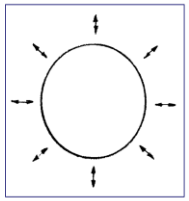
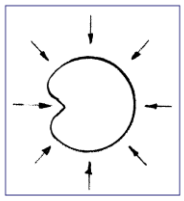
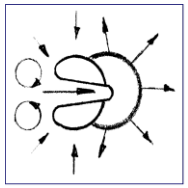
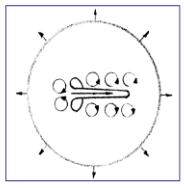
## Cavitation 101


Phase 1


Phase 2


Phase 3


Phase 4

**Phase 1:** A bubble forms in fluid, grows, and oscillates.

**Phase 2:** The bubble begins to collapse. The collapse is always asymmetric

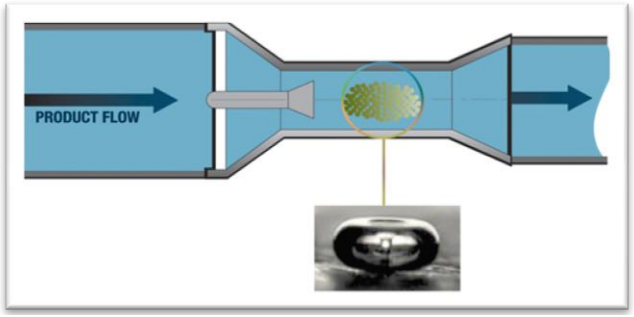
**Phase 3:** The asymmetric collapse forms a micro jet with tremendous velocity, creating huge shear forces.

**Phase 4:** The collapse generates shockwaves that deliver tremendous energy to the surrounding material.

**Bubble conditions:**

- Pressures up to 15,000psi.
- Temperatures up to 5000°C
- Lifetime of milliseconds.

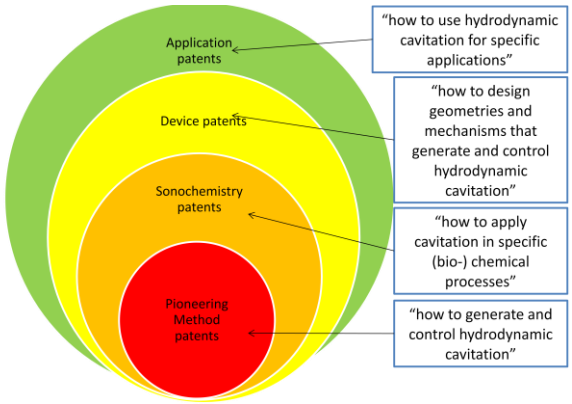
## Controlled Flow Cavitation (CFC™)




- Restricted orifice leads to acceleration of flow
- Resulting in reduction of pressure (Bernoulli)
- Reduced pressure leads to evaporation and vapor bubbles
- Collapse of bubbles can generate enormous shock wave and shear forces if controlled (energy peak)

## IP Portfolio Philosophy for Best Customer Protection

An application patent cannot be practiced without a device patent, which cannot be practiced without our sonochemical patents, which in turn cannot be practiced without our method patents




## Issued Patents

**Application Patents**

EtOH – yield enhancement US 8,143,460; US 7,667,082
Biodiesel – catalyst reduction US 7,935,157; US 7,754,905
Fossil crude oil desulfurization US 8,002,971
Fossil crude oil processing US 5,969,207
Water treatment US 7,247,244
Synthesis inorganic materials US 6,365,555; US 6,589,501; US 6,869,586
Synthesis organic materials US 7,041,144; US 7,314,516
Micro bubbles in liquid US7,338,551

**Device Patents**

US 5,931,771; US 6,802,639; US 6,857,774; US 7,086,777; US 7,178,975; US 7,207,712; US 7,314,306; US 7,357,566; US 7,422,360

**Sonochemistry Patents**

US 5,937,906 US 6,012,492 US 6,035,897

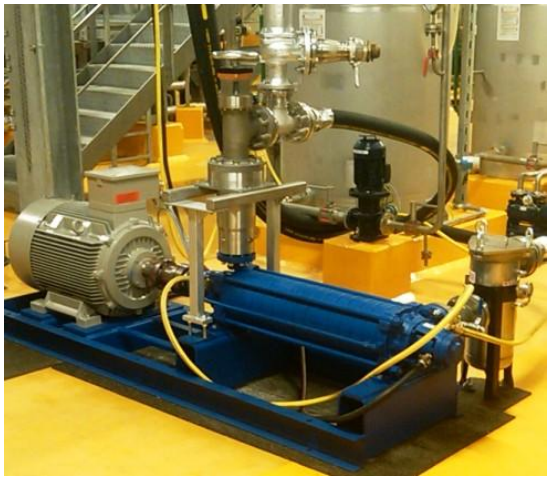
**Processing Method Patents**

US 5,492,654; US 5,810,052; US 5,931,771; US 5,971,601; US 5,810,052

arisdyne systems®

Applying the Power of Controlled Cavitation

## Sonochemical Applications for Biodiesel production



Contact Dr. Peter Reimers
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preimers@arisdyne.com
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## Easy to Retrofit

Very little pipefitting is needed because the CFC reactor will be connected to the inlet of the first reaction column without interruption to the rest of the process. These convenient installation features eliminate the need for a shutdown to facilitate steam purging. The installation time is approximately two days and the actual shut down to connect the CFC unit and start up can be as short as two hours.

This retrofit solution reduces operation costs with no requirement for additional space as the footprint is less than 1.5m x 2.5m for a 200 k MT/a plant.

Because the CFC™ chamber has no moving parts the maintenance on the reactor is equivalent to that of a centrifugal pump.

## Cavitation System Characteristics

- Small footprint
- Robust and durable
- Adjustable cavitation device for optimum performance at different capacities
- No production downtime for installation

## CFC™ Effect on Transesterification

In our process, the power of cavitation creates micro droplets which form an emulsion. Precise process control ensures a tightly regulated, repeatable droplet size distribution. Superior mixing and high droplet surface area allow for a near instantaneous and efficient reaction, which increases the catalyst efficiency.

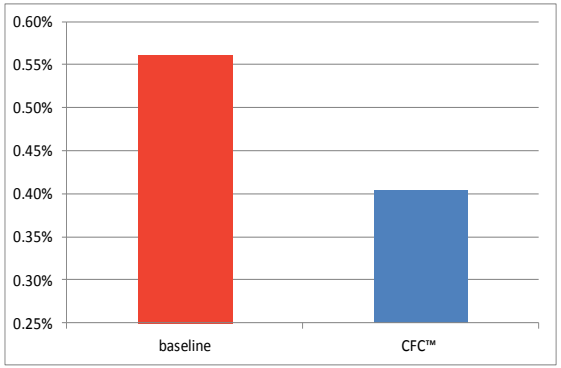
Currently tighter specification for lower monoglyceride contents can be achieved with higher catalyst consumption.

We offer an opportunity to lower monoglycerides with no additional catalyst consumption.

## Anticipated Improvements

- 25% catalyst consumption reduction
- Reduction in Monoglycerides
- Decrease of Residence time/ Capacity increase

## Example of catalyst reduction while maintaining same Mono content




x-axis shows % catalyst concentration

## Example of Mono-reduction while reducing catalyst by 15%