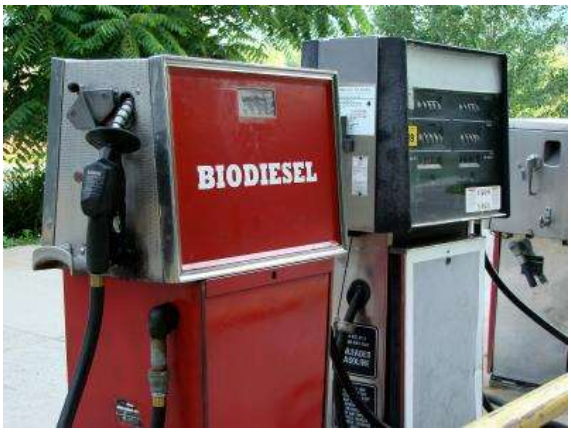
INDUSTRIAL SONOMECHANICS™

# BIODIESEL PRODUCTION

Industrial Sonomechanics, LLC (ISM), offers high-amplitude ultrasonic processors for the production of biodiesel. The processors are based on ISM's patented Barbell Horn Ultrasonic Technology (BHUT), which makes it possible to tremendously intensify the biodiesel manufacturing process and guarantees reproducible and predictable results at any scale of operation.




## BACKGROUND

Petroleum diesel is currently the main form of fuel for the transportation and logistics industry, despite the fact that its use depletes limited crude oil resources and harms human health and the environment. Biodiesel offers an attractive alternative, being a renewable, biodegradable, non-toxic and environment-friendly fuel that can be used in existing diesel engines and provides the same power and torque as petroleum diesel while having superior lubricity.

Unfortunately, due to the inefficiency of its manufacturing process, the cost of biodiesel remains high, preventing its widespread implementation. Biodiesel is produced by running a relatively slow and energy-consuming chemical process of transesterification of triglycerides - vegetable oils or animal fats. The procedure commonly takes place in a batch reactor, where feedstock triglycerides are mixed with an alcohol (methanol or ethanol) in the presence of a catalyst (base, acid or enzyme), heated to about 65 °C and mechanically stirred for 1 – 4 hours. The products are then allowed to phase separate for 5 - 10 hours (glycerol with excess alcohol and catalyst forms the bottom layer and biodiesel the top layer), after which they are collected separately and post-processed, generally yielding about 85 – 87% of biodiesel. Several aspects of this process leave significant room for improvement:

1. **Low reaction rate.** Transesterification is a mass transfer-limited reaction - it occurs at the interface between the feedstock oil and the alcohol, which are only partially miscible. Mechanical stirring helps to a degree by improving contact between the reagents, but the reaction is still very slow because stirring cannot sufficiently emulsify the two liquids (make a stable colloidal mixture) in order to increase the interface surface area between them.
2. **Long separation time.** Excess amounts of alcohol and catalyst are commonly used in order to drive the equilibrium transesterification reaction towards biodiesel formation. During the following step, however, excess alcohol tends to solubilize glycerol in biodiesel, which slows their separation.
3. **Post-processing complications.** Biodiesel must be washed with water in order to remove any remaining catalyst and soap byproduct. The leftover alcohol needs to be purified and recycled. Therefore, using excess alcohol and catalyst complicates the post-processing procedures.

## ULTRASOUND-ASSISTED PRODUCTION OF BIODIESEL

Ultrasound-assisted transesterification is very advantageous for each of the process steps:

1. **High reaction rate.** High-intensity ultrasound creates acoustic cavitation, which produces violently and asymmetrically imploding vacuum bubbles, causing shock waves, micro-jets, and strong shear forces as well as extreme local temperatures and pressures. This results in extremely efficient mixing, leading to ultra-fine, kinetically stable emulsions (nano-emulsions) of immiscible or partially miscible liquids. The interfacial surface area between the liquids is, therefore, increased by orders of magnitude, which greatly promotes mass transfer-limited reactions such as transesterification. Studies show that the time of

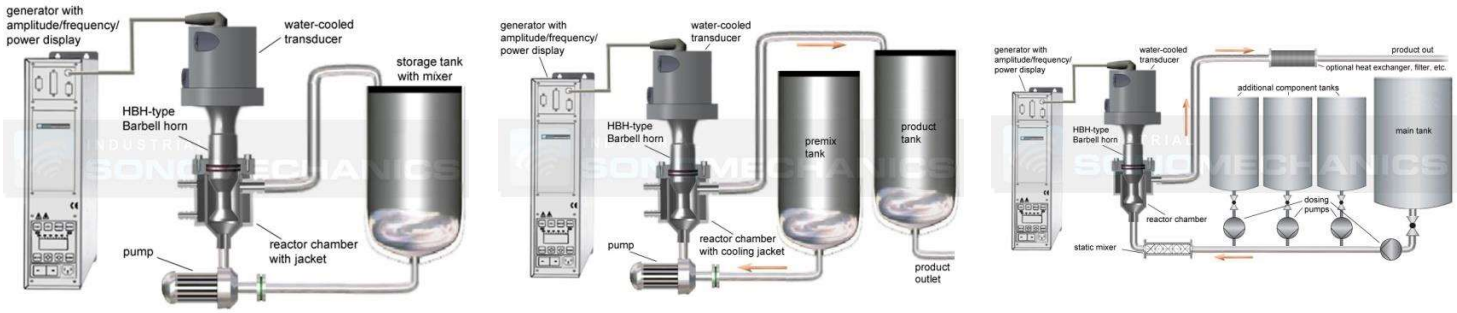
the reaction can be decreased from **hours** to **minutes** [*Singh, A.K., et al., Base-catalyzed fast transesterification of soybean oil using ultrasonication, Energy & Fuels, 2007. 21: p. 1161*].

2. **Short separation time.** Since the ultrasonic exposure results in better contact between the feedstock oil and the alcohol, a much lower excess of alcohol is required. This decreases the amount of alcohol leftover after the reaction. Alcohol-mediated solubilization of glycerol in biodiesel is reduced, and the separation time can drop from **5 – 10 hours** to about **30 minutes**.
3. **Simplified post-processing.** Using lower excess of alcohol lowers the efforts required for its subsequent recycling. In addition, since mixing is more efficient, the amount of catalyst can also be significantly reduced (by 50 - 60%), which simplifies the biodiesel washing step.
4. **Additional benefits.** a) Exposure to high-intensity ultrasound provides the activation energy needed for the reaction. Heating the reaction mixture, therefore, becomes less important, which saves energy and effort. b) The process can be converted from batch to continuous, substantially increasing the production scale. c) Biodiesel yield can be increased to about 95 - 99% [*Singh, A.K., et al., Base-catalyzed fast transesterification of soybean oil using ultrasonication, Energy & Fuels, 2007. 21: p. 1161*].

## THE IMPORTANCE OF HIGH ULTRASONIC AMPLITUDES

Ultrasonic intensification of commercial-scale biodiesel production requires the use of an industrial-size flow-through ultrasonic processor able to maintain high vibration amplitudes. The amplitudes directly relate to the intensity of ultrasonic cavitation-generated shear forces and must be maintained at a sufficiently high level for the mixing to be efficient. Researchers at the Iowa State University (*Chand, P., et al., Enhancing Biodiesel Production from Soybean Oil using Ultrasonics, in ASABE Paper No. 8. 2008. St. Joseph, MI, USA*) have run laboratory studies which show that the amplitude must remain on the order of 100 microns. A similar amplitude value was found to be required for the production of high-quality nanoemulsions – a process which is a prerequisite for the mass transfer-limited transesterification reaction.

### Why ISM's Ultrasonic Technology?




Industrial Sonomechanics is the only company that offers **high-amplitude** industrial-scale ultrasonic processors. The processors are based our proprietary Barbell Horn Ultrasonic Technology (BHUT), which permits increasing the sizes of ultrasonic horns without sacrificing the amplitudes they provide. ISM's ultrasonic biodiesel processors can be implemented in **recirculating** and **single-pass continuous**. Sometimes it is also convenient to include dosing pumps with the single pass continuous mode, in which case no premixing step is necessary. These modes of operation are shown above. Bench-scale (BSP-1200) and Industrial-scale (ISP-3000) processors can both be used in these configurations, and are designed to maintain high ultrasonic vibration amplitudes (up to 100 microns) during continuous (24/7) operation under production floor conditions.

## HAVE QUESTIONS?

Request a free initial consultation
with a process specialist

Contact Us

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