A-O8 AAPPS-DPP2019

3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Effect of hydrogen/carbon ratio on graphene synthesis using magnetically stabilized gliding arc discharge

Zhongshan Lu, Cheng Wang@, Dongning Li, Weidong Xia@

Department of Thermal Science and Energy Engineering, University of Science and Technology

e-mail: lzhsh@mail.ustc.edu.cn;

Corresponding author: awcheng@mail.ustc.edu.cn; xiawd@ustc.edu.cn

Abstract:

Few-layer graphene nano-flakes (GNFs) are successfully prepared by a non-thermal plasma based on the magnetically stabilized gliding arc discharge (MSGAD) at atmospheric pressure. The effects of feedstock gas type, feedstock gas flow rate and H/C mole ratio on the morphologies and microstructures of pyrolysis products are investigated and discussed. The pyrolysis products are characterized by transmission electron microscopy (TEM) and Raman spectrum analyses. The synthesized GNFs consist of 2-10 sheets per stack with dimensions between 100 and 200 nm. Results show that high H/C ratio in the feedstock not only increases the relative content GNFs of the pyrolysis products, but also promotes crystallinity and reduces the thickness of samples; increasing the H/C ratio in the feed stream by adding H_2 has similar effects, but excessive H/C ratio reduces the crystallinity and the conversion of feedstock. Moreover, decreasesing feedstock rate increases the relative GNFs content of the pyrolysis product and results in an observed shift in relative proportions of the carbon forms towards preferential graphitic content. Based on above results, it is assumed that the formation mechanism of such GNFs is consistent with soot formation in combustion. The main process of synthesis of carbon nanomaterials could be divided into four stages[1]: homogeneous nucleation of particles, particle coagulation, particle surface reactions (growth and oxidation), and particle agglomeration. Polycyclic aromatic hydrocarbons (PAHs) is assumed as precursors to carbon nanomaterials. Low PAHs concentration and appropriate H/C ratio are considered the essential condition for the formation of GNFs in the process. The increasing the H/C ratio in the feed stream not only reduces PAHs concentration but also inhibits the rolling and closing of graphene sheets by terminating the dangling carbon bonds . In addition, hydrogen has other function of etching the amorphous carbon to improve crystallinity, but excessive etching effect of hydrogen may bring in some crystal defects.

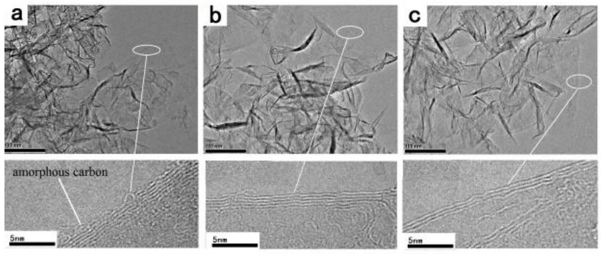

Figure1 TEM images of GNFs at different H/C mole ratios:

(a) H/C=8/3 (Q_{C3H8}=0.33L/min Q_{Ar}=19.67L/min)
(b) H/C=4 (Q_{C3H8}=0.33L/min Q_{Ar}=19.00L/min Q_{H2} =0.67 L/min)
(c) H/C=8 (Q_{C3H8}=0.33L/min Q_{Ar}=18.50L/min Q_{H2} =1.17 L/min)

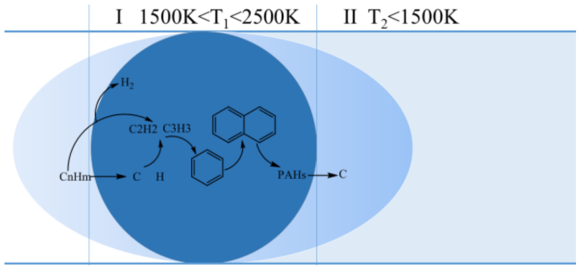

Figure2 Schematic illustration of formation mechanism of carbon nanomaterials by MSGAD

References

[1] Frenklach M. Reaction mechanism of soot formation in flames[J]. Physical chemistry chemical Physics, 2002, 4(11): 2028-2037.

Acknowledgement: The program is supported by NSFC (No. 11675177) and Hefei Carbon Art S&T Ltd.