Cavitation in aqueous systems: sonochemistry at 20 kHz and 515 kHz

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The sonochemistry of water based systems is of interest in a large number of areas including pollution remediation, chemical synthesis and safety implications in medical systems. In principle, sonication of water is quite straightforward, giving H• and OH• radicals which can then react further. Additional reaction pathways occur when volatile compounds evaporate into the bubble as it grows. However, there remain many details of the process that are unclear. We have been studying the effects of cavitation in aqueous solution using a variety of methods as shown in Figure 1.

Fig. 1: Techniques used to study cavitation in aqueous systems

These methods have been used to measure the rates of radical production in water and a range of solutions used in industrial processes, including emulsions. We have also applied the methods to a number of medical and dental ultrasound instruments. Some results for each area will be described.

In conjunction with groups at the University of Melbourne in Australia and the UK’s National Physical Laboratory, we have investigated [1] how the experimental conditions affect changes in sonoluminescence and in acoustic emission. We have shown that the rate of radical production, the acoustic emission arising from the collapsing bubble and the results from luminescence quenching experiments show good agreement. In addition, some unexpected effects were noticed when using ultrasound with two different ultrasound set-ups; a 20 kHz horn and a 515 kHz emitting transducer. A possible model to explain some of these results has been proposed suggesting that the type of cavitation is different in the two situations in terms of the proportion of stable and transient bubbles that exist. Some recent experiments aimed at clarifying the situation will be described, for example, the effect on each of the measurements of adding surfactants and other additives has been determined. Again, different effects have been noticed when operating at the two different frequencies. Further experiments that need to be performed before we have a complete picture of aqueous sonochemistry and these questions will also be posed during the presentation.

Fig. 1: Use “Figure Legend” for labelling.

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