J Biot Phyt 2017

Pulsed laser ablation in liquids: what can we learn from the bubble diagnoses?

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Pulsed laser ablation in liquids (PLAL) is a versatile technological approach to producing nanoparticle colloids with ligand-free or functionalized surfaces. Therefore, PLAL has aroused a lot of commercial interests recently. Despite this widespread use, the underlying mechanisms of PLAL are not fully understood yet. In a first step, a liquid confined plasma is created by the laser ablation. Then, numerous authors reported the formation of an expanding bubble from which nanoparticles are released. According to small angle x-ray scattering (SAXS) measurements and laser-light scattering measurements the bubble cavity should support nucleation and growth of nanoparticles. However, two fundamental features remain largely unknown: the chemical composition and the thermodynamic properties within the bubble. Using time-resolved plasma spectroscopy and ultrafast imaging, we address both issues. We then develop theoretical approaches. From a Rayleigh-Plesset based model, we demonstrated that (i) inertial forces drive the bubble dynamics, (ii) vapor evolution is adiabatic, and (iii) the bubble is mainly composed of evaporated solvent. Moreover, we present a fully microscopic approach based on a first-principle study, and propose a scenario of composition gas evolution leading to the first seeds. This approach is illustrated in the framework of alumina. These results will be discussed in the framework of the state of the art (diagnoses and models).

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