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ENVIRONMENTAL TECHNOLOGY: APPLICATIONS OF ULTRASOUND

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ABSTRACT

Sonicate are sound waves inaudible to the human ear, with frequency greater than 20 KHz. They are responsible for generating bubbles of cavitation, i.e. gas bubbles that are collapsing in the center of a liquid, releasing large amounts of energy. This methodology can be considered as a new environmental technology, to homogenize samples, break cellular structures, change chemical reactions and to break the dormancy of seeds. Promising technology in the environmental area, because of its low cost, fast and easy to manipulate, decreases the amount of reagents and generates no hazardous waste to the environment.

***Keywords: Ultrasound, Environment, Technology*.**

1. INTRODUCTION

The acoustic spectrum is subdivided into three regions: range of infrasound, sounds audible and ultrasonic. Infra-sounds are sounds with frequencies below 20 Hz, these sounds are not captured by the human ear, but are captured by other animals. Audible Sounds are sounds with frequencies higher than 20 Hz and below 20,000 Hz, these sounds are picked up by the human ear. Ultrasonic sounds are often greater than 20,000 Hz, are not captured by the human ear (KORN et al., 2005).

Based on the natural ability of some animals to make the echo-evaluation projects, human beings have developed the "echo-localisation projects artificial" with radar, sonar and ultrasound. The echo-evaluation projects is the ability of some animals generate Ultrasound waves, these moving through, reaching the obstacle to be identified and returned to the sender, which processes the information received by identifying the position of the obstacle. For many animals, such as bats and dolphins, this ability is used to locate, hunting and escape from predators (CUNHA, 2010).

The ultrasound is a physical method that uses frequencies inaudible noise to induce activity cavitacional, create mechanical effects and improve the interaction between the materials involving phenomena of surface (VINATORU et al., 1997; YALDAGARD et al., 2008).

It was discovered in 1880 by Pierre and Jacques Curie, studying the piezoelectric effect, which is the ability of some crystals to generate electrical current in response to a mechanical pressure (CASTRO 2006; VAZIRI, 2011).This vibration was known as cavitation when the researchers Thornycroft and Barnaby in 1894 observed that in the propulsion of missiles launched by a rain check on resulted in a source of vibration causing implosion of bubbles. In 1912 Langevin has developed SONAR (Sound Navigation And ranging), which sends pulses of ultrasound of the keel of a boat to the bottom of the sea, and this wave is reflected to a detector, also located on the boat (SORIANO, 2006; MARTINES et al., 2000).

In 1927, Alfredo Loomis was the first chemist to recognize the effect of anomalous sound waves intense spread by a liquid, called sonoquímico (SORIANO, 2006). From the 1980s, there was the development of Sonoquímica and many studies have been published with applications in different systems (SORIANO, 2006; MARTINES et al., 2000).

Sonicate are mechanical waves with frequency greater than 20 KHz that spread in successive cycles of compression and rarefaction through any material and that cannot be perceived by human beings. Vibrations of this nature when applied to a liquid medium cause a physical phenomenon called cavitation, which is responsible for the release of a large amount of energy.

Currently the ultrasound is used in industry for cleaning materials, welding of plastics, chemical processes, preparation of emulsion and suspension, to obtain information about defects, fractures,

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agglomerates, inclusion and anisotropy; in hospitals for image analysis and stimulation of bone callus. The meter has a range of applications in medicine, biology and engineering. In the area of interest of the biology, the ultrasonic are employed to break walls of cells and homogenization of liquid samples.

The ultrasound of low frequency has been used for various purposes among them, the therapeutic, aesthetic and environmental. Among environmental factors, we can highlight the homogenization of samples, the cell disintegration and the treatment for breaking dormancy of seeds (YALDAGARD et al., 2008).

2. EQUIPMENT GENERATORS ULTRASOUND WAVES

Usually in lab are used two types of equipment capable of generating Ultrasound waves: the "bathroom" and "probe". The first is usually used for cleaning materials, its energy is transmitted through a liquid, presents its piezoelectric transducer stuck on the bottom of the tank, so your energy is more dispersed. The "probe" is generally used to break cell membrane, thus freeing the intracellular material of interest, the probe is attached to the end of the amplifier of the transducer, thereby having a direct contact with the sample, and is considered more efficient than the bathroom, since the bathroom power is more dispersed (BARBOZA et al., 1992).

Equipment with low frequency are responsible for causing cavitation, i.e. creation and implosion of gas microbubbles in the center of a liquid. The Ultrasound waves in a liquid environment cause a pressure variation, which is responsible for cavitation.

The Ultrasound waves in the liquid cause an effect of coming and going too fast, shaking the air bubbles present in the liquid, making them grow to a diameter of 5 microns for another 50 microns. The external pressure (liquid) becomes much greater than the internal pressure (of molecules of air), this makes the bubbles implodam, reducing its size from 50 microns to approximately 0.1 micron in diameter. The implosion of bubbles warms the liquid and releases a large amount of energy, causing what we call ultrasonic cavitation (FU, 2009; WHEATLEY, 1990).

The frequency of equipment can change its effect on means, because of the bubbles of cavitation that have different diameters according to the frequency. In equipment with frequency of 25 KHz the average diameter is 36 µm, already in equipment with frequency of 40 KHz the size of bubble cavitation is much lower approximately 26 µm (Figure 1). However, the diameters of the bubbles can also vary depending on the density, surface tension of the liquid, the amount of gas contained in environment, temperature and viscosity. Smaller bubbles have a higher penetration power, although resulting in less violent implosions (ARAÚJO FILHO, 2013).

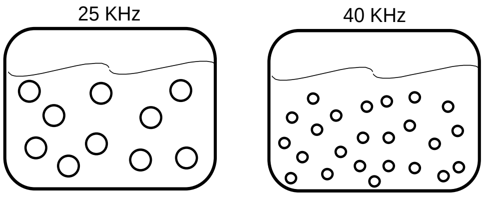

Figure 1. *Representation of bubbles of cavitation in ultrasound system, illustrating that the 25 KHz (left) the bubbles of cavitation are larger and therefore with low penetration power and 40 KHz (right) bubbles with less volume characterizing with high penetration power.*

3. APPLICATIONS OF WAVES ULTRASSONICAS IN ENVIRONMENT

The applications of ultrasound in the environment are responsible for generating a promising future in environmental technology. When compared with conventional techniques the use of ultrasound can bring many benefits, such as low-cost, fast, generates no hazardous waste to the environment, easy to manipulate, decreases the amount of reagents.

Among the various applications of ultrasound in the environmental area, we can highlight: homogenization of samples, disintegration of cellular structures, sonoquímica and breaking of dormancy in seeds.

3.1 Homogenization of samples

The homogenization of samples with Ultrasound waves are used to reduce particles present in a liquid, so that they may become uniformly small and distributed. A reduction in the diameter of the particles will be responsible for increasing the number of individual particles.

Particles with similar sizes reduce the tendency to agglomerate during the process of sedimentation or to climb. The decrease of the particles is caused by the process of cavitation, the implosion of microbubbles form jets of water under high pressure and speed to reach agglomerates of particles causing its defragmentation (SANVAGE et al., 2004).

The cavitation ultrasonic enables the emulsion of immiscible liquids, such as for example, water and oil. Many products are distributed in the market are made wholly or partly of emulsions, such as paints, fuels, cosmetics and pharmaceutical products.

Sanvage et al. (2004) conducted a study to assess the effect of ultrasound as a pre-treatment of industrial effluents, subsequently the effluent suffered conventional biological treatment. The ultrasound through the cavitation transformed complex molecules into simpler molecules, thus enabling a greater efficiency of the bacterial community in the degradation of molecules, thereby increasing the speed of degradation.

Falheiro et al. (2011) evaluated different methods for preparation of sediment samples for grain size, the ultrasound proved to be the more efficient than conventional methods, such as for example the use of deflocculant. The samples submitted only the ultrasound showed their granulometric distribution more symmetric and homogeneous, decreased the average value of the grain size, being considered very efficient breakdown of particles.

3.2 Disintegration of cellular structures

The ultrasonic cavitation can also be effective to break cellular structures, thus enabling the release of intracellular materials of interest. The implosion of the microbubbles generate shock waves in the liquid, resulting in impact and the increase of shearing tension, causing the cell disruption and consequently the release of intracellular material (NEVES, 2003; ASSIS et al., 2009).

This effect can be used for fermentation, digestion, among other conversion processes of organic matter.

Assis et al. (2009) evaluated the efficiency of cavitation for disinfection of water for human consumption. The application of this methodology allowed the disinfection in short times of exposure, so it is considered to be a rapid and efficient treatment. Furthermore, it avoids the use of chemical reagents, used in traditional treatments, and generates no hazardous waste to the environment.

Ultrasound may be used in combination with another technique for water disinfection process , such as the combination of ultrasound and ozone , avoiding the use of chlorine (JYOTI et al., 2004; PASCHOALATO et al., 2008). The hybrid techniques are very efficient to completely inactivate pathogens (ABDALA NETO, 2014).

Using ultrasound to the activated sludge management produced by wastewater treatment plants end up with a major problem of treatment plants. The technology reduces sludge disposal , forced through cell lysis caused by cavitation , increasing degradation of volatile solids (PARSEKIAN et al., 2005).

3.3 Sonoquímica

The sonoquímica is the area of chemistry that studies the influence of Ultrasound waves on the chemical systems, which can increase the speed of reaction, provide a more efficient use of energy, improve the performance of catalysts to transfer phase, activate metals and increased reactivity of reagents.

The ultrasonic cavitation can be used for removal of chemical contaminants, such as, for example, the direct oxidation of chemical residues and pesticides in combination with other techniques, such as ozonólise and ultraviolet light (ROCHA et al., 2011).

Souza et al. (2009) conducted a study with the objective of removing metals (Co, Cu, Fe, Mn, Pb and Zn) in soil using ultrasound. The samples were dried for 2 minutes in the bath of ultrasound, showing recoveries greater than 84% for Co, Cu, Mn and Zn, and Fe and Pb presented recoveries of 76% and 74 %, respectively. This methodology was very efficient by decreasing the amount of reagents used and the time of extraction.

3.4 Breaking dormancy of seeds

The ultrasonic cavitation can be used as treatment for breaking dormancy of seeds, a methodology that arouses great interest on the part of researchers in the world of agriculture (YALDAGARD et al., 2008).

The use of ultrasound as treatment for breaking dormancy of seeds has only been effective when they are in a liquid medium, because this treatment enables the absorption of water by the seed, which entails the germination (GORDON, 1963; YALDAGARD et al., 2008). The ultrasound increases the speed of germination and development of seedlings (PASSOS et al., 2013), however must be taken into account the dosage applied, because an excessive dose can cause severe damage to the seed, preventing the germination.

Studies show that the ultrasound is efficient in the germination of seeds of grasses, the results show that this treatment promotes the absorption of water by the seed, reducing the period of germination (CHEN et al., 2012; KRATOVALIEVA et al., 2012).

Passos et al. (2013) performed a study with seeds of gliricídia (*Gliricidia sepium* (Jacq.) Steud.), evaluating different immersion times in water (2, 4, 8 and 16 minutes) in the bath of ultrasound. At the end of the study concluded that the time in the bath of ultrasound influence the absorption of water in 2 minutes were achieved higher results in the percentage of germination and the GSI. This technique has proved to be very efficient for promotion of seed germination of gliricídia, but a long time in the bath of ultrasound can cause deleterious effects on living tissue.

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4. FINAL CONSIDERATIONS

On the basis of the literature review it can be concluded that the ultrasound waves are considered excellent for environmental treatments, in particular for homogenization of samples, disintegration of cellular structures, sonoquímica and breaking of dormancy in seeds.

Proving that the ultrasonic cavitation is able to mix, disperse, disintegrate and change chemical reactions in different environmental samples. It is considered a promising technology and clean, by presenting several benefits, such as low cost, speed, generates no hazardous waste to the environment, easy to manipulate and decreases the quantity of reagents.

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