ON THE INTERACTION OF FULLERENE IONS WITH ELECTRONS AND IONS

Hathiramani D., Bräuning H., Trassl R., Scheier P.(1), Presnyakov L.P.(2), Narits A.A.(2), Salzborn E.*

Institut für Kernphysik, Justus-Liebig-Universität, Leihgesterner Weg 217, D-35392 Giessen, Germany

(1)Institut für Ionenphysik, Universität Innsbruck, A-6020 Innsbruck, Austria

(2)P.N.Lebedev Physical Institute, 117924 Moscow, Russia

INTRODUCTION

Fullerenes have been the subject of intense research within the last decade. The interaction of these molecules with various projectiles, e.g. photons, electrons, ions and atoms, has been investigated extensively. In general, however, **neutral** fullerenes have been used as targets.

Employing the crossed-beams technique as described in [1,2] we have studied the interaction of electrons and ions, respectively, with fullerene **ions**.

ELECTRON-ION COLLISIONS

Single-ionization cross section measurements for fullerene ions C_{60}^{q+} have been performed for charge states q=1,2,3. These cross sections show a behaviour that has not been observed with any atomic or light molecular ion. After the typical increase above the ionization threshold, the cross sections remain constant over a large energy range. Furthermore, the cross sections do not show any structure which could be attributed to indirect ionization processes.

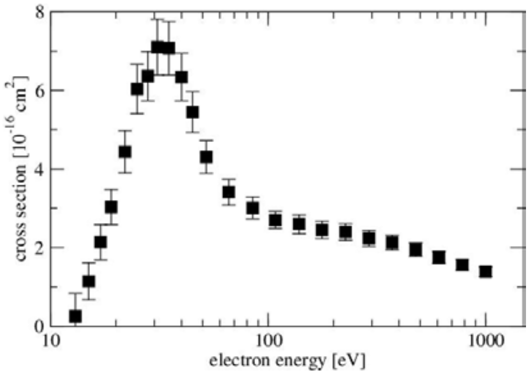

Fig. 1. Absolute cross section for C_2 fragmentation from C_{60}^+ by electron impact: $C_{60}^+ + e^- \rightarrow C_{58}^+ + ...$ The error bars indicate the total experimental uncertainties.

When energetic electrons collide with a C_{60}^{q+} molecule fragmentation may occur in addition to ionization. This mainly happens through the evaporation of neutral C_2 dimers. The measured cross section for the process $C_{60}^+ + e^- \rightarrow C_{58}^+ + ...$ is shown in figure 1. Cross sections for the same kind of reaction but with doubly and triply charged ions show the same shape differing mainly in the absolute value. The energy dependence suggests the presence of two different mechanisms as shown in figure 2.

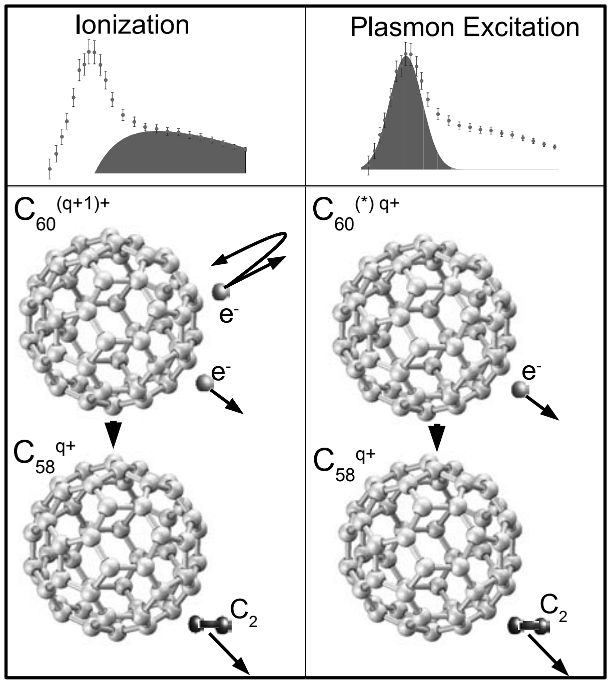

Fig. 2. C_2 fragmentation from C_{60}^{q+} by electron impact.

The high-energy part of the cross section for the reaction $C_{60}^{q+} \rightarrow C_{58}^{q+}$ can be fitted by the Lotz formula [3] which is able to describe direct ionization only (left side of figure 2). However, since the charge state of the reaction product is the

*Fax: +49 641 99 15109 E-mail: Erhard.Salzborn@strz.uni-giessen.de

same as that of the parent ion, the behaviour can be explained as an "unsuccessful ionization". This means that the outgoing electron has an energy which is low enough to be re-captured by the fullerene. The shape of the cross section at low energies is very similar to the giant plasmon resonance observed by Hertel [4]. It therefore suggests that at low electron impact energies, the fragmentation process induced by electron impact is predominantly caused by a plasmon excitation (right side of figure 2).

ION-ION COLLISIONS

In the first ever ion-ion crossed-beams experiments involving fullerene ions, we have studied electron transfer in the systems $He^{2+} + C_{60}^{+}$ and $C_{60}^{2+} + C_{60}^{+}$, respectively, at keV collision energies. As expected, the experimental cross section for the resonant system does not depend significantly on the collision energy. Surprisingly however, the absolute value is comparable to the electron transfer cross section obtained by Rohmund and Campbell [5] for the collision system $C_{60}^{+} + C_{60}$ at center-of-mass energies between 0.2 and 2 keV. Our experimental data is also in very good agreement with a model developed by Shen et al. [6] to explain double electron capture in the collision system $C_{70}^{3+} + C_{60}$. In their model the cross section is dominated by the cross section for single electron transfer in the intermediate system $C_{70}^{2+} + C_{60}^{+}$, which they evaluate using the dipole polarizability of C_{60}.

The use of a position sensitive detector to detect the C_{60}^{+} product ions after the collision allows us in principle to investigate possible fragmentation. However, beam optics currently allows us only to specify an upper limit for the production of C_{58}^{+} and C_{56}^{+} ions in the collision $C_{60}^{2+} + C_{60}^{+}$ □ $C_{n}^{+} + C_{60}^{2+}$ (with n=60, 58 and 56). The upper limits for fragmentation are 6.5% for C_{58}^{+} and 4.5% for C_{56}^{+}.

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