Improving the performances and the arc stability in a in a N_2-O_2 Gliding Arc Plasma: selecting the optimum resistance for the discharge

Filippo Manaigo[1,2], Omid Samadi Bahnamiri[1], Abhyuday Chatterjee[1], Annemie Bogaerts[2], Rony Snyders[1,3]

[1] *Chimie des Interactions Plasma-Surface (ChIPS), CIRMAP, Université de Mons, 7000 Mons, Belgium;*

[2] *Research group PLASMANT, Department of Chemistry, University of Antwerp, Universiteitsplein 1, BE-2610 Antwerp, Belgium;*

[3] *Materia Nova Research Center, Parc Initialis, 7000 Mons, Belgium*

filippo.manaigo@umons.ac.be

Nitrogen Fixation (NF), i.e. the process of converting N_2 into molecules with a weaker bond, is a fundamental procedure for the industrial manufacturing of fertilisers and, therefore, for the fulfilment of the world food demand. Currently reductive NF is mainly performed through the Haber-Bosch process, which, in its most commonly used design, requires high temperatures (650K – 750K) and high pressures (around 100 bar) to be efficient[1]. Plasma driven NF, such as Gliding Arc Plasma discharge (GAP), is gaining interest as an alternative compatible with a downscaled, more diffused and local production[2].

The stability of a GAP is a crucial topic which has been investigated on the arc behaviour perspective[3]. This work addresses the plasma stability in a N_2-O_2 GAP used for NOx synthesis operating at atmospheric pressure. Specifically, its main focus is the investigation of the effects of the choice of a ballast resistance on the arc behaviour and on both yield and energy efficiency for the production of NO_x.

The GAP is powered through a DC power supply and average currents in the range between 50 and 200 mA are applied. 2-19 kΩ resistances are placed between the power supply and the cathode of the reactor. A 5 slm N_2 and 5 slm O_2 gas mixture is injected in the chamber. The densities of the produced species were analysed by Fourier Transform Infrared (FTIR) spectroscopy through the absorption lines at 1875 cm^{-1} for NO and at 1616 cm^{-1} and 2906 cm^{-1} for NO_2. The results reveal how the choice of the resistance:

- greatly reduces the arc current-voltage instabilities allowing to operate with lower arc currents as its value increases (from 100 mA with 2 kΩ, down to 50 mA with 15-19 kΩ).
- does not affect the average values for current and voltage of the arc. As a consequence, the NOx yield and energy costs stays consistent, regardless of the resistance value, between 0.8% and 1.7% and between 3.5 MJ/mol and 4.5 MJ/mol as a function of the arc power.
- strongly affects the overall cost of energy needed for the stabilization of the discharge for NO_x production due to dissipation through the Joule effect. The average energy cost rises from 4 MJ/mol to 12 MJ/mol when the resistance is increased from 2 kΩ to 19 kΩ.

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