

Ultrasound in Environmental Protection

Some Recent Developments



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DEVELOPMENT OF GREEN SONOCHEMISTRY

The progress of sonochemistry in green and sustainable chemistry is dependent upon the possibility of scaling up the excellent laboratory results for industrial use.

There are currently several systems commercially available with configurations to suit most applications

Industrial scale examples will be chosen from:

**ENVIRONMENTAL PROTECTION
and
PROCESS TECHNOLOGY**



ULTRASOUND IN ENVIRONMENTAL PROTECTION

AIR

Agglomeration of smokes and aerosols

LAND

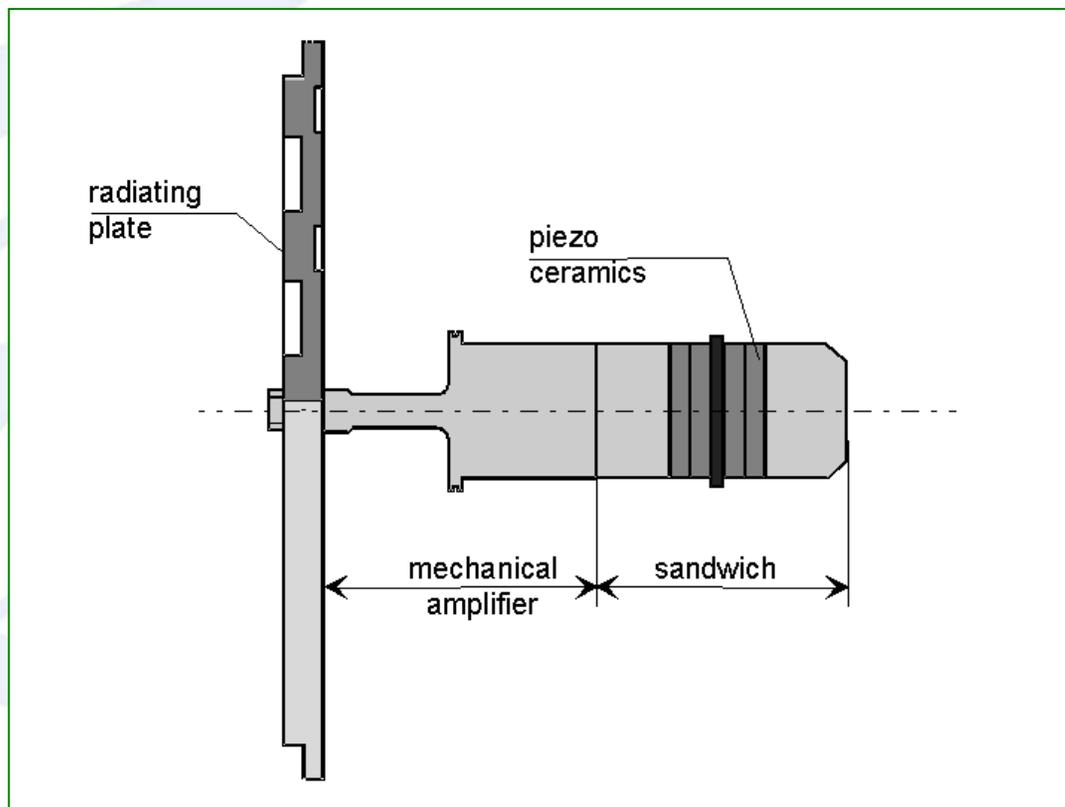
Removal of contamination from soils

WATER

Biological and chemical decontamination



AGGLOMERATION OF SMOKES AND AEROSOLS



Airborne emitter with circular plate and a stepped profile (20kHz)

Electroacoustic unit for generating high sonic and ultrasonic intensities in gases and interphases, J.A. Gallego, G. Rodriguez, J.L. San Emeterio, F. Montoya, USA Patent No. 5299175 (1994).

Airborne ultrasound for the precipitation of smokes and powders and the destruction of foams, E Riera J A Gallego-Juarez, T J Mason, Ultrasonics Sonochemistry 13, 107-116 (2006)

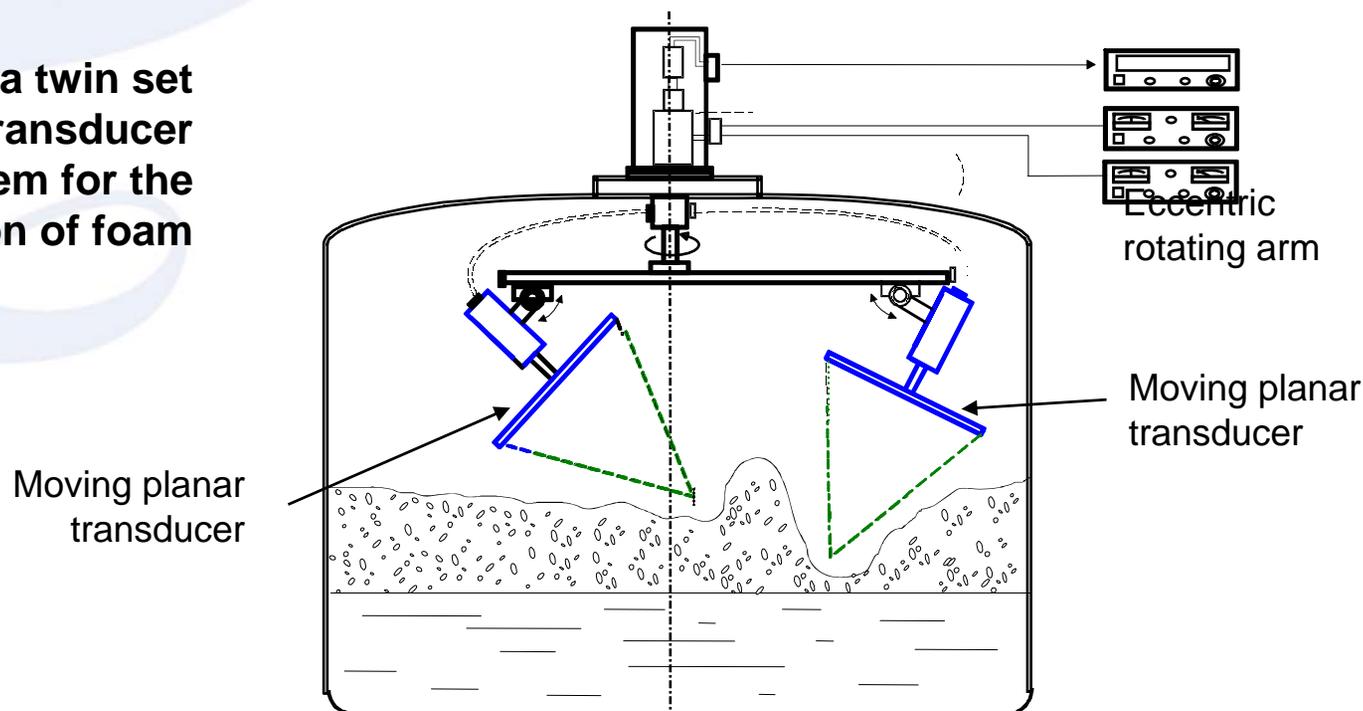


ULTRASONIC DESTRUCTION OF FOAMS

Ultrasonic destruction of foams - a combination of a number of effects including:

- **partial vacuum on the foam bubble surface produced by high acoustic pressure**
- **impingement of radiation pressure on the bubble surface**
- **resonance of the foam bubbles which create interstitial friction causing bubble**
- **acoustic streaming**

**Design of a twin set
focused transducer
system for the
dissipation of foam**



Procedimiento y sistema ultrasónico de desespumación mediante emisores con placa vibrante escalonada, J.A. Gallego, G. Rodríguez, V.M. Acosta, E. Andrés, A. Blanco, F. Montoya (2002), Spanish Patent 200202113.



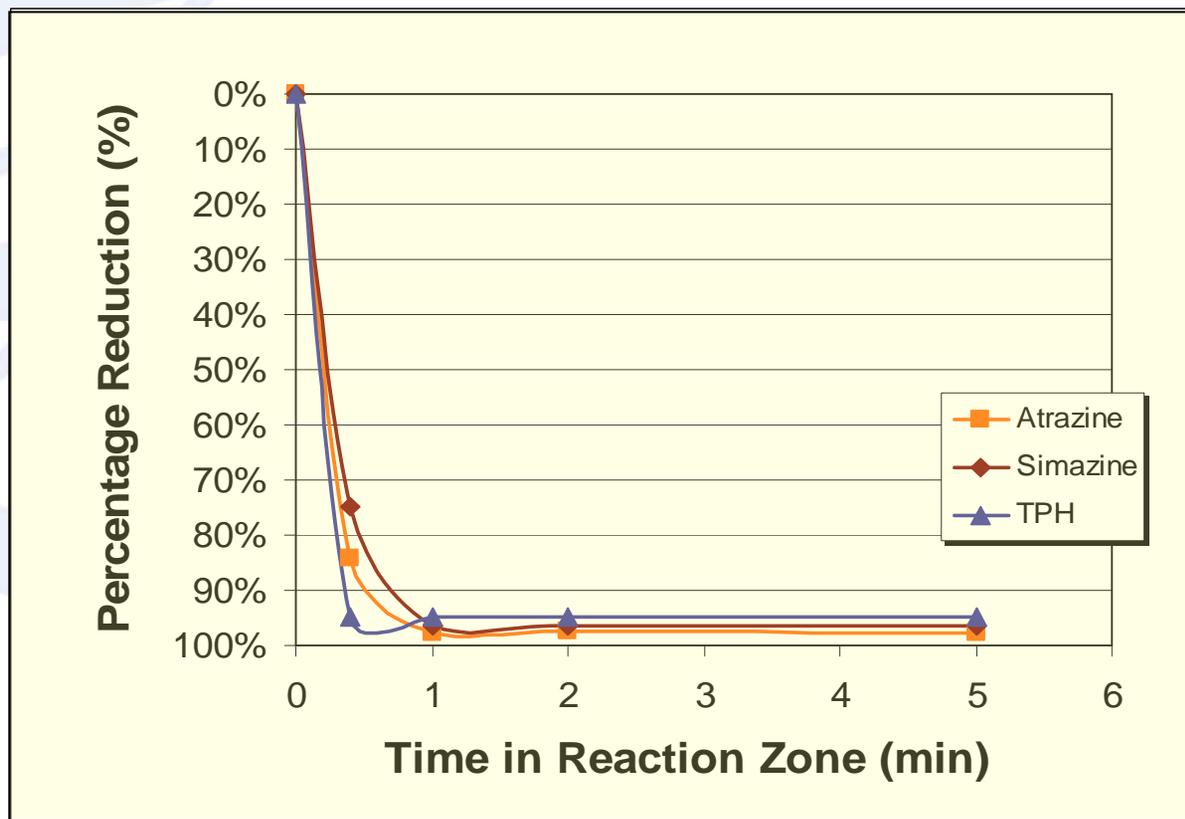
ADVANTAGES OF ULTRASONIC OR ACOUSTIC SOIL CLEANING

- On Site Treatment – Transportable on Trucks
- Hydraulic Transport of Materials for Treatment
- No Dangerous By-products
- Can be Combined with Bioremediation
- Potentially Low Operating Costs



ATRAZINE, SIMAZINE AND TPH

Destruction rates at 20kHz in real clay samples



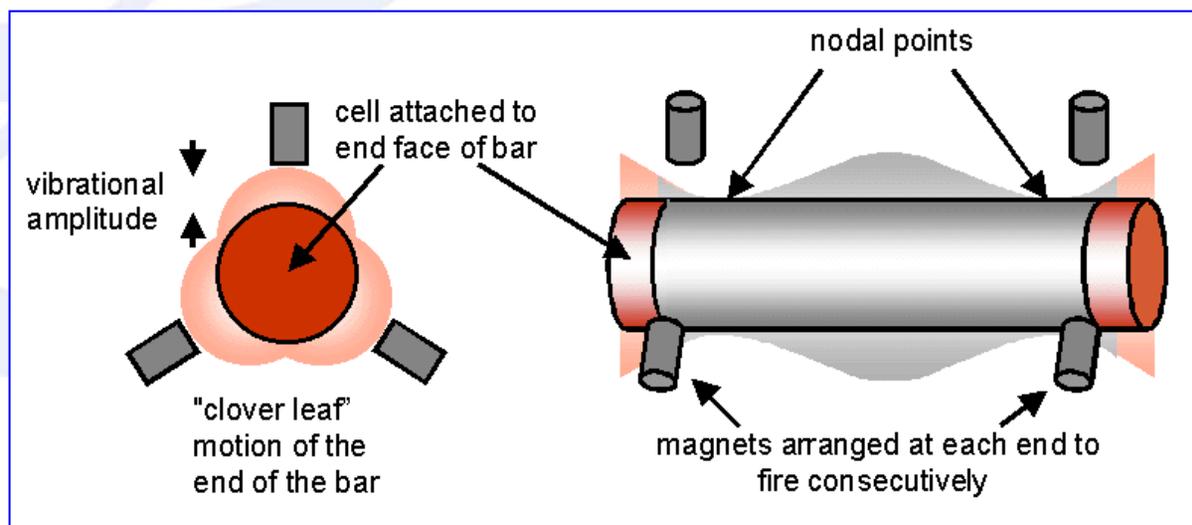
Contaminants removed from clay and destroyed in water

Sonic and ultrasonic removal of chemical contaminants from soil in the laboratory and on a large scale,
T J Mason, A Collings, A Sumel Ultrasonics Sonochemistry 11, 205-210 (2004)



SOIL WASHING WITH ACOUSTIC TREATMENT OF EXTRACT

A PROCESS OF WASHING WITH ORGANIC SOLVENT TO CLEAN THE SOIL FOLLOWED BY TREATMENT OF THE CONCENTRATED EXTRACT WITH SODIUM IN AN ACOUSTIC RESONATING CHAMBER TO DESTROY POLLUTANTS



Electromagnetic drive oscillates a steel bar into resonance
Operating frequency 100 Hz (75kW)
bar = 4.3 x 0.36 metres 2.7 tonnes

Sonic Environmental Solutions, Vancouver, Canada



THE EFFECTS OF ULTRASOUND ON BACTERIA

Current research has revealed a range of effects depending upon conditions used

decreasing acoustic energy
↓

CELL DESTRUCTION

TEMPORARY CELL WALL WEAKENING

INCREASED MASS TRANSFER TO CELL

DISRUPTION OF SUSPENDED CELL CLUMPS

↑
Increasing frequency

**MODERN TECHNOLOGY MAKES ULTRASONIC
STERILISATION A VIABLE TECHNIQUE**



SONOXIDE

treatment of cooling tower water

Controls algae, bacteria, fungi, and biofilm in aqueous systems.

Indications that it also controls Legionella

**Purely physical action
no biocides or chemicals added**



INTEREST IN ULTRASONIC PROCESSING

Examples of use on an industrial scale

Sewage Sludge Treatment

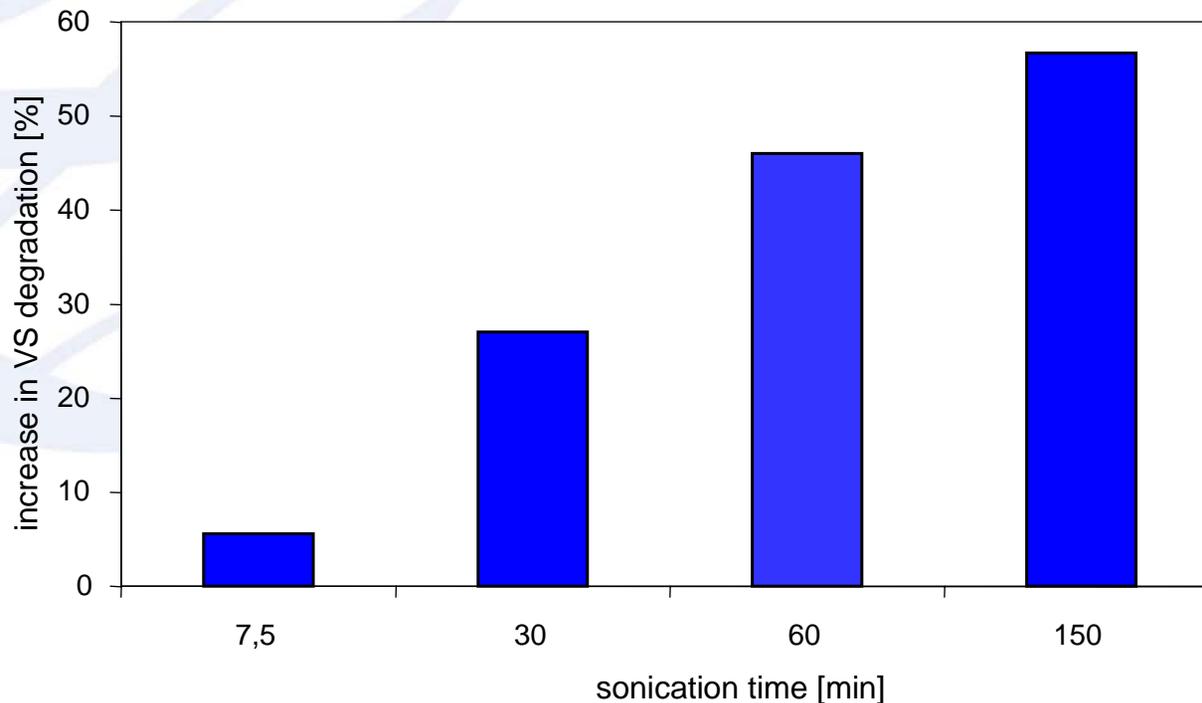
Crystallisation



Sewage Sludge Treatment

Effect of ultrasonic pretreatment on

ANAEROBIC DEGRADATION OF WASTE ACTIVATED SLUDGE



(Sludge Retention Time 8 days, frequency 41 kHz)

Ultrasonic disintegration of sewage sludge for enhanced biodegradation, U.Neis, K.Nickel, A.Tiehm *Advances in Sonochemistry*, **6**, 59-90 (2001)



SCALE-UP USING PROSONIX FLOW CELL

Crystallisation in Alumina Production



**Flow through
10 bar, 70°C, 6M NaOH**

**Harsh conditions
Continuous operation
70 ton per hour**

February 2005 – the commissioning of a continuous sonocrystallization system at Europe's largest alumina production facility. Aughinish Alumina, Askeaton, Ireland.



OTHER CURRENT DEVELOPMENTS INCLUDE

Food technology

Green Chemical Synthesis

Nanotechnology

Therapeutic Ultrasound

(Nuclear Fusion)

etc.....

**SEVERAL OLDER SONOCHEMISTRY PROCESSES
ARE UNDER REVIEW NOW THAT SCALE-UP
SYSTEMS HAVE BECOME AVAILABLE**



1st International Congress on Green Process Engineering

Toulouse - France, 24 - 26 April 2007

Sustainable and clean technologies

- Ultrasonic processes
- Microwave assisted processes
- Electrochemical processes
- Catalysis and reaction engineering
- Photochemical processes

New reaction media, green solvents in chemical processes

Innovative process design

Safety and Risk management

Biomass Pyrolysis and Gasification for Fuels and Chemical Products

