Auger-Electron Emission Following Fast (MeV) Molecular- and Atomic-Ion Impact on Thin C-foils

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Auger electron emission following the excitation of molecular (CO_2^+ and N_2^+) and atomic ions (C^+ and N^+) in thin carbon foils has been measured at MeV impact energies. Relative Auger electron yields from molecular-ion impact have been compared to that from atomic ion impact at equal ion velocities. Fig. 1 shows a comparison of continous electron spectra from 1 MeV C^+ and 2.33 MeV CO^+ ion impact on 5 $\mu g/cm^2$ C-Foils. Within the electron energy range the electron yield decreases by about 5 orders of magnitude. The structures are due to Auger electrons caused by target and projectile excitation. The spectrum produced with a 2.35-MeV CO^+ beam shows two distinct peaks due to Auger-electron emission from the two molecular partners.

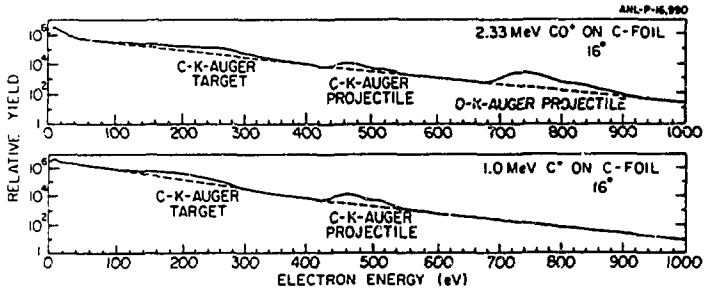

Fig. 1. Relative yield of secondary electrons versus electron energies up to 1000 eV. The electron emission is observed at 16° observation angle (w.r.t. beam axis).

The yields per incident ion are determined after background subtraction and integration of the remaining measured intensities from measurements at forward angle. It is found that the Auger yields from molecular ion impact are up to 40% lower than from the corresponding atomic beam impact. For the cases studied the inner-shell vacancy production and decay in the solid can be interpreted within the framework of the Fano-Lichten model.[2] Previous studies[3] have shown that in order to produce a K vacancy via rotational coupling, the distance of closest approach in the collision must be smaller than approximately 0.1 Å. The molecular bond length of e.g. N_2 is approximately 1 Å, this means that the chance of making two violent K-vacancy-producing collisions with the nitrogen atoms in a nitrogen molecule is negligible and, accordingly, can be ignored. This assumption, does not imply that the probability of producing a K vacancy in such collisions is insensitive to the molecular nature of the target.[3] The quasimolecule formed in the collision of a molecular ion with a target atom is rather complex. The decrease in the Auger-yield and therefore the inner shell vacancy fraction can be assumed to be due to the vicinity of the molecular partner atoms. The influence of the other atoms in the target molecule is felt through the mechanism determining the number of $2p\pi$ MO vacancies in the diatomic ion-atom system at small internuclear distances. Considering the nitrogen case, the internuclear distance of an N_2^+ molecule is about 2.2 a.u. This distance varies due to the Coulomb explosion in the foil target. A 1.5-MeV N_2^+ molecule extends to an internuclear distance of about 4.4 a.u. when the cluster molecule emerges from a 5 $\mu gr/cm^2$ carbon foil. These distances are comparable to internuclear distances where the radial coupling mechanism between MO's becomes effective in the individual quasimolecule (e.g.N + C) formed in the collision. An increase of the effective nuclear charge in the individual nitrogen atom due to the proximity of the partner atom can explain a decrease in the vacancy production via radial coupling. Therefore a decrease of vacancy transfer from the $2p\pi$ into the $2p\sigma$ and the increased effective nuclear charge in nitrogen could cause a reduction of the vacancy transfer probability int the K-shell of nitrogen.

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References

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