Using a novel atmospheric pressure direct-current plasma source for the synthesis of nanomaterials

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Background and state of the art

As nanotechnology consolidates –leaving the space of emerging trend to become a main scientific and technological stream- there is a growing need for new methods of synthesis of nanomaterials. These new synthetic pathways must be aimed at the discovery of new materials, the improvement of existing ones and, last but not least, the development of approaches that can be scaled up to satisfy the needs of a growing nanotechnology market.

Plasmas are weakly ionized gases that allow withdrawing energy from an electrical field to induce chemical reactions. A type of plasma called "glow discharge" (GD) has been extensively used in the synthesis of nanomaterials because –as they usually work far from equilibrium conditions- can trigger physical and chemical processes that are otherwise difficult to achieve. Furthermore, GD provide clean, tunable and efficient synthetic pathways. Despite of these advantages, the use of plasmas is not free from practical problems. The simplest plasmas –that can be sustained with direct current- usually require working under relatively low pressures (<1Torr). Plasma that work at atmospheric pressure require working with alternate current (radiofrequency, microwaves, etc), which makes the instrumentation and operation extremely more complex and costly.

During the last few years, a new type of GD that can be operated at atmospheric pressure and that works with direct current has been reported. This GD is simple to build and to operate and –due to the advantages of the collisional cooling that occurs at atmospheric pressure- shows unique features. This "atmospheric pressure GD" has shown extraordinary results in the fields of atomic spectroscopy and mass spectrometry. The applications of this novel glow discharge to the synthesis of novel nanomaterials has not yet been explored. There are, however, many reasons to believe that this new type of plasma may bring considerable benefits to the nanomaterials synthesis field. Cost and potential for scaling up the approaches are among them.

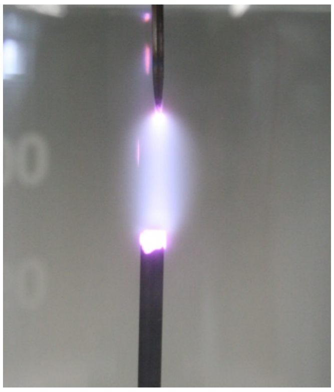

Image of a homemade Helium atmospheric pressure GD

Aim of the work

This work will be focused on the exploration of the use of this novel atmospheric pressure glow discharge for the generation of nanomaterials. A plasma source using a Helium GD will be first systematically explored, in order to evaluate synthetic possibilities directly from the GD materials. Characterization of the structure of the electrodes after running the plasma under different conditions will be evaluated. Then, modification of materials by exposing surfaces to the reactive species generated in the plasma will be tested. Finally, different types of atmospheric pressure plasmas –with liquid electrodes- will be evaluated.

Candidate profile

This work has a very strong experimental bias. Therefore, it is expected that the ideal candidate is a challenging, hands on, self motivated person, with curiosity and willingness to explore, and skills and ability for building experimental systems. Proficiency in chemistry is essential, and basic knowledge on electronics (or willingness to learn it) will be an important advantage.

Recommended reading

(1) Zajíčková, L. Jašek, O. Eliáš, M. Synek, P. Lazar, L. Schneeweiss, O.; Hanzlíková, R. *Pure and Applied Chemistry*. **2010**, *82*, 1259-1272.

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(3) Bystrzejewski, M. Huczko, a; Lange, H. Płotczyk, W. W. Stankiewicz, R. Pichler, T. Gemming, T.; Rümmeli, M. H. *Applied Physics A*. **2008**, *91*, 223-228.

(4) Lee, Y. Kyung, S. Kim, C.; Yeom, G. *Carbon*. **2006**, *44*, 807-809.

(5) Nozaki, T.; Okazaki, K. *Plasma Processes and Polymers*. **2008**, *5*, 300-321.