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A simple thermal plasma method to produce pure graphene flake structures

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Thermal and non-thermal plasma processes have been exploited over the years for the gas phase synthesis of carbon nanoparticles targeting specific industrial applications. In our laboratory, we use a one-step thermal plasma process to generate and functionalize graphene nano-flake (GNF) structures that show exceptional properties in terms of purity and crystallinity. This specific carbon structure is designed for the replacement of Pt catalyst in PEM fuel cells. The non-noble catalyst contains iron atoms dispersed at the atomic level directly on the carbon nanoparticles using nitrogen coordination. The structure developed mimics the blood heme structure for the oxygen reduction reaction (ORR), with metal atoms acting as catalytic sites rather than metal nanoparticles as is commonly used. This technology proved recently to have activities that can rival Pt-based catalyst. The high crystallinity of the support structure also proved to strongly improve the stability to the point of seeing no loss of activity in 100 hours long PEM fuel cell operation.

The high temperatures attained for carbon nanoparticle nucleation in thermal plasma reactors enabled the increased crystallinity, however the control, reproducibility and purity are often lacking in such devices. These are addressed in the present research. Modeling and experimental results related to the design of the flow/energy/nucleation fields in an ICP-thermal plasma reactor enabling the nucleation of the specific GNF carbon nanomaterial, and its specific functionalization is presented. A "properly" designed conical geometry of the reactor enables a fine adjustment of the nucleation zone that minimizes the condensation process and essentially eliminates coagulation of the particles. Very good control over purity and reproducibility are attained through the elimination of recirculation fields. The local high temperature enables the nucleation of pure graphene flakes having between 5-16 atomic planes, and planar structures of typically 50 nm x 100 nm.

Biography

Ramona Pristavita has completed her Ph.D. in 2011 from McGill University, Montreal, Canada and postdoctoral studies from the same university in 2012. She is working as Course Lecturer and continues a closed collaboration with the Plasma Processing Center at McGill University. She has published several papers related to the carbon nanoparticles production using plasma technology. She acts as a reviewer for several journals and she is the co-inventor of "Fabrication and functionalization of a pure non-noble metal catalyst structure showing time stability for large scale applications".

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