
Plasma jets above or inside liquids: basic but tricky and promising setups

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This work reports on the interaction of so-called plasma jet with or within liquid solutions. The use of the Plasma Gun as an archetypical setup for processing liquid samples or humid tissues in the context on plasma biomedical applications but also in a more innovative configuration where plasma jet is immersed in solution to generate plasma in gas bubbles will be discussed. In the "above solution" setup, recent experiments have shown that reactive species generation and delivery in the liquid could be very non intuitive, revealing the existence of steady state vortexes, surface accumulation zones, needle-like transient patterns, ... depending on various operating conditions such as gas flow, pulse repetition rate, distance to the sample, while being quite universal for various liquid containers typically used for biomedical applications. Conversely, the in-bubble plasma generation while being very dependent on the operating conditions as well and on the liquid electrical conductivity, is shown to allow for a, at a first glance surprising, very fast and very homogenous delivery of reactive species in liquid samples. Plasma generation in gas bubbles will be documented, together with the reactive species generation efficiency versus gas flow rate, number of plasma pulse delivery in a single bubble. It is shown that plasma generation in gas bubble has drastic impact on the bubble expansion dynamics and that synchronization of plasma pulse generation during the bubble lifetime could be a key parameter to optimize the reactive species generation and balance. Perspectives for multi bubble plasma reactors delivered in large liquid volume processing will be discussed.