BIOdiesel TechNOTES

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FASTER BIODIESEL PROCESSING WITH ULTRASOUND-ASSISTED REACTORS

In biodiesel production, vigorous mixing is required to create sufficient contact between the vegetable oil/animal fat and alcohol, especially at the beginning of the reaction.

Ultrasound is a useful tool to mix liquids that tend to separate. Ultrasonic waves cause intense mixing at micro-levels and improve mass transfer greatly, so that the reaction can proceed at a much faster rate. Although not currently in wide use, ultrasound is a promising technology for biodiesel production.

Ultrasound processing results in similar yields of biodiesel with a much shortened reaction time compared to the conventional stirred-tank procedure. Ultrasonic reactors can process triglycerides into biodiesel within minutes. In addition, current users of the technology claim that much less catalyst and methanol are required. Ultrasonic processing can be used successfully with a wide variety of feedstocks, including high free fatty acid feedstocks. In addition, ethanol can be used instead of methanol. Catalysts can include potassium and sodium hydroxide and sulfuric acid. Researchers have also reported using enzyme catalysts with ultrasonic processing, and showed good results without much loss of enzymatic activity during the time of the study.

How Ultrasound Works

"Ultrasound" refers to sound waves that are above the frequency for human hearing, which is approximately 20 kilohertz (kHz), or 20,000 cycles per second. These kinds of rapidly vibrating sound waves transfer energy into the fluid and create violent vibrations, which form "cavitation" bubbles as the low pressure part of the sound passes through the liquid. After the wave passes, the bubbles collapse, causing a sudden contraction of the fluid. This collapse produces very intense mixing in the area of the bubbles.

Such a high-energy action in the liquid can considerably increase the reactivity of the reactant mixture and shorten the reaction time without involving elevated temperatures. In fact, this reaction can be achieved at or slightly above ambient temperature.

Ultrasound is characterized by its frequency (kilohertz) as well as by its intensity (watts/cm^2). A higher frequency causes the sonotrode to vibrate faster, resulting in smaller cavitation bubbles and a larger surface area for mixing the alcohol and triglycerides.

Experiments have been done using frequencies ranging from 24 kHz to 1300 kHz, and biodiesel was successfully produced within minutes in this range. If the intensity is increased, the amplitude of the vibration increases. In other words, the probe travels farther back and forth with each cycle. This may increase the mixing effectiveness, and it may also help the ultrasound waves travel farther into the liquid.

More research is needed to determine optimum levels of ultrasonication power input for biodiesel production. Using a higher frequency and intensity does not necessarily increase the speed or effectiveness of the biodiesel reaction. Most experiments have used 20-24 kHz for biodiesel processing.

Because the ultrasonic waves are strongest within approximately a half inch of the probe surface, some ultrasonic biodiesel reactors use a tube design, in which the liquids flow slowly and continuously through a narrow tube fitted with a probe.

Cost of Process and Equipment

Researchers have not often reported on the costs of ultrasonication processing for biodiesel production. Because there is no need to heat the mixture, energy may be saved. However, using both heat and ultrasonication can result in a faster, more complete reaction.

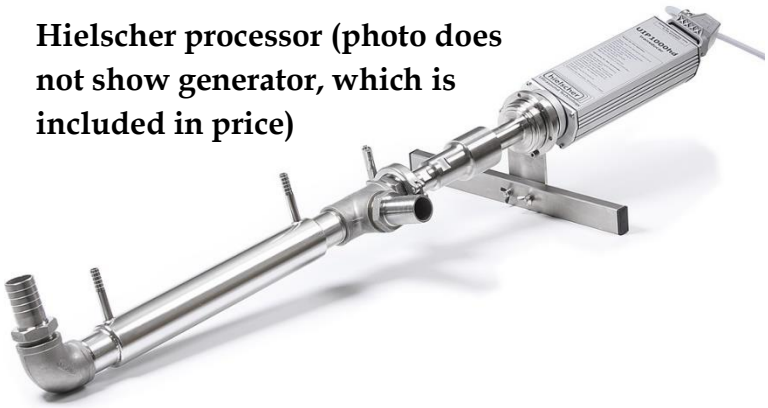
A German company, Hielscher Ultrasonics (hielscher.com/ultrasonics/index), is a pioneer in industrial ultrasonic processing equipment. According to Kathrin Hielscher, Marketing Manager, a 1kW ultrasonic system consisting of a UIP1000hd ultrasonic processor with a flow cell costs approximately $16,000, and can process approximately 160 to 320 gallons of biodiesel per hour. Their UIP2000hd (2kW) with a flow cell – an ultrasonic system to process 320 to 640 gal/hr – costs approximately $28,000.

A U.S.-based company, Ultrasonic Power (upcorp.com/ultrasonic_flowthrough_reactors), sells a six-foot-long flow-through reactor and ultrasonic generator for about $12,000. The generator provides 2,000 watts of power, and is available in several frequencies, from 40 kHz to 170 kHz. This set-up can produce about 13 gallons of biodiesel per minute (780 gallons per hour).

INCBIO (incbio.com), a London-based company, also sells their reactors in the U.S. They design custom systems for each client.

For information about biodiesel companies using ultrasonic processing, see a May 2010 article in Biodiesel Magazine: biodieselmagazine.com/articles/4202/ultrasonicbiodiesel-processing/

Hielscher processor (photo does not show generator, which is included in price)



2kW reactor for Ultrasonic Power Corporation

Researchers at the University of Idaho have written a scholarly article reviewing the development of ultrasound processing in biodiesel production. For a copy of this article, please contact Brian He at: bhe@uidaho.edu.