Shock Processing of Carbon Nanopowder: A way to Understand the Formation Mechanism of C_{60} in Circumstellar Environment

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In ranking of Astrophysical abundance of elements, carbon is the 2^{nd} element after oxygen, able to form multiple bonds and networks. Thus carbon is playing an important role in the formation of nano to micron size dust grains [1]. Back in 80s Kroto.et al. performed series of experiments to understand the formation mechanism of long carbon chain molecules in circumstellar environment and discovered a new and stable cage like structure, called Buckminsterfullerene, C_{60}[2]. Soon after its discovery, astronomers were started to search its signature in space. The unambitious spectral signature of C_{60} and C_{70} was first reported by J Cami.et al. 2010, in the outer envelope of a planetary nebula, TC1 at 7.0, 8.5, 17.4, 18.9 micron features [3]. These spectral features are also observed in Reflection Nebula, Selgren.et al,2010, in diffuse ISM, Peeters et al, 2012 and others evolved stellar environment [3]. Although C_{60} is very abundant in different astrophysical conditions, its formation mechanism in space is not well studied.
Jager et al. 2009, experimentally studied the gas phase formation route of complex carbonaceous compounds from the high temperature and low temperature conditions [4]. Top to down route to form PAH and complex carbonaceous compounds on graphitized SiC surface exposed to atomic hydrogen in interstellar conditions are well studied [5]. Another top – down route for C_{60} formation via UV processing of graphene in cold diffuse cloud has been verified by Berne et al. 2012. Formation of carbon cluster upto C_{20} due to VUV irradiation in CH4 isolated in Ne matrix has been studied by Lin et al, 2104. But all of the above explained experiments were performed in hydrogen abundant atmosphere.

Therefore, there is clearly a demand for more experiments to understand the end products resulting from carbon as the starting material hydrogen free atmosphere. We employed the high intensity shock tube in PRL to shock the pure (<100 nm) carbon powder to temperatures as high as 8000 K for about 2 ms in hydrogen free conditions. The resulting sample after shock processing was analysed using Raman, IR spectroscopy and Imaging (FE-SEM / HR-TEM) techniques. Here we present the first results from the preliminary experiments carried out by shock processing of carbon nanopowder.

References:

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