Float Like a Butterfly, Sting Like a Bee!
Unheard of Low Energy Electrons Damage Biological Molecules!

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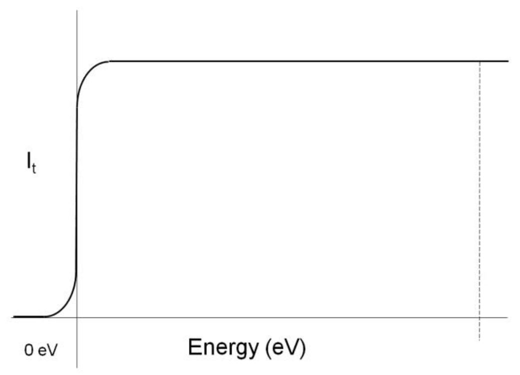
Background Information:

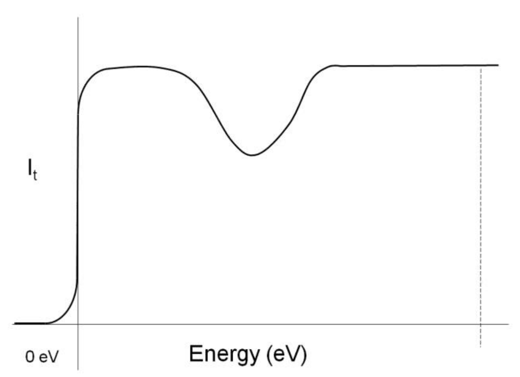
- In collision and scattering events, energy is measured in units of "electron volts" (eV). For example, a $1.5\ V$ AA battery can give an electron an energy of $1.5\ eV$.
- It has been known that high energy radiation and particles, such as X-rays and electrons around $1{,}000\ eV$ or higher, damage biological molecules.
- Our study has to do with, "do very low energy electrons with energies less than $10\ eV$ damage biological molecules?" References [1-4] show that electrons in the energy range of $(0.2-4)\ eV$ attach and damage DNA bases, break double and single strands of DNA, and damage selected Amino Acids.

Understanding Electron Transmission Spectroscopy (ETS):

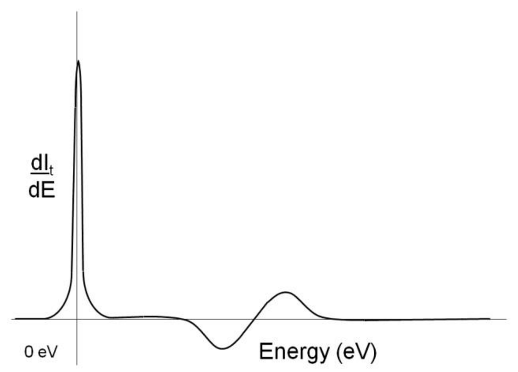
- In ETS, the energy of the electron we inject into the Lowest Unoccupied Molecular Orbital (LUMO) of molecules, in the gas phase, is measured. This energy is known as the Vertical Attachment Energy (VAE).



(A) A schematic of unattenuated electron beam current due to an empty collision cell



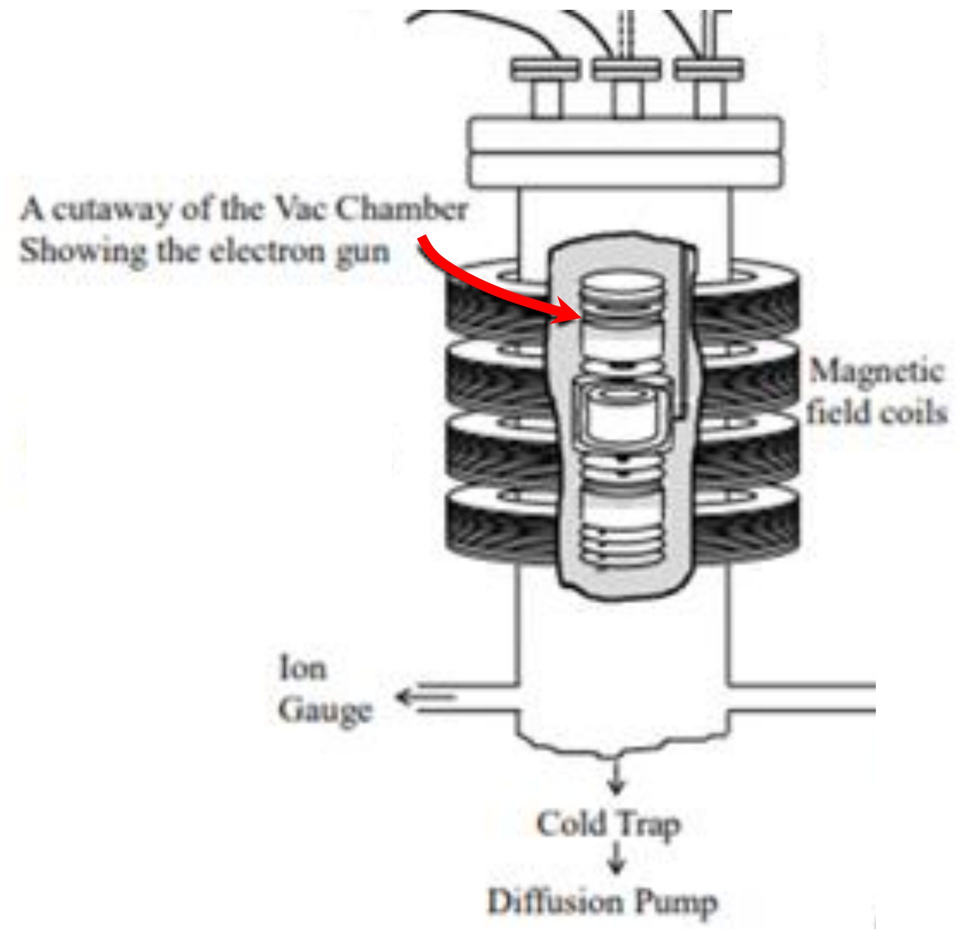
(B) A schematic of attenuated electron beam current with molecules in collision cell



(C) A schematic that shows Lock-in amplifier derivative method which enhances the detection of Electron Attachment (EA)

Our Experimental Setup:

Shown below is a cutaway of the vacuum chamber that contains the electron gun we use for ETS. Various vacuum pumps are utilized to pump the chamber pressure down to $\sim 1\times 10^{-7}\ Torr$ (for reference, here the room pressure is $\sim 760\ Torr$). Once the vacuum is established, the sample is heated into its gas phase and allowed into collision cell. Electrons are then emitted from a heated tungsten filament and tuned into a beam using a crossed electric and magnetic field. This beam is shot into the collision cell where the sample resides resulting in electron scattering and attachment.



Acknowledgments and References:

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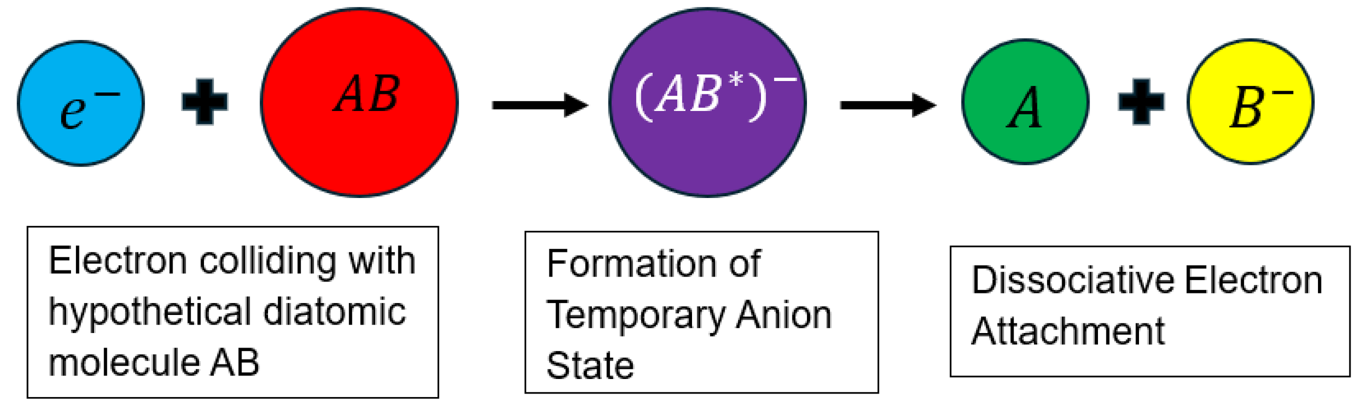
[1] A. M. Scheer, K. Aflatooni,* G.A. Gallup, and P.D. Burrow, Phys. Rev. Lett. **92** (2004) 068102
[2] K. Aflatooni, G.A. Gallup, and P.D. Burrow*, J. Phys. Chem. A **102**, 6205-6207 (1998)
[3] B. Boudaiffa, P. Cloutier, D. Hunting, M. A. Huels, and L. Sanche, Science **287,** 1658 (2000)
[4] K. Aflatooni, B. Hitt, G.A. Gallup, and P.D. Burrow, J. Chem. Phys. Vol. 115, No. 15 (2001)

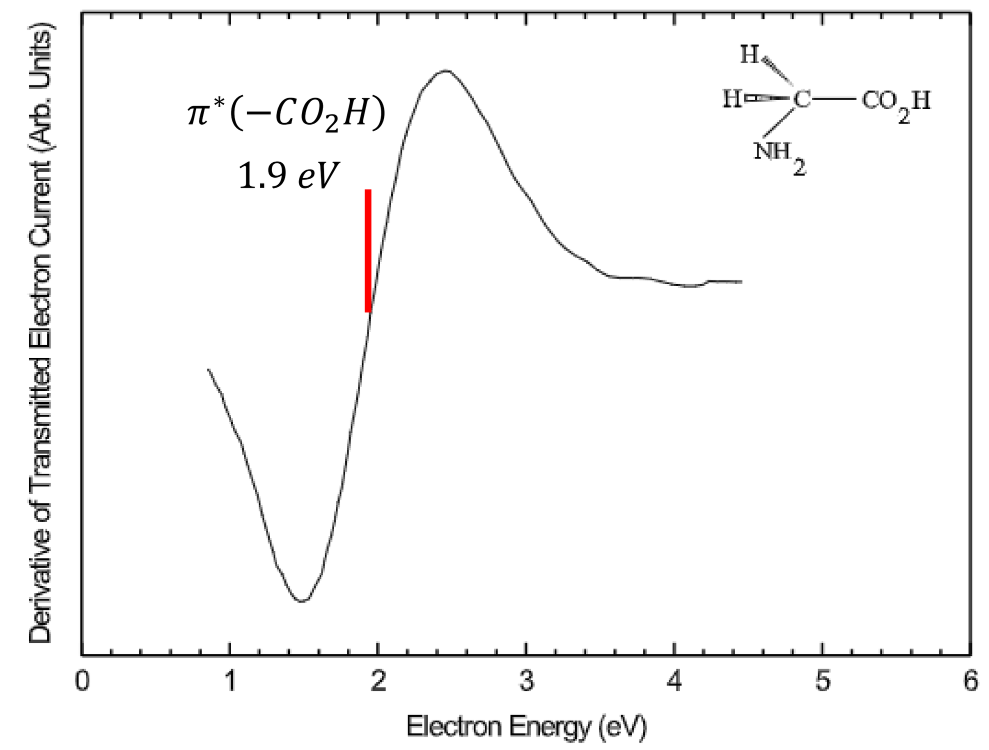
Results and Current Work:

- Attachment of a low energy electron to the LUMO of a molecule results in a temporary anion state (TNI). TNI may result in dissociation of the molecule. Shown below is a drawing of what is known as Dissociative Electron Attachment (DEA) process for a hypothetical diatomic molecule AB.



Previous Result:

- Shown to the right is our measurement of VAE to the LUMO of the amino acid Glycine. Our quantum chemical computations show that the LUMO is a π^* molecular orbital.



Current Work:

- Now we are measuring the first ever measurements of the VAE for the simplest of the proteins, Glycine-Glycine (Gly-Gly), in a gaseous phase.