Understanding graphene inception and growth by investigating early-stage particle formation

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Abstract

Microwave-assisted plasma synthesis is a promising technique for continuous, scalable, and substrate-free graphene production. However, improving yield and controlling graphene quality requires a deeper understanding of the mechanisms driving graphene nucleation and growth, as well as the interplay between synthesis conditions, gas-phase properties, and material quality. This project aims to identify key events in the reaction system through both in situ and ex situ diagnostics of gas-phase reactions; considering that variables such as precursor properties and concentration directly influence decomposition kinetics, growth rates, and mass and heat transfer profiles [1–3]. A primary goal is to establish the reactant and process conditions that favor graphene formation over other carbonaceous materials while elucidating the reactive pathways and kinetics during the early stages of growth. Preliminary results comparing ethylene and ethanol as precursors reveal significant differences in species distribution and temperature profiles. The use of ethanol exhibits a favorable C/O ratio and temperature profile, promoting the formation of few-layer graphene by enhancing graphene-promoting C_2 species over soot-producing C species (Figure 1). Identifying these critical factors will enable maximized yield and the rational tuning of process conditions, advancing graphene's functionality for subsequent application-driven projects.

References

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Figures

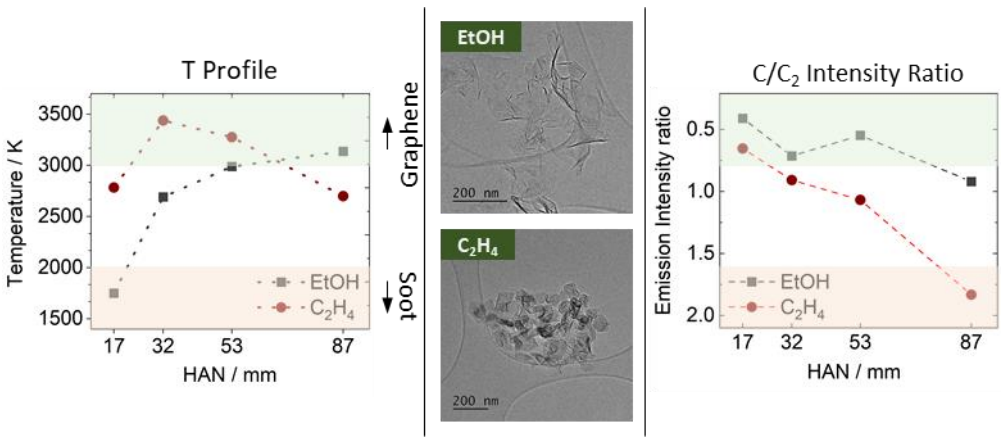

Figure 1: (Left) Temperature profiles in the plasma region for ethanol (EtOH) and ethylene (C_2H_4). (Middle) TEM images of FLG from EtOH, and mix of FLG and soot from C_2H_4. (Right) Emission intensity ratios for C and C_2 species, from Optical Emission Spectroscopy measurements.