# OC-21: The Effect of Gas Type on Single Bubble Sonochemical Luminescence

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Sonochemical luminescence has been detected in a single, stable cavitation bubble in solutions containing low concentrations of dissolved air and argon within a narrow pressure domain below the sonoluminescence threshold. This augments recent accounts of discrete, spatially separated bubble types and their size dependence in multibubble ultrasound fields. This work provides evidence that sonochemistry can occur in the bulk solution surrounding a symmetrically collapsing bubble and also that the intra-bubble conditions necessary for sonoluminescence are not necessarily conducive to sonochemistry. Furthermore, OH emission lines have been resolved for argon and xenon bubbles, showing a very close similarity in the low acoustic pressure regime to recently reported observations from multibubble systems.

## 1. Introduction

The single bubble cavitation system has proved to be a valuable source of information, giving deep insight into the physical nature of cavitation and sonoluminescence. However, the single bubble is considered to be not entirely representative of active bubbles in a typical multibubble system due to the high symmetry of collapse that results from its spatial stability, and the absence of neighboring bubbles and surfaces. Until recently, the repetitive collapse of stable single bubbles in aqueous solutions has been shown to produce a broad sonoluminescence spectrum devoid of emission lines. In contrast, discrete molecular emission lines from excited solvent molecules and their degradation products, and atomic emission lines from alkali metals are routinely observed to punctuate multibubble sonoluminescence spectra. Recently, it has been shown that, under certain experimental conditions, emission lines from sodium atoms and hydroxyl radicals are also present in single bubble sonoluminescence spectra, bridging the gap between the single and multibubble cavitation (Young et al., 2001, Schneider et al., 2010).

In the present work, the emission from OH radicals and Na atoms, as well as the sonochemical luminescence from luminol are investigated for air, argon and xenon bubbles. To augment the spectroscopic analysis, the effect of gas type on the bubble radius and alcohol quenching is also reported.

## 2. Results and Discussion

The emission spectra from pure water and an alkaline luminol solution with air as the dissolved gas are shown in Figure 1 at different acoustic pressures. The luminol emission is visible well below the detection limit of broadband sonoluminescence. At the pressure where the broadband sonoluminescence becomes discernable (where argon rectification is presumed to occur), the luminol emission diminishes and at higher pressures cannot be distinguished from the continuum. It is deduced that the conditions inside the bubble at higher acoustic pressures nullify chemical activity. A similar trend is observed when the system is pre-equilibrated with argon, although in this case the luminol emission intensity is considerably lower, compared with the case of air as the dissolved gas. The stronger luminol emission in air, as opposed to argon, is opposite to what we observe for OH and Na line emission, where emission is only observed in solutions pre-equilibrated with noble gases. Possible explanations for these observations will be discussed in detail.

The effect of gas type on the spectral characteristics of OH radical emission in multibubble sonoluminescence has been shown to be very pronounced (Pflieger et al., 2010). For certain systems, a change in the noble gas type from argon to xenon (or krypton) is accompanied by certain spectroscopic changes, e.g. a non-thermal emission band, attributed to the OH(C-A) transition, as well as a shift in the OH(A-X) peak. We show in the present work, as is evident in Figure 2, that this is also the case in the single bubble system at low acoustic pressures. The implications of this will be discussed in detail.

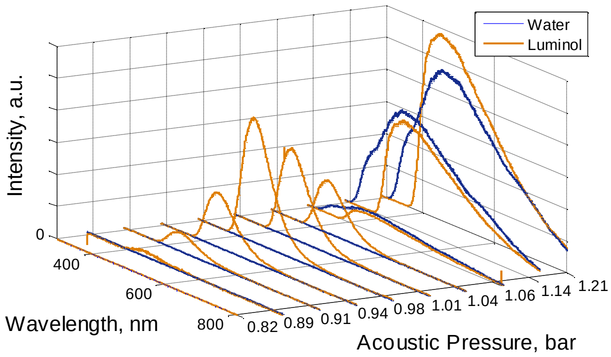


Figure 1: Single bubble emission spectra from water and 0.1 mM luminol solution at different acoustic pressures.

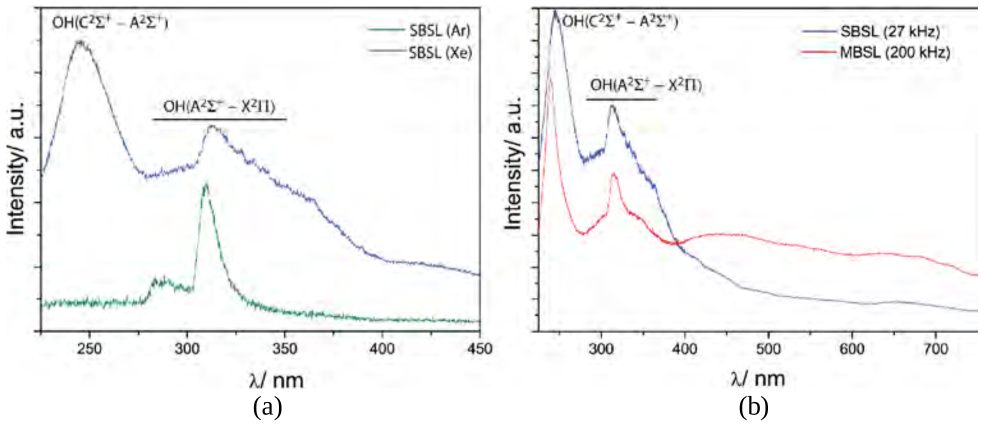


Figure 2: Sonoluminescence emission in water for (a) a single bubble system containing argon and xenon, and (b) single and multibubble systems containing xenon.

**Conclusions**

Sonochemical luminescence in the form of luminol emission, and ˙OH and Na* emission, has been observed at low acoustic pressures. The dependence of the spectral characteristics of ˙OH emission on gas type is similar to that observed in multibubble sonoluminescence. This shows that under certain experimental conditions, the interbubble conditions in single and multibubble systems are comparable.

**References**

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