Tuning a microwave plasma for the synthesis of few-layers graphene sheets from ethanol decomposition

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The study of ethanol decomposition process to synthesize few-layers graphene together with hydrogen using an argon microwave plasma sustained by a Torche à Injection Axiale sur Guide d'Ondes opened to the atmosphere is presented. In this work, plasma kinetics and by-products formation are deeply studied to identify the key plasma parameters leading to graphene production. Optical Emission Spectroscopy was utilized to measure plasma gas temperature and to identify plasmas species produced by the decomposition of ethanol molecules. Simultaneously, gaseous products at the plasma exit were identified by Mass Spectrometry. Carbon powder was analyzed by High-Resolution Transmission Electron Microscopy (HRTEM), Raman Spectroscopy, X-ray Photoelectron Spectroscopy (XPS) and Thermogravimetric analysis (TGA) and it was identified as few-layers graphene. Graphene synthesis took place only for certain argon and ethanol flows, which had an impact too on the influence of the air surrounding the discharge. In addition, plasma gas temperature value was also found to have a remarkable influence on ethanol decomposition chemistry; giving place to two different ethanol decomposition routes: (i) at higher temperatures (>4500 K) graphene flakes, H_2 and CO were produced whereas, (ii) for lower gas temperatures (<4500 K) graphene was not synthetized and H_2, H_2O, CO and CO_2 gases were produced (Figure 1). These results show that the complete ethanol decomposition by means of an atmospheric-pressure microwave plasma sustained with high gas temperatures can be tuned to result in the production of few-layers graphene and hydrogen through a clean and simple process.

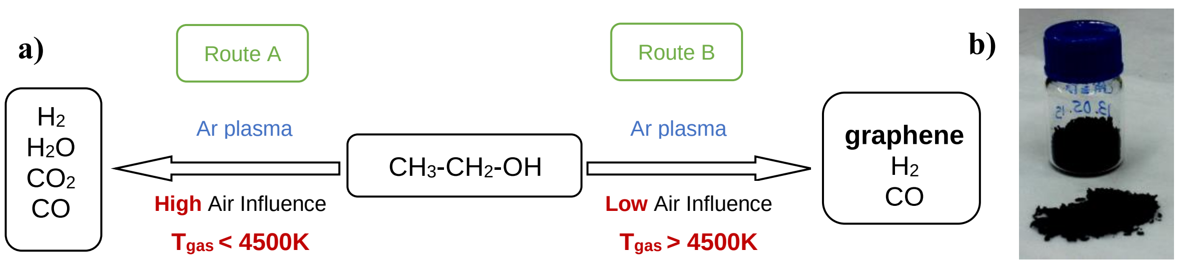

Figure 1. a) schematic representation of ethanol decomposition routes and by-products formation according to the importance of both air in the plasma and plasma gas temperature, b) synthetized graphene flakes.