Influence of surface roughness and concentration of surface active substances on kinetics of the bubble attachment to hydrophobic solid

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When a bubble collides with hydrophobic solid surface a liquid film between the bubble and solid surface is formed. If the collision time is long enough for the draining film to reach a critical thickness of its rupture then the three phase contact (TPC) is formed. In distilled water the time scale of the TPC formation is strongly affected by a roughness of hydrophobic solid surface, with the time of the TPC formation being shortened when the surface roughness was greater [1,2]. Influence of surface roughness on kinetics of the TPC formation and the bubble attachment to hydrophobic solid surface can be due to two mutually connected mechanisms. The first one is related to a fact that the rate of the film drainage is strongly affected by the film radius. Thus, time of the three phase contact formation (t_{TPC} – i.e. a time period from the moment of the bubble first collision until the TPC is formed) is shortened for the surfaces of greater roughness. In such case various local wetting films are formed at spikes and pillars of the rough surface. Lateral dimensions of these local wetting films are much smaller than radius of the entire liquid film formed by the colliding bubble; therefore the films need shorter time to drain to the critical rupture. The second mechanism is related to a presence of air (nano- and micro-bubbles) at hydrophobic solid surfaces immersed in aqueous phase. With increasing surface roughness amounts of air “entrapped” is increased [1,2]. Shorter t_{TPC} upon the bubble collision with a rougher surface can be due to a coalescence of the colliding bubble with nano and/or microbubbles present at the rough hydrophobic surface.

In our studies we have used a high speed camera to observe rapid phenomena occurring upon the bubble collisions with hydrophobic solid plates (Teflon) of different surface roughness (dimensions of scratches and crevices from 1 μm up to 100 μm) in solutions of typical flotation frothers (n-octanol and α-terpineol). It was found that depending on n-octanol and α-terpineol concentration the t_{TPC} can be either shortened or prolonged comparing to distilled water. At low solution concentrations the t_{TPC} decreased, as a result of lowering of the bubble velocity and damping the bubble bouncing. However, further increase in n-octanol or α-terpineol concentration led to a significant prolongation of the t_{TPC}. For example in the case of Teflon of medium surface roughness and α-terpineol concentration 1*10^{-3}M the t_{TPC} was equal to 33ms, i.e. 10 time longer than in the case of lower (1*10^{-5} M) α-terpineol concentration. Magnitude of this quite a surprising effect (i.e. prolongation of the t_{TPC} formation in high concentrations of flotation frothers) depended also on roughness of the Teflon surface. Increasing surfactant concentration leads to an increased stability of the foam films, therefore these data indicate that air in a form of nano- and microbubbles was present at the Teflon surfaces of different roughness. The prolongation of the t_{TPC} was a consequence of formation of the local foam films of higher stability between the colliding bubble and such air “pockets” at the Teflon surface.