

## ULTRASONIC CAPILLARY REACTOR WITH TEMPERATURE CONTROL AND HOMOGENEOUS VIBRATION.

### DESCRIPTION OF THE TECHNOLOGY

The Photochemistry and Semiconductor Electrochemistry (GFES) research group of the University of Alicante has developed an innovative capillary sonoreactor with a helicoidal probe that homogenizes the acoustic field generated without the appearance of longitudinal nodes/antinodes which avoids clogging with a rigorous temperature control.

The sonoreactor consists of a series of piezoelectric transducers stacked and attached to the probe which acts as a waveguide. Figures 1 and 2 show two forms of the ultrasonic capillary reactor which fundamentally comprise a power ultrasonic transducer that transforms electrical to mechanical energy using a control system that adjusts the frequency and amplitude of the signal. The probe, also known as sonotrode, features elements that increase the homogeneity of the acoustic field, as it can be seen in the nodes and antinodes marked as light and dark areas, respectively (Figure 1).

The capillary tube fits into a mechanized cavity that transmits vibrations with different modes: torsional, longitudinal and radial, which homogenize the acoustic field along the reaction medium.

The design allows more complex configurations; increasing the number of transducers, number of

probes or adding secondary forms to the probe by curling or folding on itself, or other possibilities. For example, folding the probe with a helical design and curling on itself would allow space to be reduced. On the other hand, additional power ultrasound transducers could be used for energy recovery, from mechanical to electrical, or to add secondary vibration modes.

The efficiency and high homogeneity achieved by the present invention allows working in at least two modes of operation:

- low power ultrasound, where the amplitude of the vibrations transmitted to the tube is sufficient to reduce the risk of clogging, but not to induce significant changes in temperature or chemical effects;
- high power ultrasound, where the amplitude of the vibrations and corresponding values of acoustic pressure can generate acoustic cavitation suitable for different physicochemical processes such as those related to sonochemistry or enhanced mixing.

For temperature control, the inner part of the helicoidal probe can be used by means of secondary tubing and a thermal paste to improve the heat transfer but not the transmission of mechanical vibrations. In addition, an external thermal system, for cooling or heating, or a forced air system can also be implemented.

### MARKET APPLICATION SECTORS

The invention provides an advantage in flow chemistry and process intensification with several applications in the pharmaceutical industry, fine chemistry, and in sonochemistry. The ultrasonic capillary reactor enables continuous manufacturing in chemical or physical processes (crystallization) allowing the handling of solids and/or the improvement of heterogeneous mixtures (gas-liquid-solid) in capillary tubes of variable diameter and length with optimal temperature control.

### TECHNICAL ADVANTAGES AND BUSINESS BENEFITS

The main innovative aspect of the capillary sonoreactor is its scalability using ultrasound which enables process intensification via enhanced heat and mass transfer of multiphase (gas-liquid-solid) mediums.

The design of the ultrasonic capillary reactor gives it a number of advantages:

- Homogeneous distribution of the acoustic field.
- It avoids metal contamination due to cavitation erosion.
- Optimal control of the reactor temperature.

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- Excitation at secondary frequencies or energy recovery.
- The helicoidal arrangement of the probe reduces the space occupied by the reactor.
- It avoids the capillary tubes clogging.
- Capillary tubes can be located on other surface of the sonotrode or via tube-in-tube configurations with different points of insertion.

### CURRENT STATE OF DEVELOPMENT

The research group owns a laboratory-scale prototype.

### INTELLECTUAL PROPERTY RIGHTS

This technology is protected by patent application, with title "Ultrasonic capillary reactor", application number P201830422, and date of application 27/04/2018.

### COLABORATION SOUGHT

The research group is looking for companies interested in acquiring this technology for commercial exploitation through patent license agreements, technical cooperation (R&D projects) to adapt the technology to the needs of the company, etc.

### RELATED IMAGES

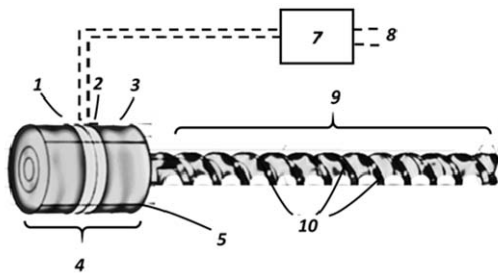


Image 1: helicoidal acting as a guide wave that homogenizes the acoustic field.

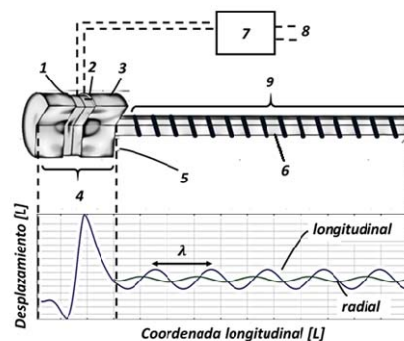


Image 2: simplified sonotrode and representation of longitudinal and radial vibration modes

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