

OC-49: The Influence of Ions On Coalescence Of Charged Bubbles in an Acoustic Field

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Bubble or droplet coalescence plays an important role in both chemical and biochemical gas/liquid reactors, in absorbers, such as agitated tanks and bubble columns, and in the stability of emulsions. Therefore, the study on the effect of surface-active solutes, salts, and viscosity on bubble-bubble or droplet-droplet coalescence is important. The study of bubble-bubble or droplet-droplet coalescence conducted in the past involved techniques such as visual observation of two approaching bubbles or droplets (Oolman and Blanch, 1986) and capillary systems (Lee, 2005). The current study demonstrates how the spatial distribution of sonoluminescence (SL) can be used as a sensitive probe to study the effect of low concentrations of different electrolytes on the extent of coalescence of charged bubbles.

The spatial distribution of sonoluminescence (SL) bubbles has been shown to be a balance between the strength of the standing and traveling wave component in an acoustic field (Lee, 2008). A strong standing wave component will result in a more homogenous distribution of SL bubbles where as a strong traveling wave component will force bubbles to move towards the liquid surface. These two components are sensitive to the degree of attenuation of the acoustic pressure by large bubbles, which are in turn affected by the extent of bubble coalescence. The addition of low concentrations (<1 mM) of sodium dodecyl sulfate (SDS), an anionic surfactant, will impart a negative charge on the bubble surface and inhibit bubble coalescence. This will decrease the concentration of large bubbles, lower the attenuation of acoustic pressure, increase the standing wave component and give a more homogeneous distribution of SL bubbles as seen in Fig. 1a for 1 mM SDS. The addition of 0.1 M NaCl to 1 mM SDS has been shown to cause the SL intensity to fall to that of water (Ashokkumar, 1997). A closer examination of the spatial distribution of SL bubbles in the presence of 1 mM SDS with the addition of NaCl is shown in Fig 1b. The transformation in the spatial distribution of SL bubbles with increasing NaCl concentration to 1 mM SDS appear to be the reverse of that shown in Fig. 1a, which supports the re-coalescence or clustering of bubbles explanation. The SL from Fig. 1b is quantified and shown in Fig. 2a. The SL intensity is observed to decrease and then increase again with increasing concentration of NaCl to 1 mM SDS. The depression in the SL occurs at the transition of the acoustic field from a standing wave to traveling wave field.

(a)

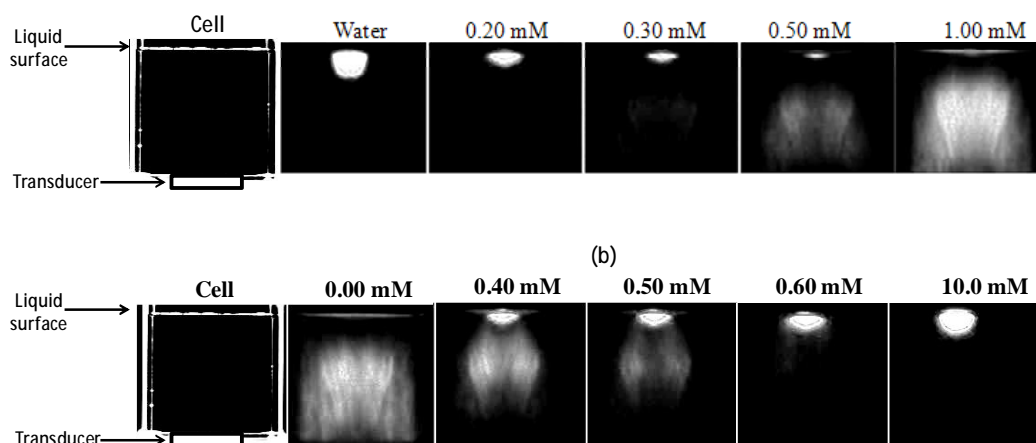


Figure 1: (a) The spatial distribution of SL bubbles with the addition of SDS to a concentration of 1 mM and (b) the spatial distribution of SL bubbles with the addition of NaCl to 1 mM SDS. The images have been inverted for better visualization of the bubbles. Thus the SL bubbles are depicted in black.

Different chloride (Fig 2a) and sodium (Fig 2b) monovalent salts were used to investigate the effect of different cations and anions on the coalescence of charged bubbles. It was found that the degree of coalescence was sensitive to the type of cations. The effect of cations on the extent of coalescence of charged bubbles was strongest for H^+ followed by K^+ , Na^+ and Li^+ . However, at high salt concentrations, the same SL intensity was reached, except for HCl which had a much lower SL intensity. The variations observed by different anions were small. Since SDS is an anionic surfactant, the cations would be expected to have a more significant effect on the screening of the charges on the bubble. The differences observed by the different cations will be explained by their differences in mobility and hydrated radius, and the protonation of the sulfate head group by H^+ ion.

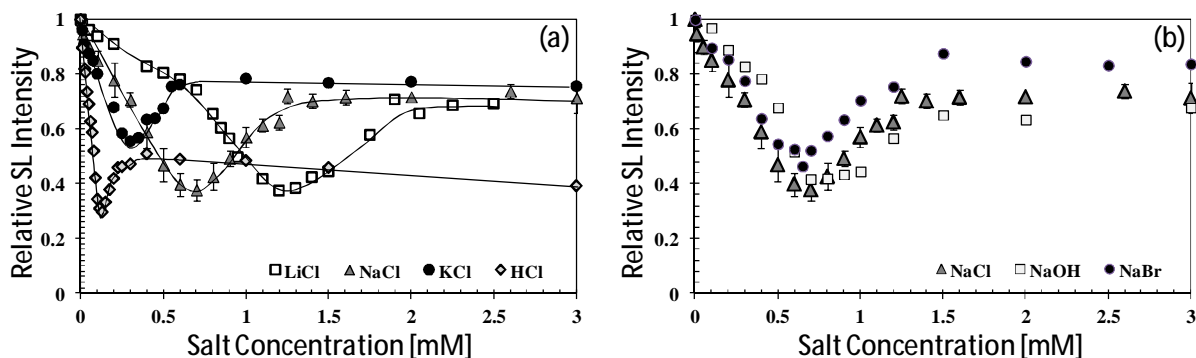


Figure 2: The addition of various electrolytes to 1 mM SDS on the SL intensity of 1mM SDS: (a) chloride salts with different cations and (b) sodium salts with different anions. The curves have been added to guide the eye.

References:

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