

5 Atomic and Molecular Clusters

5.1 High energy fragmentation of C_{60}

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The coincidence experiment initiated last year¹ has been completed. The emphasis in this study is on multifragmentation where three or more fragments heavier than the carbon dimer are produced. This process is believed to be the dominant contributor to fragments in the size range of ten to thirty carbon atoms. The experimental apparatus enables us to scan the light fragment size distribution in coincidence with two heavier fragments with similar size.

The 45 keV $C_{60} + Ar$ ($E_{c.m.}=2370$ eV) reaction has been studied using a C_{60} beam incident on an Ar gas target. As an example of the triple coincidence results, the relative yield of different light fragment masses in coincidence with $n=18$ and $n=19$ is shown in Fig. 5.1-1. The three-fragment coincidence yield varies only weakly with light fragment mass over this size range. An enhancement of the yield of light fragments with an odd number of carbons is observed. This enhancement is also observed in double coincidence results for the light fragment size distribution in coincidence with either even or odd number heavy fragments. The observed effect probably results from energetic considerations on the sequential decay of heavier primary fragments. Both for chains and rings in the $n=4$ to 10 range (and presumably for larger n) the energy required for binary fragmentation of even- n clusters favors breakup into two odd- n fragments. In all cases the most energetically favored breakup split is the one in which a C_3 is one of the partners.

Similar results to those shown in the figure have been obtained for the light fragment distribution in triple coincidence with the $n=22,23$ heavy fragment pair.

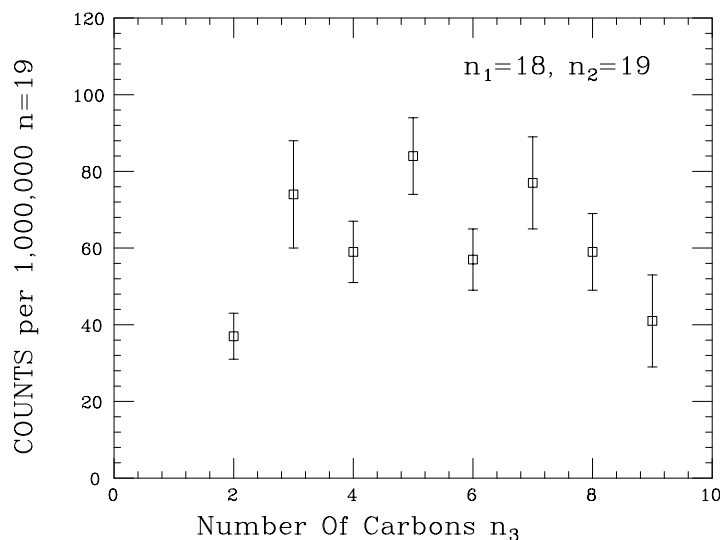


Figure 5.1-1. Relative yield of lighter coincident fragment when both an $n=18$ and an $n=19$ fragment has also been detected.

¹Nuclear Physics Laboratory Annual Report, University of Washington (2000) p. 67.

5.2 Search for gas phase dianions

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A search for small molecular species which can bind two electrons has been continued. Briefly, our method¹ consists of producing by sputtering an anion with an electropositive alkali or alkaline earth metal attached to the species whose dianion one is seeking. This anion is accelerated and focused on to a gas target where the anion is fragmented into a positive metal ion and the dianion of interest. Tentative results from a search for the gas phase dianion $\text{Si}_2\text{O}_5^{2-}$ were reported last year.² It has not been possible to obtain statistically convincing results for this anion from the fragmentation of the $\text{NaSi}_2\text{O}_5^-$ anion. The yield of the parent monoion from the sputtering of Na_2SiO_3 was rather low, and the upper limit of the dianion to monoanion yield was 2×10^{-4} . This is greater than might be expected for production of the dianion on the basis of previous results for the fragmentation mechanism for producing dianions. Thus no definitive statement can be made regarding the existence of this dianion.

Boldyrev and Simons³ have performed a theoretical search for small linear dianions. Linear species are of particular interest since our fragmentation method for producing dianions was first demonstrated on the linear anion RbC_9^- . They suggested that the $\text{Mg}_2\text{S}_3^{2-}$ dianion might be the smallest linear dianion. An attempt has been made to produce this dianion by fragmentation of the Mg_3S_3^- anion. A sputter source pellet made from mixed and finely ground Mg and S was sputtered with Cs in the usual way. Good yields of MgS and MgS_2 anions were produced, but the mass spectrum in the region of the hoped-for Mg_3S_3^- anion was very complex and low in yield. It was not possible to cleanly identify and fragment the anion of interest. Further progress will require finding a more prolific source of a suitable precursor anion.

¹R. Vandenbosch, D. I. Will, C. Cooper, B. Henry, and J. F. Liang, *Chem. Physics Lett.* **274**, 112 (1997).

²Nuclear Physics Laboratory Annual Report, University of Washington (2000) p. 68.

³A. Boldyrev and J. Simons, *J. Chem. Phys.* **98**, 4745 (1993).