ANALYTICAL ANSWERS

Electron Spectroscopy for Chemical Analysis (ESCA)

Electron Spectroscopy for Chemical Analysis (ESCA), also called X-ray Photoelectron Spectroscopy (XPS), is a surface analysis technique that provides composition and chemical bonding information on the surface of the sample. ESCA can detect all elements except hydrogen and helium. The elemental detection limit is typically in the vicinity of 0.5 atomic percent. ESCA can also frequently determine the chemical state of elements including the nature of chemical bonding. The technique can be used on both conductive and insulting samples so it has a wide application in both organic and inorganic systems

Applications:

Materials Evaluation

Oxidation states
Identification of polymeric coatings
Surface compound identification
Surface composition
Plasma treatment
Anti-reflection coatings

Failure Analysis

Corrosion product
Breakdown of lubricants
Material delamination
Discoloration of epoxy
Chemical degradation of surfaces
Catalyst poisoning

Quality Control

Breakdown of surface lubricants
Chemical degradation of surfaces
Adhesion failures
Identification of organic contamination

Principle of Operation:

Electron Spectroscopy for Chemical Analysis (ESCA) uses a probe beam of X-rays of a single energy. Since it is difficult to focus X-rays, the beam diameter is typically 5 - 10 mm for a traditional X-ray source and 0.5 - 3 mm for a monochromatic X-ray source. The X-rays penetrate several micrometers into the sample at typical ESCA source energies, liberating electrons from the atoms of the sample. The kinetic energy of the liberated electron is the known energy of the X-ray photon minus the binding energy of the electron in the atom. Measuring the kinetic energy of the electron as it is collected therefore allows the binding energy to be computed. The binding energy tells us not only what element the electron came from, but also what chemical state the atom was in. Since the escape depth for low energy electrons is 1 - 10 nm, ESCA is very surface sensitive. As in SAM, an argon ion sputter gun can be used to remove surface layers and to monitor changes in composition as a function of depth.

“Small spot ESCA” derives its name from the ability of its electron analyzer to aperture down the area seen on the sample to an area as small as 75 microns diameter. This feature, coupled with a high strength, relatively small beam X-ray source, provides the capability to extend chemical analysis to features smaller than 100 microns wide.

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Data Output:

ESCA spectra are usually plotted as the number of electrons versus electron binding energy. A "survey" spectrum usually includes the energy range of 0 eV to 1100 eV and is used to determine the elemental composition of the sample surface. A "high resolution" spectrum usually covers a narrower energy range spanning 10-30 eV and is used to determine subtle peak shape and peak energy changes. With curve fitting software, these spectral changes can be interpreted to determine the chemistry or oxidation state of the sample surface.

Sample Constraints:

The ESCA sample can be up to 60 mm diameter X 20 mm high in size. Insulators, thin films, powders and organics can be analyzed. The sample must be compatible with a vacuum of 10^{-7} to 10^{-10} torr, i.e., non-volatile.