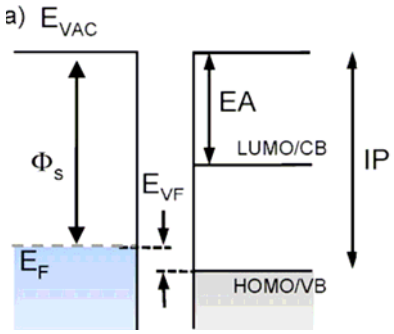
May 2011 Analytical Chemistry Cumulative Exam: "Classical Ultraviolet Photoelectron Spectroscopy of Polymers", based on paper of same title by W.R. Salaneck in J. Electr. Spect. Rel. Phenom. 174 (2009) 3

Prof. Luke Hanley, 10 May 2011

1. (10%) Write the equation in ultraviolet photoelectron spectroscopy (UPS) that relates binding energy to photoelectron energy.
2. (15%) Draw a simple experimental diagram of an instrument that can be used for UPS of polymers, labeling all the major parts, and noting at least one photon energy commonly used. Do not include vacuum pumps or sample transfer hardware (i.e., load locks).
3. (10%) Give one reason why UPS of polymers is performed only on very thin polymer films that are on top of electrically conductive substrates.
4. (10%) What electronic states of a polymer are probed by UPS and how are electronic structure calculations used to interpret UP spectra?
5. (20%) Define and explain the following terms in the figure below (at left), which describes the band edge alignment (energy level) scheme for a generalized semiconducting polymer-metal interface:



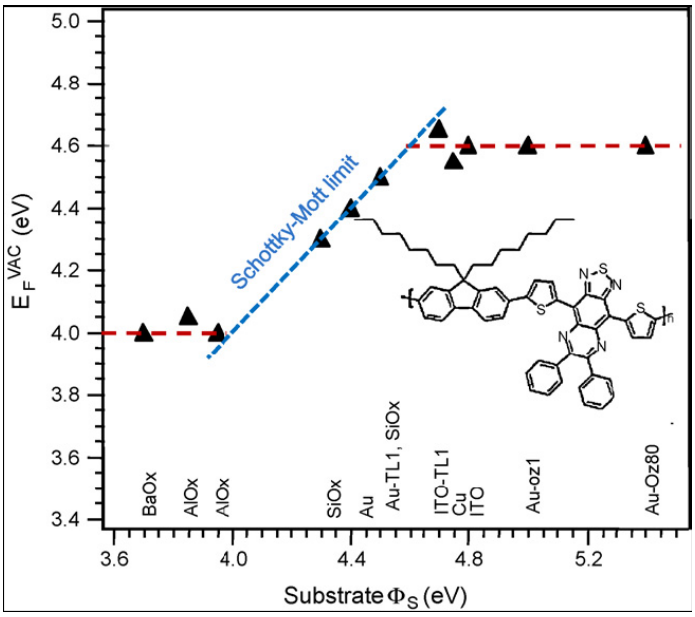
EA,

LUMO/CB,

HOMO/VB,

IP

6. The figure at right shows the position of the Fermi level, E^{VAC}_F or E_F, of a thin film of a semiconducting polymer (shown in inset) on top of several different metallic electrodes of varying substrate work function, Φ_S.



   (a) (15%) Part of the data follow very closely the Schottky–Mott limit line, where the Fermi level E^{VAC}_F is linearly dependent on the substrate work function Φ_S with a slope of unity. Explain this using the diagram above left. Describe in plain language what this means for the polymer interaction with the substrate.

   (b) (10%) Part of the data shows the Fermi level E^{VAC}_F to be independent of the substrate work function Φ_S with slope of zero (horizontal lines). Explain this using the diagram above left. Describe in plain language what this means for the polymer interaction with the substrate.

7. (10%) Frank Osterloh's seminar in the department on May 4 mentioned another completely different analytical method that can provide similar information as this type of UPS data. Name that method.