OC-19: Correlation between Sonochemistry and Sonoluminescence at Various Frequencies

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Acoustic cavitation in liquids generates sonoluminescence (SL) and sonochemistry (SC). Several studies have focused on the structure of cavitation field using SL bubbles. The overall SL intensity has also been used for evaluating the efficiency of SC of a system. Recent studies have indicated the existence of different populations of cavitation bubbles. Some bubbles may be sonochemically active without emitting SL. In this study, the structures of SL and SC bubbles generated at various frequencies and power levels have been analyzed. In addition, the overall activities of SL and SC under similar experimental conditions have been measured quantitatively for comparison purposes. The confinement of the sonication liquid by placing a lid on the surface or leaving the solution interface open to the atmosphere has been found to influence the SL and SC bubble populations. The confinement of cavitation activity is also found to affect the properties of sonochemically synthesized materials.

All experiments were carried out in aqueous medium at room temperature. An ELAC (Germany) ultrasonic generator/transducer system was used in all experiments. Luminol was used to capture sonochemiluminescence (SCL) images. SL and SCL intensities were recorded using a photomultiplier in a dark enclosure. Hydrogen peroxide (H_2O_2) yields were measured using an analytical procedure involving iodide oxidation.

To compare the cavitation efficiency of different systems, SCL images, SL and SCL intensities and H_2O_2 yields were recorded. Consider the SCL images taken for the 213 kHz system shown in Figure 1. The SCL intensity seems to be brighter and more “defined” for the system where a glass plate was present at the solution surface.

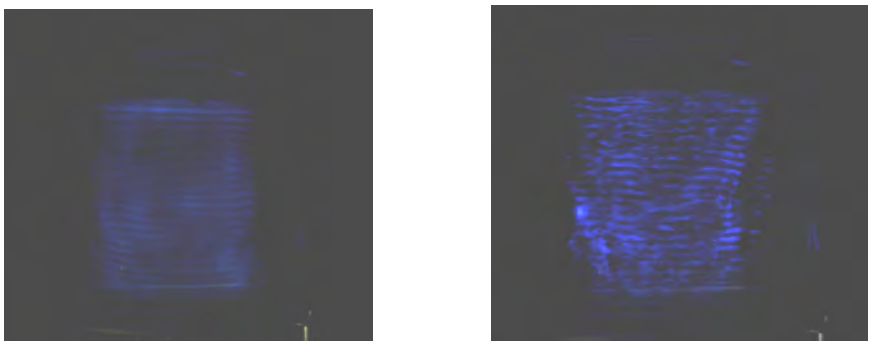

Figure 1: Photographs showing SCL: Left – open system,
Right – closed system; Frequency = 213 kHz; Power 20 W; 1 min exposure.

One would predict based on this visual observation that using a lid at the interface may increase the overall cavitation activity. However, a comparison of the quantified SCL intensities indicated that the closed system produced a lower SCL intensity. SCL arises from the reaction between luminol and OH radicals generated by cavitation. Another parameter that can also be used for quantifying OH radicals is the H_2O_2 yield. The H_2O_2 yield measured is found to correlate with the SCL data observed at 20 W, i.e., a slight reduction in the cavitation efficiency when a glass plate was used at the solution surface. It is generally believed that the SCL and SL trends should correlate for a given system since they both depend upon the bubble temperature and the total number of bubbles. The SL intensity measured for the above system also correlates with the SCL and H_2O_2 trend. However, the relative differences between SCL and SL for the open and closed systems are found to be different. For example, the SCL intensity is decreased by less than 10% compared to a 50% reduction in SL intensity for the closed system. The relative changes between open and closed systems are found to be dependent upon the acoustic frequency and power. A detailed discussion on the correlation between SC and SL activities under various experimental conditions will be discussed.