceability is the main difference between successful and unsuccessful producers.

Final polishing is the last production stage in order to achieve stringent industry quality standards. Irrespective of the wash method used, final polishing is required to remove microscopic contaminants invisible to the naked eye, that could result in serious engine damage.

Final Polishing Units

BD6000 portable Final Polishing Units can be fitted with optional on-line particle and water monitors. With a choice of 2,4,6 or 8 pots, these units have the capacity to meet your increased production volumes.



X Series Skids

The X Series filtration skids are compact, self-contained filtration systems equipped with high efficiency, high capacity elements capable of removing sediment and/or water quickly and economically.

Quality Control

Online Quality Control

If you are a high volume producer, minutes count. Finding that you have produced dirty fuel an hour late can leave you with thousands of gallons of problem fuel. Online sensors can help you catch the problem before your customer does. While particle and moisture sensors will not tell you if your centane number is correct or if your flash point is acceptable, they will tell you how much particulate or moisture is in your biofuel. As the fuel passes the sensor, it can display a problem with a filter upstream and if the dry washing chemical (or any other particulate that could clog a fuel filter) is not being removed to standard.

Offline Quality Control

Taking and examining samples during various stages of your production process can provide a priceless level of visibility to troubleshooting or even just understanding your current biodiesel production processes.

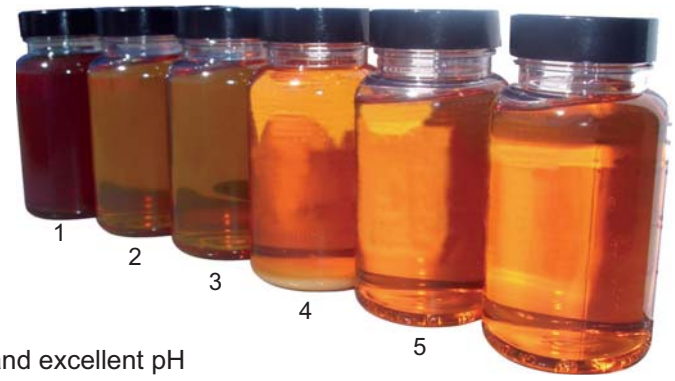
The samples below show how much the appearance of biodiesel changes as it progresses through the various stages of production. These samples were taken at key stages in the production process and clearly demonstrate the importance of effective filtration throughout.

1) WVO (Waste Vegetable Oil): Pre-filtered

2) Biodiesel after reaction and initial glycerin drain

3) After 8 hour settling-final glycerin drain

4) Dry washing using Magnesol. Sample taken from wash tank. Significant improvement in clarity and excellent pH neutralization at this stage. Magnesium silicate powder still clearly visible at base of sample bottle

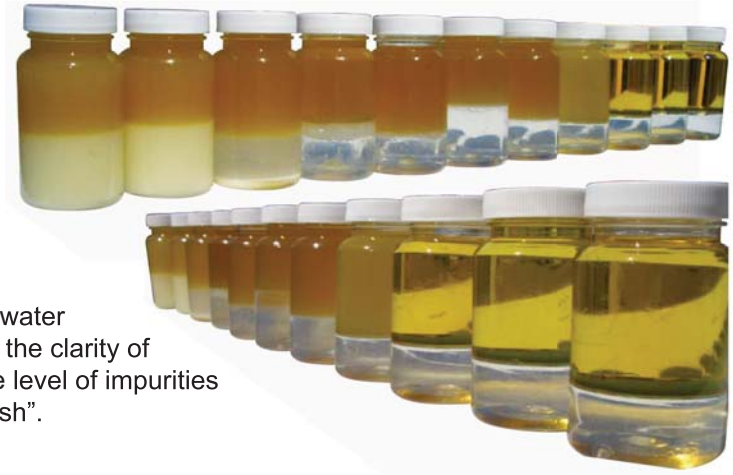


5) Sample taken after the BioDiesel Wash Tower showing great clarity and further reduction in pH value

6) After final polishing using the BD6000. Final effective contaminant and moisture removal and yet further reduction in pH values. Cleanliness in accordance with ISO 4406: 16/14/11

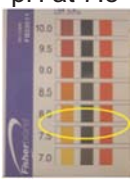
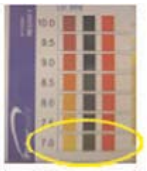
Simple Water Test

The line of sample bottles below shows the difference between freshly produced, “dirty” biodiesel still highly contaminated with production chemicals ie. Methanol and NaOH (left) through to the washed and polished clean samples (right). By adding a small amount of water to a sample bottle containing biodiesel, the water will collect at the base of the bottle and the clarity of the water is a very good indicator of the level of impurities present. This in effect is a mini “wet wash”.



Quality Control

Sample Reference Chart

STAGE	VISUAL SAMPLE	pH	Simple Water Test
UNWASHED BIODIESEL		pH at 8.5 	 settled water still highly contaminated
WASHED BIODIESEL		pH at 7.8 	 major reduction in production residues & soaps
POLISHED BIODIESEL		pH reduction to 7.2 	 water test shows excellent purification

Even though your fuel has been washed and polished, sometimes (due to climate or process change) the fuel will appear to have particulate in it. While one may think that a dry washed fuel could certainly have magnesium silicate particles still in it, other factors may be at play. As you will see, understanding your process and fuel from samples can change the way you address any issues in your process.

The sample to the right shows Magnesol deposits still present in the final sample. This is unsatisfactory and would suggest that the seals in the wash unit have not been correctly positioned or that the cells have been overused and need replacing.

Note the dark bed that Magnesol forms on the base of the sample bottle. The reason it is dark is that it has absorbed production impurities from the fuel. Ensure that the seals are correctly aligned, re-wash and polish this batch to remove Magnesol deposits.

The sample to the left shows biodiesel that is starting to wax/ crystallize. This should not be confused with Magnesol deposits. As seen above, Magnesol will form a dark bed on the base of the sample bottle if still present. Winter waxing and crystallization will appear as a “whispyness” and may resemble cotton wool in appearance.

The best way to verify what this is, is to introduce heat ie. heat up in the microwave for ± 20 seconds. If the cloudiness disappears then we know that it is winter gelling or crystallization. Now reduce the temperature and watch the whispyness return. If your samples look like this you would need to consider a winter additive or pour point depressant to eliminate this.

Quality Control - BioFuels Test Kits

Benefits for Biodiesel Producers

The information obtained from the Biodiesel Test Kits allows manufacturers to:

- Save money by optimizing the ratio of chemicals used
- Check the quality of the base stock at the time of delivery
- Refine and trouble-shoot the manufacturing process
- Ensure the quality and consistency of the end product

End Users

The critical parameters determined by the Biodiesel test kits allow end users to safe-guard machinery by:

- Ensuring the quality of the biodiesel at the time of delivery
- Monitoring the consistency of the biodiesel from batch to batch
- Checking stored biodiesel for any deterioration over time

Patch Test Kit

A patch test is an excellent way to see how effective wash systems, polishing systems and filtration products remove all traces of Magnesium Silicate and other contaminants. Patch slide analysis can be preformed using Schroeder BioFuels' BioDiesel Mobile Lab – Patch Kit (BML-P; See page 29). The kit contains the following:

- Biocular Microscope
- Hard Vacuum Pump
- Carry Case
- Contaminant size reference chart
- Filter Membranes and Mounting slides
- Plastic Beaker
- Solvent
- Instruction manual
- Forceps & Clamps

How Does It Work?

A sample of the test fuel is passed through a filter membrane via a vacuum pump. The sample is then dried and mounted into a membrane holder ready for visual assessment. The comparison slides are available to readily identify fuel cleanliness levels and to differentiate between the different types of fuel contaminants.

Analysis

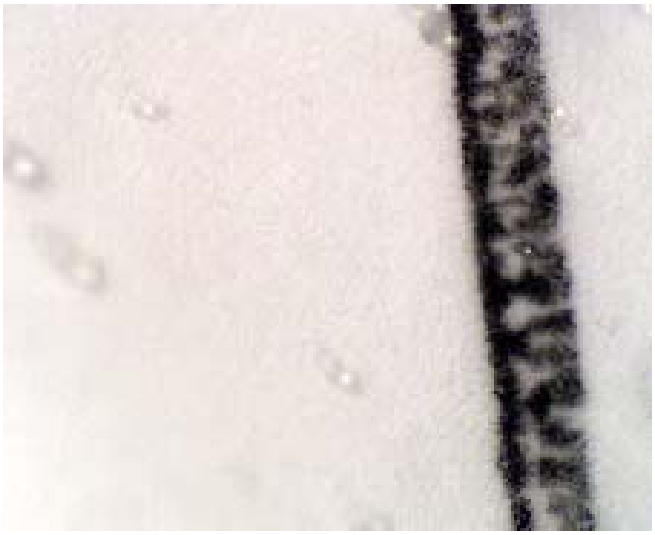
In the examples shown on page 20, three samples were pulled through a 1.2 micron patch under vacuum and viewed under a microscope with 400x magnification. The dark black lines visible are the grid-lines on the slide which allow visual comparison to actual particle size.

Quality Control - BioFuels Test Kits

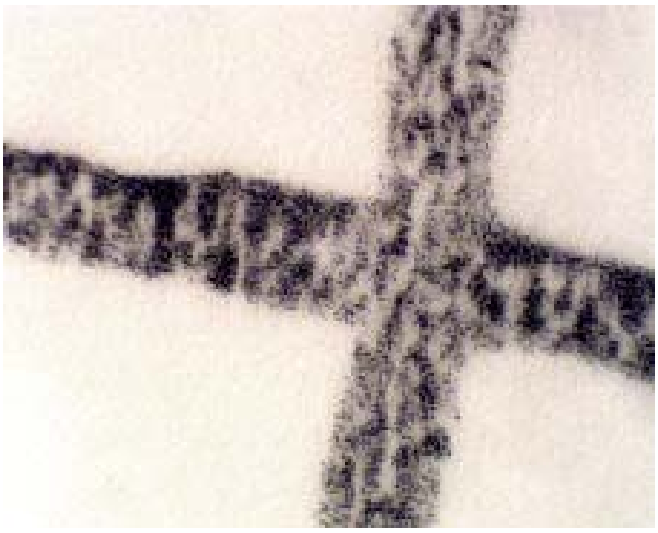
Sample Reference

Sample 1:
During the agitation stage from the wash tank.

Sample 2:
Taken downstream
of our Dry Wash System. A significant reduction in Magnesium Silicate now showing minimal traces.



Sample 3:
After final polishing using the BD6000. Slides now showing excellent clarity.



Quality Control - BioFuels Test Kits

Density

The density test is used to ensure the product is high quality, per biodiesel. Post manufacture, density testing can be used to check yield and to optimize the process.

Operating Range 850-950 kg/m3 (EN 14214 Specifications: 0.86-0.90)

- Ensure biodiesel meets specification
- Check yield and help manufacturing variables

Water

Water in biodiesel can lead to microbiological growth as well as the production of acids. In manufacture, water in the base feedstock oil can reduce yields and increase process time. The EN14214 upper moisture limit is 500 ppm. If you are not achieving this standard on your final product you will need to address the following issues:

- Better pre-treatment of base feedstocks and increased setting times
- Increased filtration and polishing times
- Ensure adequate methanol removal
- Ensure adequate storage conditions for MAGNESOL™. MAGNESOL™ is hygroscopic, hence the fact that it is so effective in the biodiesel purification process
- Analyze your process for moisture ingress and condensation traps
- Check biodiesel storage conditions (if appropriate)

Two operating ranges:

Range 1

- Operating Range 100-3000 parts per million (ppm) (EN 14214 Specifications: 500 ppm max)
- Ensures biodiesel meets specifications
- Highlights drying and washing times
- Check stored fuel for moisture ingress/absorption

Range 2

- Operating range 200 - 100000 parts per million (ppm)
- Increases manufacturing yields by ensuring base feed stock is dry
- Allows for quality control of incoming base feed stocks
- Allows better understanding of drying/wash process during production

Viscosity

High viscosity biodiesel can lead to poor combustion and possible engine damage. It can also be an indication of contamination present from the manufacturing process.

1-10 cSt @ 104°F (40°C) range

- Ensures biodiesel meets specification
- Indicates possible glycerine/glyceride or methanol contamination
- Helps optimize settling, purification and filtration processes during production

TAN (Total Acid Number / Acid Content)

As biodiesel is stored, it can acidify, reducing energy output and potentially leading to corrosion of storage vessels and fuel system components.

- Range 0-6 TAN (Upper limit is 0.5 TAN)
- Ensures biodiesel meets specifications
- Check stored fuel for degradation

Check oil base stock for acid levels to optimize catalyst. If you are not achieving this standard on your final product you will need to address the following issues:

a) Ensure sufficient catalyst is used in the process
b) Ensure base feed stock is of adequate quality
c) Check for over heading of oils

Biodiesel Test Kit Specifications

Test Parameter	Equipment Included	Range	No. of Tests
Water	DIGI Water Cell Reagents & Consumables	100-3000 ppm, 200-10000 ppm and 0-1-%	50
Density	Hydrometer Hydrometer Jar Digital Thermometer	850-950 kg/m 0-110°C (1°C increment)	Unlimited
Viscosity	Falling Ball Viscometer Calibration standard	1-10 cST @ 40°C	Unlimited
TAN / Acid Content	ECON TAN drop test Regents and Consumables	0-1.5, 0-3 & 0-6 TAN	25
Visual Test	Sample bottle Sample beaker	Qualitative	Unlimited