BIOdiesel Tech NOTES

Issue TN #14 (Fall 2011)

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Sponsored by USDA under 2014 Farm Bill

USING ADSORBENTS TO LOWER FFA LEVELS IN BIODIESEL FEEDSTOCKS

As any biodiesel producer knows, feedstock is the most expensive part of the biodiesel production process. Lower-cost feedstocks, such as animal fat or used vegetable oil, are frequently of lower quality, containing a higher percentage of free fatty acids (FFAs) that will react with an alkaline catalyst to make soap. This soap must be removed from the biodiesel.

Currently, the most common methods for dealing with free fatty acids tend to be expensive and/or cumbersome. For example, pre-treatment with an enzyme catalyst can be expensive. Acid pre-treatment requires the addition of a lot of hazardous sulfuric acid and alcohol. Distillation, also known as steam stripping, requires millions of dollars of equipment. These methods can make sense when a producer is working with very low-cost feedstocks that are very high in free fatty acids.

However, when using a feedstock that has between 1% and 5% free fatty acids, a producer may be stumped for a good, low-cost pre-treatment. When using virgin vegetable oil, which usually has a fatty acid level of well below 1%, producers simply allow the FFAs to convert to soap, and then remove the soap. Above 5% FFA, acid pre-treatment becomes a viable option, partly because the acid allows the entire feedstock to be converted to methyl esters, instead of causing a loss of yield by removing and discarding the fatty acids.

But what about that middle range of 1% to 5% FFAs?

Commercial food frying operations use adsorbents to remove the FFAs that accumulate in frying oils. One such product is Magnesol 600R, made by the Dallas Group. This is not the same type of Magnesol that is often used to clean biodiesel after it is made. Post-treatment Magnesol is called D-SOL (also known as D60).

Magnesol 600R and several other additives that have been anecdotally recommended for FFA removal from oils and fats were tested.

Additives tested

The following additives were tested:

- Magnesol 600R – a magnesium silicate blend manufactured by the Dallas Group of America.
- X-Tend – a commercial frying oil purifier manufactured by Selecto Scientific in Suwanee, GA.
- Super Bio-Z – a zeolite manufactured by JNS Ranch Company in Rathdrum, ID.
- Montmorillonite K-10 – a bentonite clay manufactured by Acros Organics in New Jersey.

These additives are all "adsorbents," which work by attracting impurities and binding them with weak chemical bonds to a solid particulate. The additive and the impurities are then filtered and discarded, and the remaining feedstock is processed into biodiesel using a normal alkaline catalyst and methanol. Since the impurities are chemically attached to the adsorbent, it is usually not worthwhile to try to recycle and reuse the adsorbent. Because the FFAs are discarded, there is a loss of yield from initial feedstock volume to biodiesel volume.

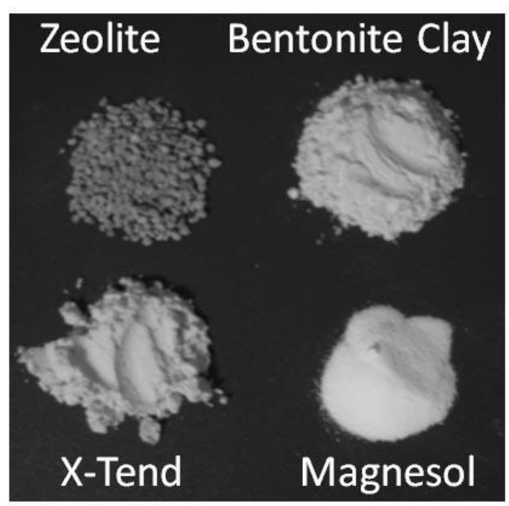


Figure 1

Additive	Initial FFA level	FFA level after 0.5% treatment	FFA level after 1% treatment	FFA level after 2% treatment	FFA level after 3% treatment
Magnesol	3.86%	3.23%	2.33%	1.24%	NA
X-Tend	3.91% - 3.94%	4.04%	3.84%	3.58%	3.91%
Zeolite	3.37% - 3.73%	3.38%	3.31%	3.06%	3.33%
Bentonite Clay	3.38% - 3.56%	3.50%	3.51%	3.57%	3.37%

Experimental method

The additives were intended to be tested at four different concentration levels (0.5%, 1%, 2%, and 3%) in chicken fat with an FFA level about 3.8%. Because the Magnesol 600R could not be filtered at the 3% concentration level, that concentration was dropped from the test. The Magnesol was also tested at three different concentration levels (0.5%, 1%, and 2%) in a mixture of chicken fat and refined vegetable oil, which had an FFA level of about 1.45%.

Each adsorbent was mixed with the feedstock and stirred for 20 minutes at 60°C. The feedstock was then poured through a filter made up of a 0.7um glass fiber filter plus an additional celite filter aid on top of the glass filter. (The celite filter aid was added because the glass filter alone had trouble filtering the additive, especially at higher concentrations).

After filtration, the feedstock was tested for FFAs, water, calcium, magnesium, and phosphorus. Researcher also wanted to see if the adsorbents would remove any other contaminants in addition to the FFAs. In addition, a portion of the pre-treated oil samples were converted to biodiesel, washed with water, and tested with the cold soak filtration test to see if the adsorbents could improve the results for that procedure.

Did the additives work?

The goal was to reduce the FFA level to at or near 1%. At that level, the feedstock could be processed normally with an alkaline catalyst.

As seen in Table 1, Magnesol 600R was the only additive that was able to significantly reduce the percentage of FFAs in the chicken fat. At the 2% concentration level, Magnesol 600R brought the FFA level down to about 1.24%. The other additives had almost no effect on the FFA levels.

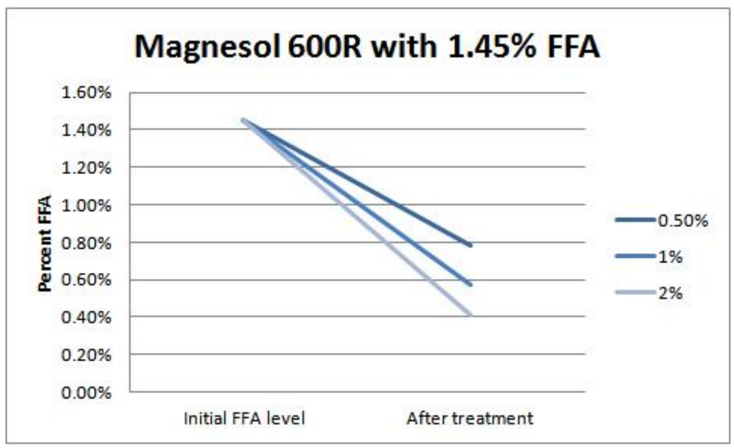
The Magnesol 600R was then tested with the blended chicken fat and vegetable oil feedstock (FFA level of 1.45%). At all concentration levels, the Magnesol 600R reduced the FFA levels below 1% (see Figure 1).

Other impurities

The bentonite clay reduced calcium, magnesium, and phosphorus at all treatment levels before the feedstock was converted to biodiesel. X-tend reduced calcium, magnesium, and phosphorus at all treatment levels before transesterification, except for magnesium at the 0.5% treatment level.

Both Magnesol and Zeolite increased the calcium and magnesium levels. Zeolite at the 0.5% treatment level also increased the phosphorus level of the feedstock. None of the additives had any effect on the cold soak filtration test.

Figure 1



Conclusion

Magnesol 600R appears to be a low-cost, viable solution for reducing FFA levels of 4% and below.
As of fall 2011, Magnesol 600R costs $1.75/lbs for less than 2,000 lbs; $1.13/lb for 2,000 to 10,000 lbs; and 90 cents/lbs for a truck load of 40 pallets (80,000 lbs). This price does not include shipping from the distribution plant to the destination. At 90 cents/lbs, this works out to about 5 cents per gallon per percent FFA reduction.

Magnesol 600R was not tested in a feedstock with FFA levels higher than 4%. It was also not tested at a concentration level above 2%, because the mixture of Magnesol 600R plus oil or fat is very hard to filter at higher treatment rates and with high FFA levels.