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MASS ANALYSIS OF CESIUM ION INDUCED FRAGMENTATION OF C_{60}

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Results of Cs ion induced C_{60} fragmentation in source of negative ions by cesium sputtering (SNICS) from 5 MeV Tandem accelerator are presented. The mass analysis was performed from bending magnet. Mass spectra of C_{60} fragments are compared with that of graphite under similar conditions. Yield of carbon clusters for both cases is plotted for Cs ion energy range of 2-5 keV. It is observed that heavier clusters appear in the case of C_{60}. Intensity of C_2 is much higher in comparison with other clusters for both C_{60} and graphite due to difference in their bond energies. Prominence of C_2 yield confirms formation mechanism of C_{60} by addition of C_2 route.

Keywords: C_{60}, Graphite, Mass spectrometry, Fragmentation, Sputtering

1. Introduction

In continuation to our previous work on C_{60} and graphite [1,2] for investigating formation and fragmentation mechanisms, we present Cs ion induced fragmentation study of C_{60} alongwith graphite for comparison. The discovery of C_{60} [3] led to the study of different properties of this molecule due to its importance in various areas of physics, chemistry and material science [4]. Many researchers have investigated the fragmentation process of C_{60} as it is considered to follow the same route as formation mechanism. Many approaches have been used by scientists such as electron induced fragmentation of C_{60} in the time of flight mass spectrometric experiments by Scheier et al. [5]. Senn et al. and Matt et al. also reported electron induced C_{60} fragmentation and studied the phenomenon to be due to the sequential loss of C_2 [6,7]. Recently, Zeeshan et al. reported fragmentation of the condensed C_{60} based on energetic pulsed electron ablation and compared it with that of graphite under similar conditions [8]. Fragmentation of C_{60} can also be carried out with the laser ablation as developed by Kroto et al. [3]. In the electron ablation mode, the energy is transferred in electron–electron collisions while in the case of laser ablation the energy transfer takes place in photon–electron interaction. Another approach to the study of fullerene fragmentation is the impact of ion collision. Ionization and fragmentation of C_{60} by highly charged, high energy Xe ions was carried out by Cheng et al. who measured the relative yield of cluster fragments [9]. Tsuchida et al. presented experimental results for ionization and fragmentation of C_{60} bombarded by various projectile ions and found that for heavier ions, multiple ionization occurs and hence lighter fragments are produced predominantly [10]. Ionization and fragmentation studies were also carried by Itoh et al. by lithium ions [11].

Theoretical as well as the experimental studies have established C_2 as a basic unit during the self-assembly of C_{60} [12]. A model has been proposed based upon the C_2 addition route leading to cage closure and the series of sequences for the formation of C_{60} [13]. Carbon clusters have applications in material modification and can be used to coat amorphous films on metals. Amorphous films reduces secondary electron yield from the walls of high energy particle accelerator [14]. Recently, Javeed et al. and Janjua et al. used

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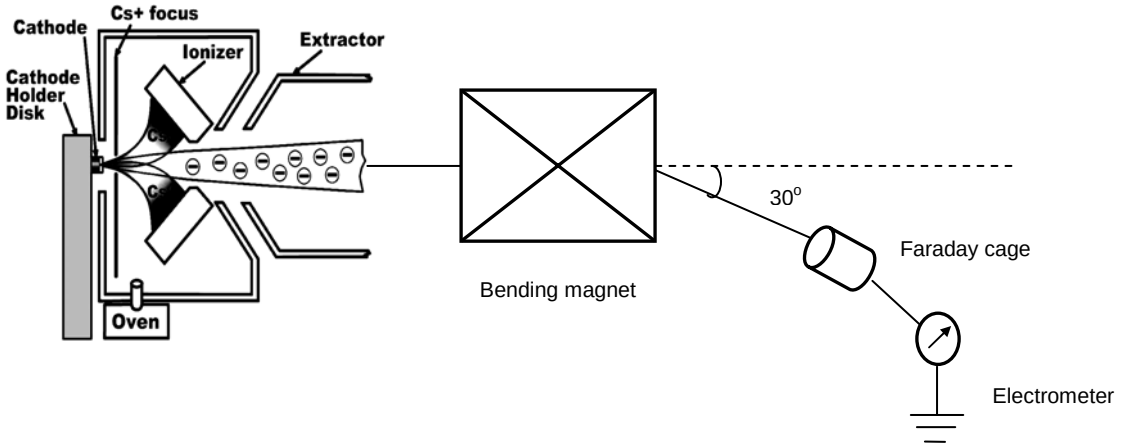

Figure 1. Schematic of experimental setup for Cs ions induced fragmentation.

carbon clusters from regenerative soot to coat carbon films on Al and Cu [15, 16]. In the present communication, mass spectra of C_{60} fragmentation are presented as a result of Cs ion bombardment at energies of 2-5 keV and compared with graphite under similar conditions.

2. Experimental

A schematic diagram of experimental set up is shown in Figure 1. Source of negative ions by cesium sputtering (SNICS) is used for fragmentation of C_{60} and graphite using 5MeV UDH Tandem accelerator. In SNICS cathode is a Cu capsule of dia 7 mm containing compressed C_{60} and graphite powder. A reservoir of Cs metal is heated in an oven to approximately 80°C to form vapours. These vapours rise to an enclosed region between the cooled cathode and the heated ionizer. The ionized Cs ions are accelerated towards the cathode which induces sputtering from the cathode surface. Pressure is maintained at 7 x 10^{-8} torr. 40 keV negative ion beams of fragments of C_{60} and graphite are extracted by varying cathode voltage from 2-5 keV. The beam is passed through the bending magnet of 1.69 T to obtain mass spectra at 30^{o} using Faraday cage.

3. Results and Discussion

Figure 2 shows the mass spectra obtained from the fragmentation of C_{60} by Cs ions. Figure 2 (a), (b), (c) and (d) are for Cs ion energies of 2, 3, 4 and 5 keV respectively. It is observed that carbon cluster intensity increases subsequently with higher energies. At 2 and 3 keV, carbon clusters upto C_5 are observed. At 4 keV a small kink of C_8 is also observed which grows at 5 keV. A small and broad peak is observed at 20 a.m.u which may correspond to water molecules. Other peaks observed at 16 and 31 a.m.u are likely to correspond to O and O_2/NO/N_2 respectively. Figure 3 depicts the spectra obtained from fragmentation of graphite under similar conditions. Here, increase in number of carbon clusters with increasing energy is also evident. For graphite, clusters upto C_4 are obtained in the spectra. C_3 and C_4 are observed only for 4 and 5 keV. We also get similar residual gas peaks as that of C_{60} for graphite. We calculate carbon cluster yield with respect to C_1 for both graphite and C_{60} as shown in Figure 4. Concentration of C_2 is the highest for both cases.

In graphite, carbon atoms are less tightly bound as compared to those in C_{60} that may affect the relative bond breaking efficiency which may be the reason of obvious difference in the intensities in two cases. The processes and the dynamics of fragmentation of C_{60} are considered to follow the same route as formation through insertion of C_2 in successive steps and it has been observed in our technique by prominence of C_2 yield compared to other clusters.

4. Conclusions

Mass analysis of fragmented species of C_{60} powder was performed and compared with graphite using sector magnet. The carbon cluster yield for C_{60} is much higher as compared to graphite which may be attributed to difference in

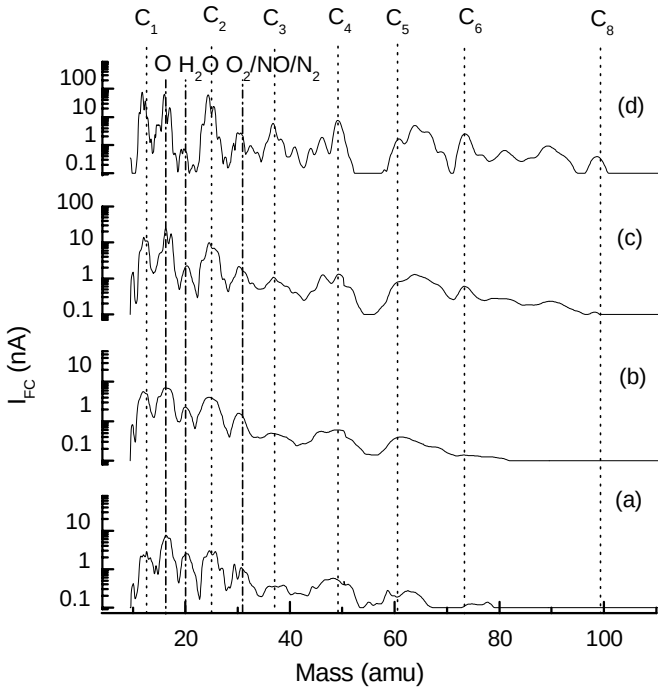

Figure 2. Mass spectra obtained from C_{60} fragmentation at (a) 2 keV (b) 3 keV (c) 4 keV (d) 5 keV.

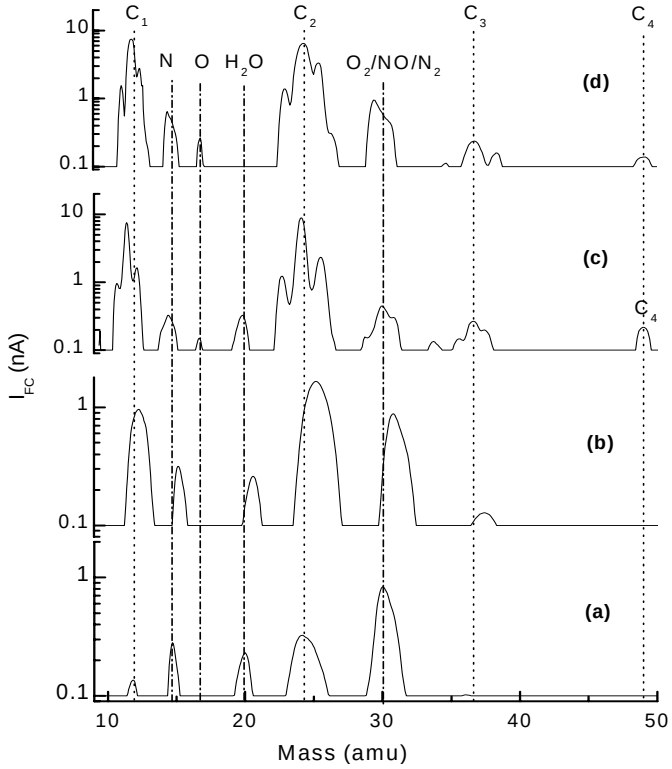

Figure 3. Mass spectra obtained from graphite fragmentation at (a) 2 keV (b) 3 keV (c) 4 keV (d) 5 keV.

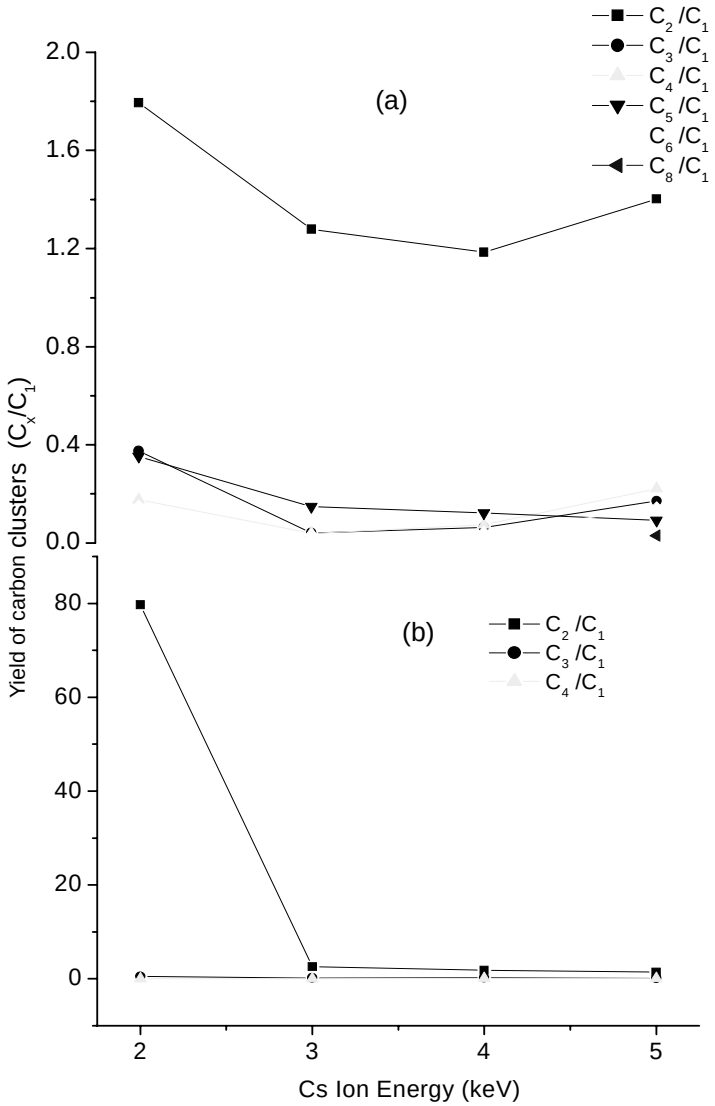

Figure 4. Yield of carbon clusters w.r.t. C_1 for fragmentation of (a) C_{60} (b) graphite.

bond energy of graphite and C_{60}. We have observed prominent C_2 yield as compared to other clusters which confirms addition of C_2 route for formation of C_{60} as predicted by previously proposed model.

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