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Atmospheric Pressure Streamer-Spark Discharge on Water Droplets: Production of silver Nanomaterials

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Cold plasma-liquid interactions have emerged as a pivotal area of research, particularly for their applications in nanomaterial synthesis. This study explores atmospheric pressure streamer-spark discharges on water droplets, with a focus on the production of silver-based nanomaterials. By systematically varying experimental parameters such as droplet electrical conductivity (ranging from distilled water to 5 mS/cm.) and applied voltage (10-20 kV, 70-500 ns pulses), we investigated discharge dynamics in three distinct configurations: anodic-, cathodic-, and floating-droplet setups. The electrical behavior of the discharge-droplet system was characterized, while the temporal and spatial evolution of the discharges was captured using ICCD imaging.
In the case of droplets containing $AgNO_3$, the synthesized nanomaterials were analyzed using UV-Visible spectroscopy and transmission electron microscopy (TEM). The results revealed that specific discharge modes significantly influence the reduction of Ag^+ ions by electrons, leading to the formation of diverse nanostructures. Notably, under certain conditions, Ag nanosheets were synthesized without the need for a substrate or a surfactant, highlighting the unique role of the droplet-air interface as a surrogate substrate. This finding opens new possibilities for substrate-free synthesis of oriented nanostructures, which are typically challenging to achieve without a template.
The interplay between discharge modes and droplet properties (e.g., electrical conductivity) governs the charge fluxes on the droplet, thereby dictating the morphology and structure of the synthesized nanomaterials. These insights not only advance our understanding of plasma-liquid interactions but also provide a versatile platform for the controlled synthesis of advanced nanomaterials. The ability to produce 2D nanostructures, such as Ag nanosheets, without a substrate underscores the potential of this approach for innovative applications in nanotechnology and materials science. This work paves the way for further exploration of plasma-driven synthesis techniques and their scalability for industrial applications.

Keyword-1

Nanomaterials

Keyword-2

Nonthermal plasma

Keyword-3

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