

## Effects of the concentration of emulsion of oil-in-water on the propagation velocity and attenuation

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**Abstract.** Soybean oil is an important feedstock for production of biodiesel that generates about 20 % of oily effluents. This paper studied the effect of concentration of soybean oil-in-water emulsions, in the range from 6 000 to 14 000 ppm, on the propagation velocity and ultrasonic attenuation. The Emission-Reception method has shown that the propagation velocity depends linearly on the concentration. The behavior of attenuation is similar to the velocity. Thus, both parameters can be used to measure oils and greases content in water.

### 1. Introduction

Large wastes produced mainly by the branches of energy and biofuel industries are water polluted by high concentrations of oil and grease. Extractions processes, improvement and oil recovery of several sources lead to concern that oil wastes must be treated and measured, before they were disposed on nature.

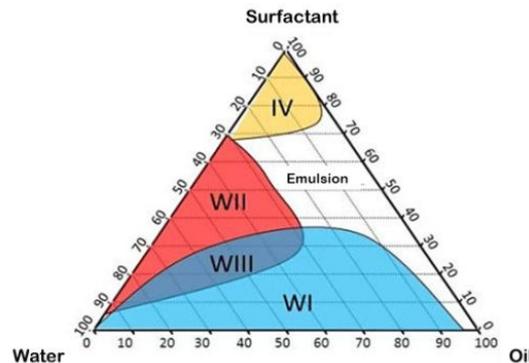
The National Council for the Environment (CONAMA) delimits quantities of oil-in-water and greases wastes, in order to reduce potential impacts on the natural receiving bodies. According to the CONAMA Resolution nr. 430/2011, oil and grease content in water, daily disposed, have to be limited to 50 ppm for vegetable oils and 20 ppm for oils of mineral sources.[1]

Measurement of oil and greases in water are taken into account like parameters to release wastes of water on natural receiving bodies. It is constituted by hydrocarbons dissolved and dispersed in water and others compounds like phenols and carboxylic acids [2].

There are many techniques used to oil and greases measurement, among them, analyzers of total organic carbon (TOC), a destructive technique and infrared spectroscopy, a nondestructive technique. The infrared technique is widely used. Nevertheless, it requires extraction by tetrachloroethylene (TCE) solvent on a large volume. TCE is an expensive solvent used in sample preparation for infrared analysis too. Losing on the sampling process and high cost on the solvent are disadvantages thereof [3].

Generally, oil contains potential surfactants that act on the thermodynamic balance and affect phase behavior on a system. In addition, oil phase could lay itself on water like a film. Otherwise, it could be dissolved in water medium and dispersed forming an emulsion. The figure 1 illustrates phase behavior.



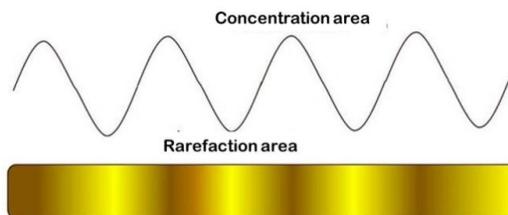


**Figure 1.** Representation of pseudo ternary phase diagram. WI – emulsion balanced with oil phase, WII – emulsion balanced with water phase, WIII – emulsion balanced with oil and water phases, IV – microemulsion.

Due to multiple equilibrium, a study of phase behavior must be taken into account in order to delimit one region, where ultrasound parameters must be acquired and assessed.[4]

Ultrasound comprises acoustic waves with frequencies above 20 kHz, it does mean, over the upper limit of the range of human audition (20 Hz to 20 kHz). These waves are formed due the piezoelectric properties of materials, which exhibit response to electric potential applied, with elastic deformations of its shapes and vice versa. [5,6]

Piezoelectric properties are fundamentals to ultrasonic transducer because of its use like vibrant source. Once ultrasonic transducer is in contact with a liquid, its vibration is able to generate areas with pressures different at all around. The particles (molecules, ions or atoms), in the structural arrangement of the medium, go through processes of compressing due to high pressure areas followed by relaxation on low pressure areas in alternating way. That is the physical phenomenon by which the propagation of ultrasonic waves takes place. It is illustrated in figure 2. [7]

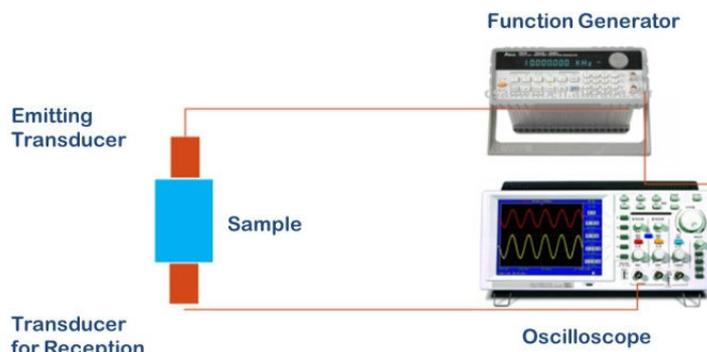


**Figure 2.** Propagation of ultrasonic waves.

Ultrasonic parameters allow us to make assessment through techniques which have fundamentals on scattering, propagation velocity, vibration potential and attenuation in order to characterize dispersion or emulsions systems. Ultrasonic velocity depends on the hardness of the material and the specific weight thereof. Attenuation is a response to loss of energy that occurs to a wave travelling along a medium.[8]

## 2. Materials and method

This paper describes the method named Emission-Reception. In the Emission-Reception method, two ultrasonic transducers which have nominal frequency of 15 MHz, 12.5 mm diameter (Panametric-NDT-Olympus Co. Japan) were accurately aligned on vertical axis, one on top other on bottom of the sample, like figure 3 illustrates.



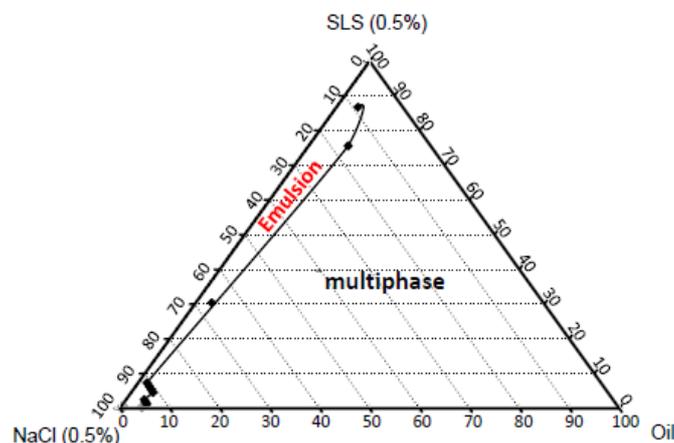
**Figure 3.** Emission-Reception method Set-up.

The sample concentrations were prepared within emulsion region and, in sequence, diluted 25% one after another. Attenuation parameters and the time of fly in a burst were acquired through manual mode. Measurement had been made for deionized water and it was taken like reference. The measurement was made on 5 replica for each concentration level. Velocity and attenuation on samples were obtained by comparing to those of the water in repeatability condition of measurement.

### 3. Results and discussion

#### 3.1 Phases diagram

Mixtures of Sodium Lauryl Sulfate (SLS) 0.5 % at aqueous medium and soybean oil at organic phase were carried out at 10 levels of proportion. Aliquots of Sodium Chloride (NaCl) 0.5 % in aqueous solutions were used like titrant for each level of mixtures. It resulted on the phases equilibrium demonstrated in figure 4.

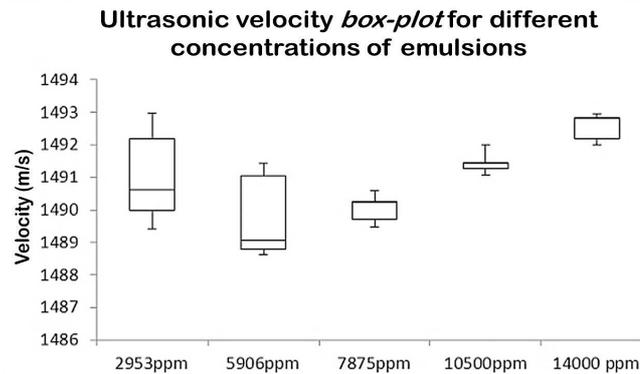


**Figure 4.** Pseudo ternary phase diagram of the system saline water (NaCl), surfactant (SLS) and soybean oil.

Despite the emulsion region seems to be thin, it's homogeneous and stable enough to allow us to perform the experiments.

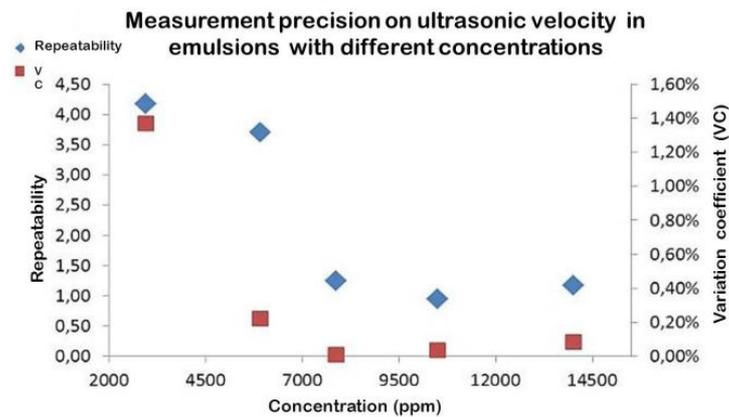
#### 3.2 Propagation velocity of ultrasonic waves through emulsion

Ultrasonic velocity was obtained by the measurement of five replicas of the mixture of oil in water for each level of concentration and comparing with reference liquid. The figures 5 and 6 show the measurement precision.



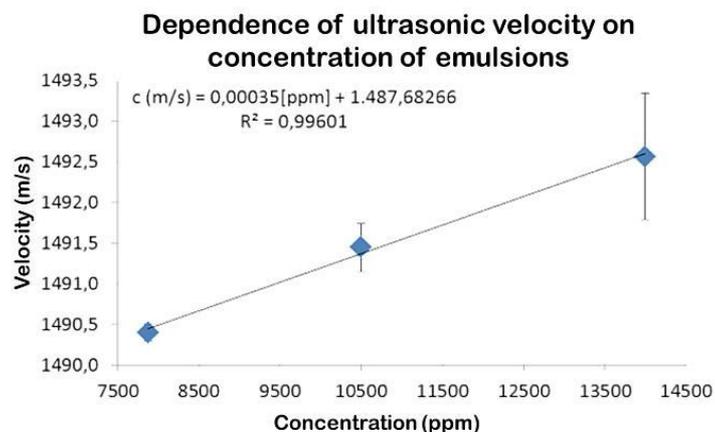
**Figure 5.** Ultrasonic velocity *Box-plot* of 5 levels of concentration of oil-in-water emulsions.

According to the figure 6, the samples with concentrations 2 953 ppm and 5 906 ppm have high repeatability estimative values (4,17 e 3,71, respectively).



**Figure 6.** Measurement precision on ultrasonic velocity.

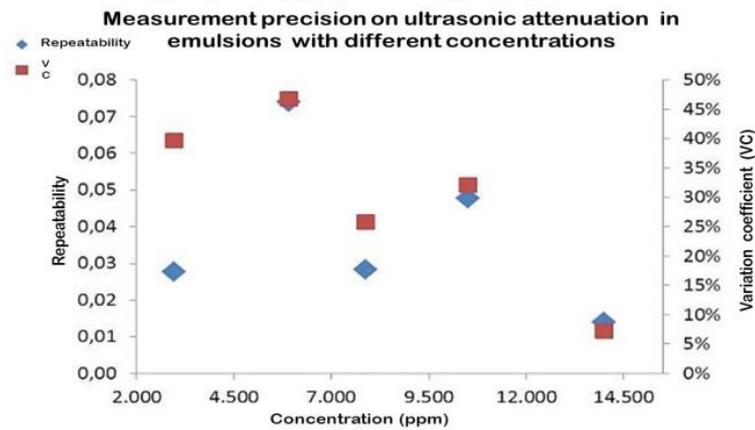
It was established that the criteria of acceptance of repeatability estimative values had to be less than 1.5. Likewise, the variation coefficient, VC values, had to be less than 0.15 %. Therefore, it was decided to discard measurements of 2 953 ppm e 5 906 ppm of the linear regression, shown in figure 7.



**Figure 7.** Effect of oil-in-water emulsions on ultrasonic velocity

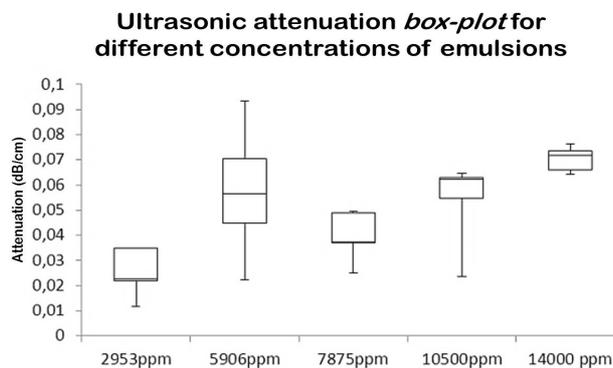
### 3.3 Oil-in-water emulsions ultrasonic attenuation

Attenuation had been assessed and shown low measurement precision, observed in figure8. It may be attributed to undesired dispersion on measures, due to manual mode of acquisition or measurement bias.

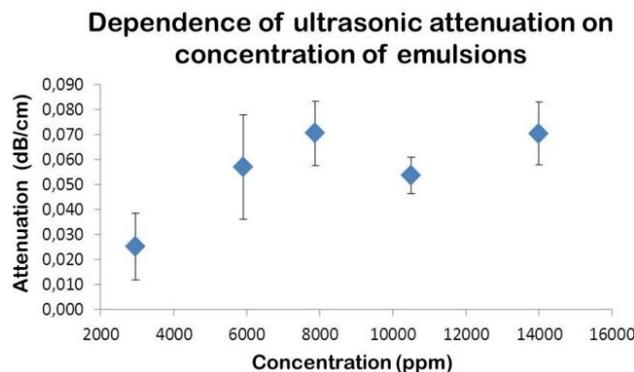


**Figure 8.** Measurement precision on ultrasonic attenuation

Nevertheless, once the median value can be taken as most likely value which is unaffected by extremes, we may assume that a linear curve could match that dispersion within a certain reasonability. It's illustrated in both figures 9 and 10.



**Figure 9.** Ultrasonic attenuation *Box-plot* of 5 levels of concentration of oil-in-water emulsions



**Figure 10.** Effect of oil-in-water emulsions on ultrasonic attenuation.

#### 4. Conclusion

The dependence of oi-in-water emulsions on ultrasonic velocity and attenuation have been studying after varying five levels of concentration.

The linear correlation between ultrasonic velocity and concentration proved to be useful to obtain an analytical curve that should be need to measure oil and grease content in water within the range from 6 000 to 14 000 ppm.

The attenuation measurement allows us to assume that there is a linear bias on data, which should be assessed with improvements of the method.

#### Acknowledgements

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