Experimental study of bubble dynamics in aqueous solutions of simple alcohols: CFD validation data

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Simple short-chain alcohols and their aqueous solutions are widely used in industrial, biological and pharmaceutical applications. The physico-chemical properties of these solutions, such as dynamic viscosity and surface tension, are highly affected by the complex structure of water-alcohol mixtures.[1] Dilute solutions of alcohols act as a strong surfactant that can immobilize the bubble surface and consequently affects bubble rising dynamics and shape deformations.[2]

The aim of this work was to obtain experimental values of terminal velocities and shape deformations for a wide range of bubble sizes and compare them with theoretically calculated values. These data were obtained for the whole concentration range of aqueous solutions of 1-propanol and ethanol and will be used for validation of CFD results in future work.

From the obtained results three distinctive regions were identified. In mixtures with very low alcohol content (x_P, $x_E \leq 0.005$) the molecules of alcohol behave as a surfactant and adsorb on the bubble surface. Depending on the bubble size, the surface is fully or partially immobilized. The transitional region ($0.005 \leq x_P \leq 0.07$ and $0.005 \leq x_E \leq 0.18$) is characterized by the shift from immobile surface to fully mobilized at higher alcohol concentrations. In the third region, where the concentration is above the critical aggregation concentration ($x_P \geq 0.07$, $x_E \geq 0.18$), the surface mobility of the bubble is not affected. However, the bubble terminal velocity reaches a minimum, which is caused by one of the anomalies of alcohol-water mixtures, an existence of the dynamic viscosity maximum of the solution. The addition of alcohol beyond this point results in the minor increase of the velocity, as the viscosity lowers to a value of pure liquid.

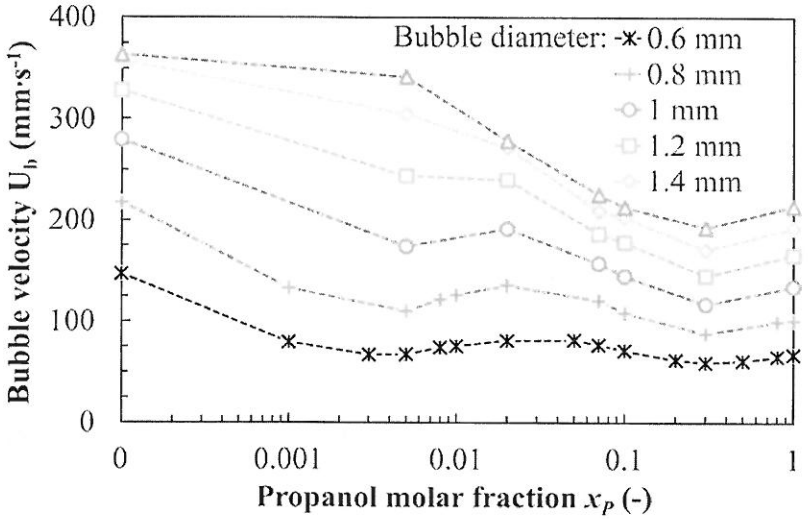

Figure 1: Effect of the propanol concentration on the bubble terminal velocity for different bubble diameters.

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References

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