

Lawrence Berkeley National Laboratory

Recent Work

Title

SURFACE EFFECTS IN THE EJECTION OF ELECTRONS BY ELECTRONICALLY EXCITED MOLECULES

Permalink

<https://escholarship.org/uc/item/59j645x3>

Authors

Clampitt, R.
Newton, A.S.

Publication Date

1968-05-01

UCRL-18239

Cy J

University of California

Ernest O. Lawrence
Radiation Laboratory

TWO-WEEK LOAN COPY

This is a Library Circulating Copy
 which may be borrowed for two weeks.
 For a personal retention copy, call
 Tech. Info. Division, Ext. 5545

SURFACE EFFECTS IN THE EJECTION OF ELECTRONS

BY ELECTRONICALLY EXCITED MOLECULES

R. Clappitt and A. S. Newton

May 1968

RECEIVED
LAWRENCE
RADIATION LABORATORY

JUN 27 1968

LIBRARY AND
DOCUMENTS SECTION

Berkeley California

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

To be submitted to Surface Science
as "Letter to the Editor"

UCRL-18239
Preprint

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

SURFACE EFFECTS IN THE EJECTION OF ELECTRONS

BY ELECTRONICALLY EXCITED MOLECULES

R. Clampitt and A. S. Newton

May 1968

SURFACE EFFECTS IN THE EJECTION OF ELECTRONS
BY ELECTRONICALLY EXCITED MOLECULES*

R. Clampitt** and A. S. Newton

Lawrence Radiation Laboratory
University of California
Berkeley, California 94720

May 1968

The detection of electronically excited atoms and molecules by electron ejection from a metal surface¹) has provided a means for the study of such excited species for many years²⁻⁶). However, published curves showing the variation in gas-phase excitation cross-sections with bombarding electron energy, for a given species, differ considerably. Some such curves, often called 'excitation functions', for the production of N_2^* by gas-phase collisions with electrons, are shown in fig. 1, together with the types of surfaces used for detection. The sharp resonant $E^3_{\Sigma_g^+}$ state of nitrogen, first observed by Olmsted, Newton, and Street⁴), is clearly resolved in the two experiments (curves a and b) in which high resolution electron guns were used^{4,5}). We have shown, by a method of delayed-coincidence counting⁵), that the photon contribution to the nitrogen excitation function is negligible in the cases³⁻⁵) where the crossed molecule-electron beam method is employed. The differences in the shapes, therefore, might be attributed to the different surfaces used as detectors⁷). In our experiments, an ultra-high vacuum prevailed: the curve b is for a photo-sensitive detector surface, Cs_3Sb ,

* This work was supported by the U.S. Atomic Energy Commission

** PRESENT ADDRESS: The Culham Laboratory, Abingdon, Berks., England.

exhibiting an S-4 photoelectric response. This surface was obtained by removing the vacuum envelope of an RCA 931A photomultiplier in a detection chamber operating at ultra-high vacuum⁵).

Figure 2 shows the first differentials, for emphasis, of the nitrogen excitation function⁸) before and after deposition of cesium onto an antimony surface. The composition and photoelectric response of the cesium-coated surface are not known. It is seen that the coefficient of electron ejection does not change uniformly upon deposition of cesium, but varies with the state of electronic excitation of the molecule. In this particular case, a loosely bound cesium layer on an antimony surface, the following mechanism for the observed effect is suggested: By analogy with Penning ionization of atoms in the gas phase, the adsorbed cesium atom is ionized by the incoming excited particle: $Cs + M^* \rightarrow Cs^+ + M + e$. The free electron is drawn off the surface by an applied positive potential gradient and the yield of electrons versus excitation energy of the excited molecule will thus reflect the shape of the ionization efficiency curve for the production of Cs^+ by a Penning-like ionization process. Figure 3 shows the ionization efficiency curve of Tate and Smith⁹) for the production of Cs^+ by electron bombardment of cesium in the gas phase. There are two distinct changes in ion (or electron) yield, at respectively ~10 eV and ~15 eV, both of which could account for the shape of the curve of fig. 2(b).

Redhead has shown¹⁰) that the shape of the ionization efficiency curve for the production of O^+ , by electron bombardment of chemisorbed oxygen on molybdenum, is similar to that for the gas-phase production of O^+ from O atoms. His results also favour the interpretation of fig. 2 in terms of the above mechanism.

We conclude that, at least in the case of a cesium deposit (of unknown density) on an antimony surface, the coefficient of electron ejection varies with the excitation energy of the interacting particle. Also for this particular case, the correlation of fine structure in the excitation functions with spectroscopic states, may be erroneous because of the nonlinear variation of the coefficient of electron ejection. It is evident from this result that there is a need for more work, under conditions of ultra-high vacuum, on (i) the coefficients of electron ejection from atomically clean metal surfaces for molecules possessing different amounts of electronic potential energy, and (ii) on the effects of adsorbed molecules on the mechanism of electron ejection.

REFERENCES

- 1) H. W. Webb, Phys. Rev. 24 (1924) 113.
- 2) R. Dorrestein, Physica 9 (1942) 447 for early work; and, references 3 to 6 for more recent work.
- 3) W. Lichten, J. Chem. Phys. 26 (1957) 306.
- 4) J. Olmsted, Amos S. Newton and K. Street, J. Chem. Phys. 42 (1965) 2321.
- 5) R. Clampitt and Amos S. Newton, UCRL Report No. 18032, 1968.
- 6) H. F. Winters, J. Chem. Phys. 43 (1965) 926.
- 7) J. Olmsted has also suggested this recently: Radiation Research, 31 (1967) 191.
- 8) The $E^3_{\Sigma_g^+}$ resonant state is not clearly resolved in these curves because the electron gun was not used in a high-resolution mode.

- 9) J. T. Tate and P. T. Smith, Phys. Rev. 46 (1934) 773.
- 10) P. A. Redhead, Can. J. Phys. 42 (1964) 886.

FIGURE CAPTIONS

Fig. 1. Excitation functions for production of N_2^* by electron impact.

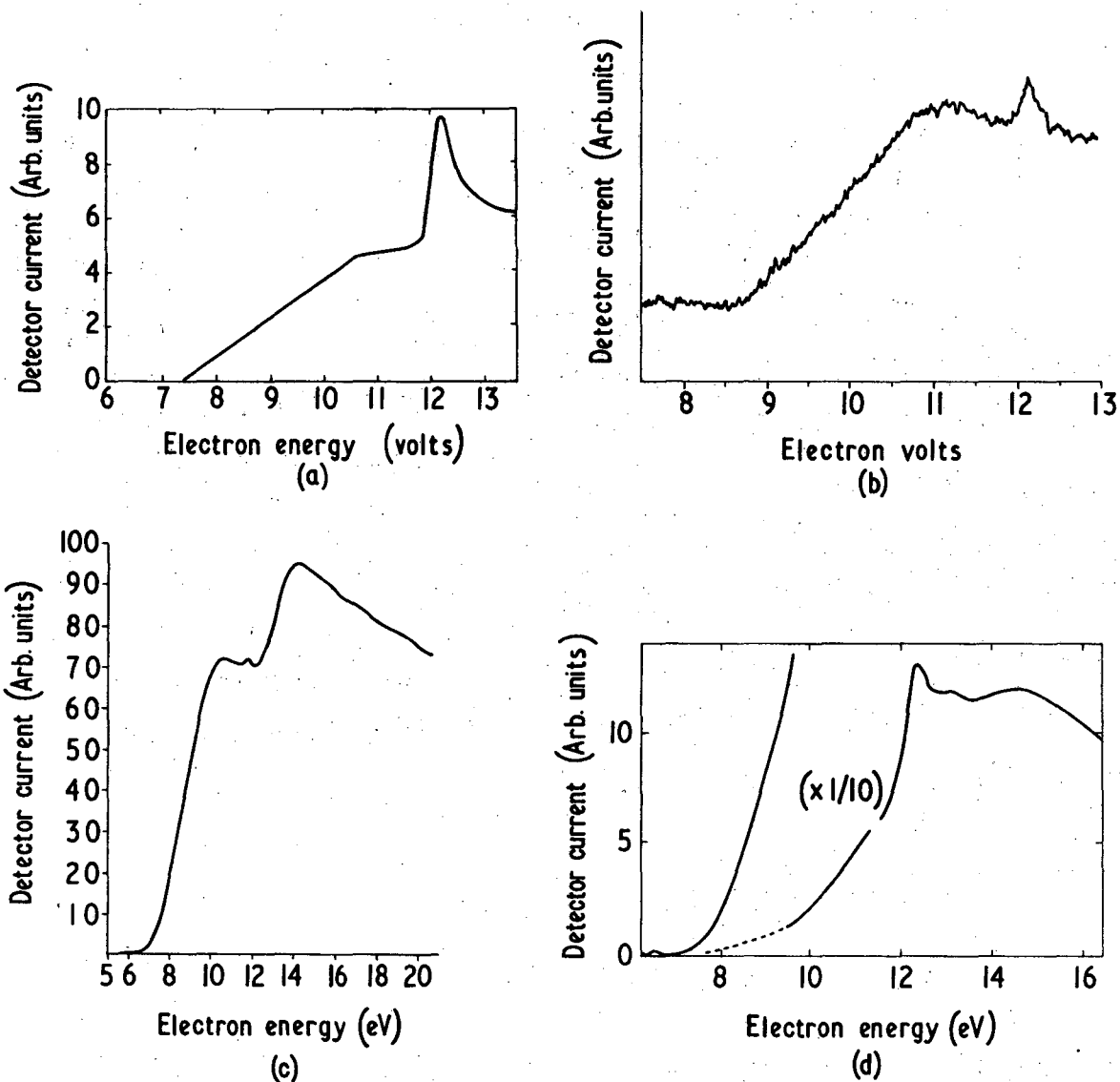
a) Ref. 4, Ag-Mg alloy surface; b) Ref. 5, Cs_3Sb surface;

c) Ref. 6, Ni surface; d) Ref. 3, Mg surface.

Fig. 2. First differentials of N_2^* excitation function.

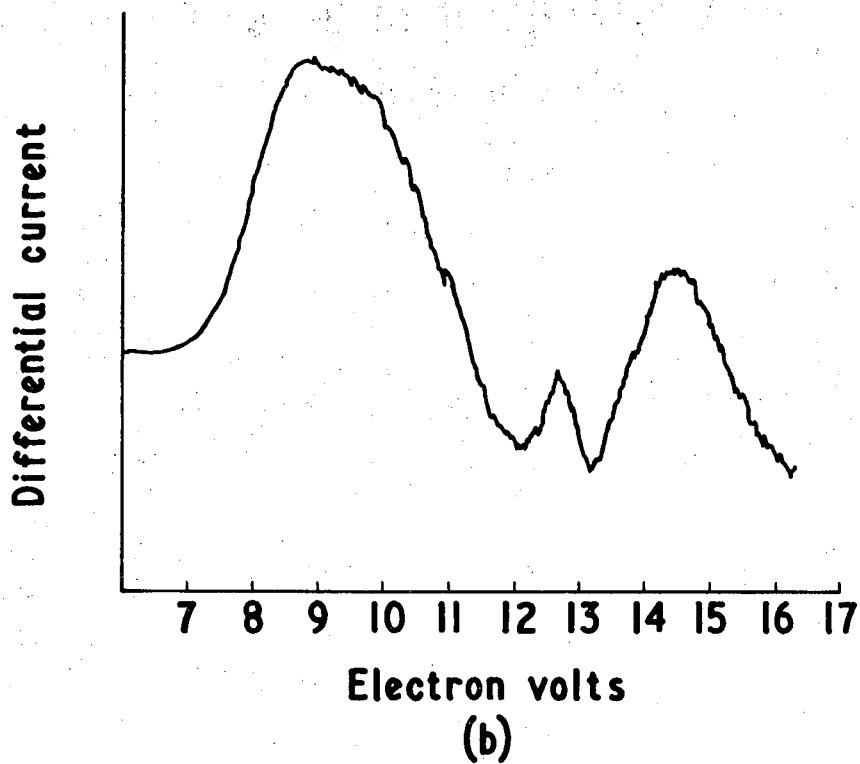
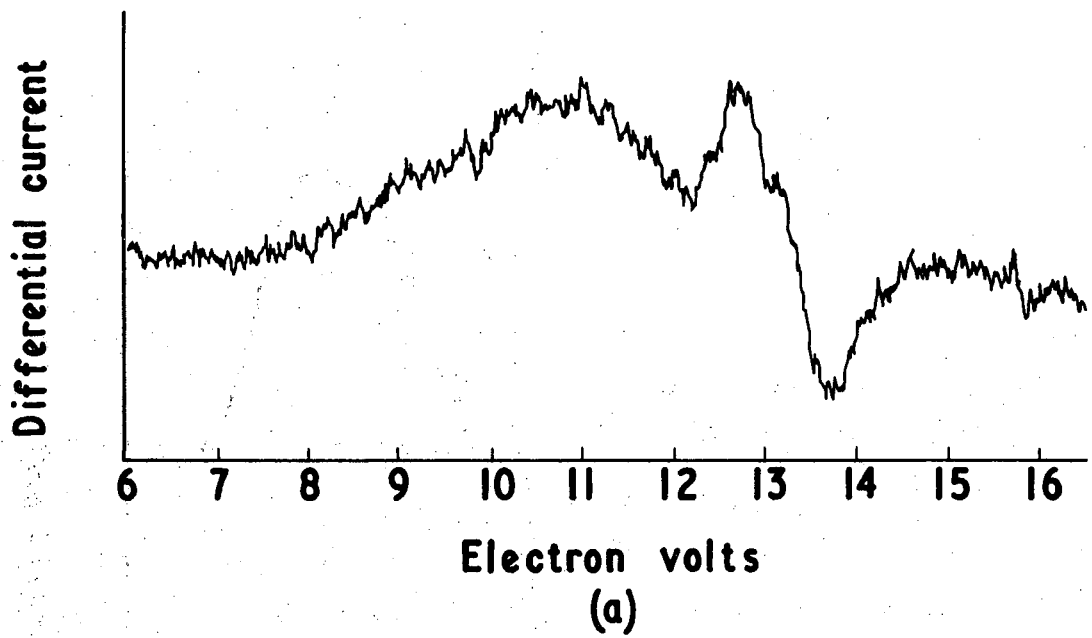
a) Sb surface; b) Cs deposit on Sb surface; detector current in b) is 100X that in a).

Fig. 3. Ionization efficiency curve for Cs^+ (after Tate and Smith).



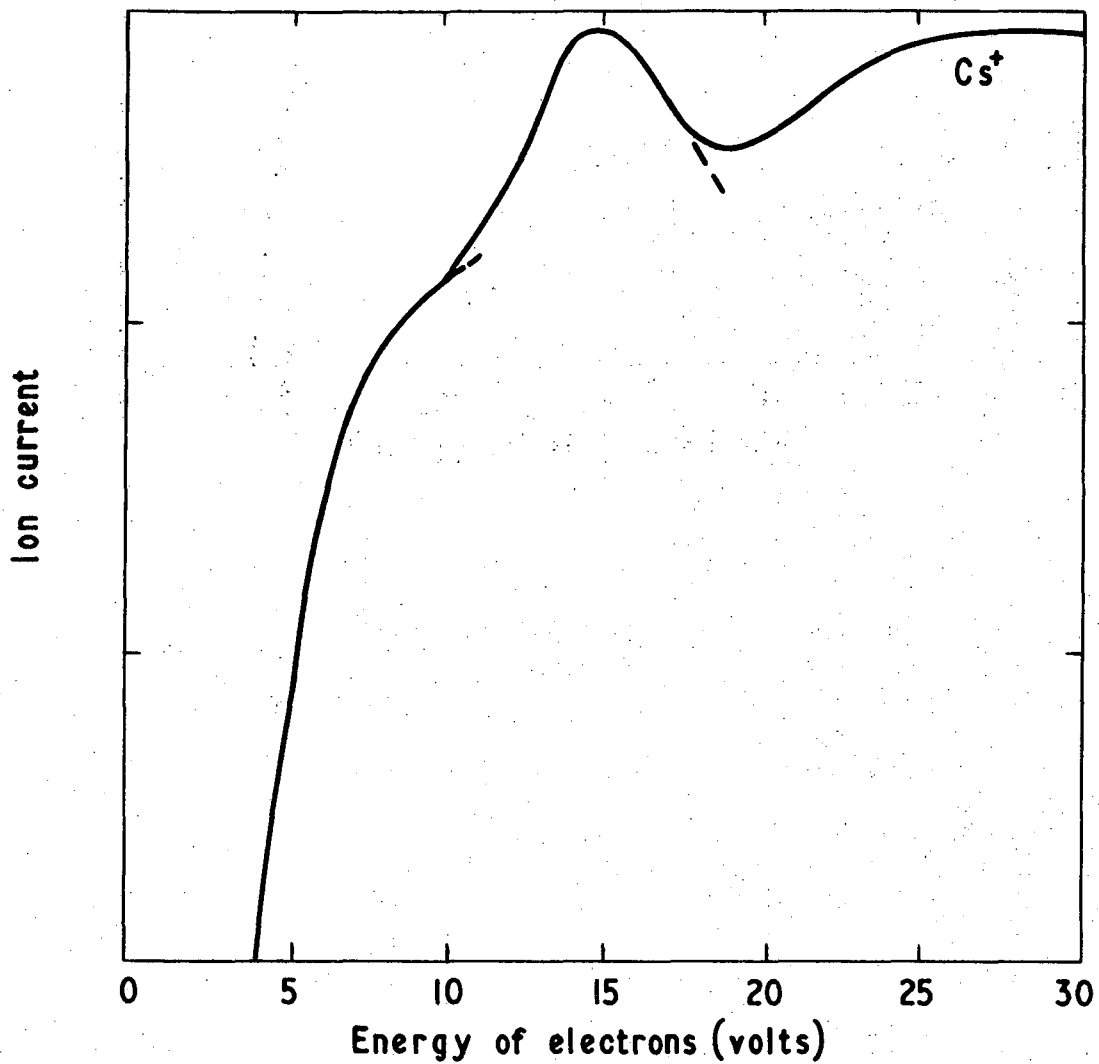
XBL 685-754

Fig. 1. Excitation functions for production of N_2^* by electron impact. a) Ref. 4, Ag-Mg alloy surface; b) Ref. 5, Cs_3Sb surface; c) Ref. 6, Ni surface; d) Ref. 3, Mg surface.



XBL 685-755

Fig. 2. First differentials of N_2^* excitation function.
a) Sb surface; b) Cs deposit on Sb surface; detector current in b) is 100x that in a).



XBL 685-756

Fig. 3. Ionization efficiency curve for Cs^+ (after Tate and Smith).

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

