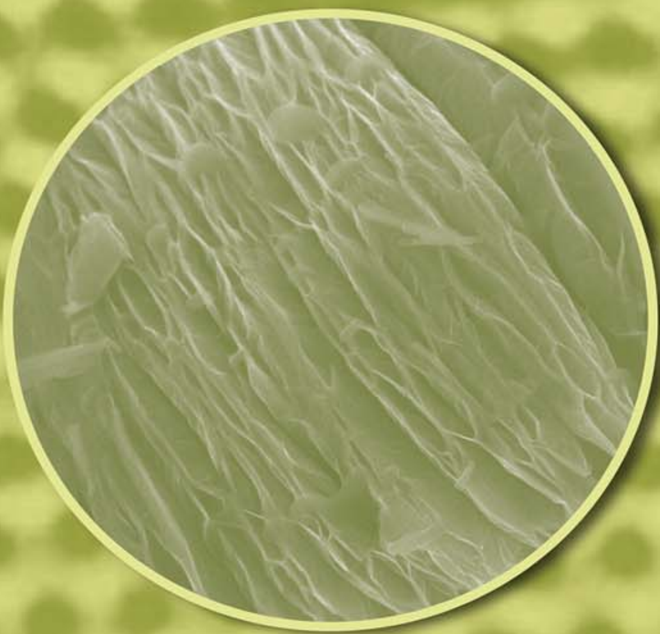
NANOLAYER RESEARCH

METHODOLOGY AND TECHNOLOGY FOR GREEN CHEMISTRY

TOYOKO IMAE



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CHAPTER 8

Nanolayer Analysis by Photoelectron Spectroscopy

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8.1 Principle of Photoelectron Spectroscopy

Photoelectron spectroscopy (PES), or photoemission spectroscopy, is one of the most important and useful techniques for investigating electronic and chemical states in solids, especially in nanolayers because of its high-energy resolution and surface sensitivity [1–5]. The physics behind PES is an application of the photoelectric effect. Through photoelectric ionization by irradiating samples with X-rays, vacuum ultraviolet (VUV) or ultraviolet (UV) light, the energies of the emitted photoelectrons are characteristic of their original electronic and chemical states. Therefore PES is one of the most sensitive and accurate techniques for measuring the energies and shapes of electronic states and molecular orbitals. X-ray photoelectron spectroscopy (XPS) was developed by Kai Siegbahn in 1957 and is used to study the energy levels of atomic core electrons, mainly in solids. Siegbahn referred to the technique as electron spectroscopy for chemical analysis (ESCA), since chemical structure can be determined by analyzing the core levels with small chemical shifts depending on the chemical environment of the atom. Siegbahn was awarded the Nobel Prize in Physics in 1981.

Since photoelectrons can escape only from the surface region ranging from a monolayer or nanolayer to several tens of nanometers, depending on incident photon energy and sample materials, only the surface layer or nanolayers can be analyzed, as shown in Fig. 8.1. [6]. Therefore clean ultrahigh vacuum (UHV) condition is strongly required. The emitted photoelectrons are energy analyzed, resulting in a spectrum of electron intensity as a function of the measured kinetic energy. The kinetic energy values E_k can be converted into binding energy values E_B by using the equation: $E_k = h\nu - E_B - \phi$. Here, $h\nu$ is the energy of incident photons, and ϕ is the work function. Synchrotron radiation source is the most promising light because of its brightness, cleanness, variation of energy, directionality, linear and circular polarizability, and pulse character [6–8]. Taking advantage of these characteristics, ultrahigh energy resolution analysis, surface and bulk sensitive analysis, nanospace analysis, magnetic property

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