A148 Forensic Characterization of Surface-Modified Fibers Via X-Ray Photoelectron Spectroscopy

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After attending this presentation, attendees will understand how x-ray photoelectron spectroscopy may be used to characterize fibers that have received one or more surface modification treatments.

This presentation will impact the forensic science community by showing how single fibers (one of the most common and most important types of trace evidence) may be subcategorized by using x-ray photoelectron spectroscopy to detect and characterize any thin surface modification layers.

X-ray photoelectron spectroscopy (XPS) is virtually unknown to forensic science. X-ray photoelectron spectroscopy (XPS) is a quantitative spectroscopic technique that measures the elemental composition, empirical formula, chemical state and electronic state of the elements that exist within a material. XPS requires ultra-high vacuum (UHV) conditions. XPS spectra are obtained by irradiating a material with a monochromatic beam of X-rays while simultaneously measuring the kinetic energy and number of electrons that escape from the top 1 to 10nm of the material being analyzed.

A proof of concept study shows that via XPS single fibers, that in all other respects are identical, may be characterized and distinguished if one fiber has no surface modification while the other does, or if one fiber has one manufacturer's proprietary surface modification while the other has some other manufacturer's (different) proprietary surface modification.

Today most fabrics have received one or more type of surface-modification treatment such as stain resistance, permanent press, or water proofing. For example, white cotton fibers are so common and have so few distinguishing features that today they are largely ignored by forensic scientists. XPS can distinguish, on a single fiber basis, between the following otherwise identical cotton fibers:

1. white cotton fiber with no surface modification,
2. white cotton fiber with some type of silicone surface modification,
3. white cotton fibers that have a surface modification (some type of fluorocarbon) applied by a plasma process,
4. white cotton fiber with some type of silicone surface modification plus the 3M Company's surface modification treatment (some type of fluorocarbon applied by a wet process),
5. white cotton fiber with some type of silicone surface modification plus some other company's (not specified) proprietary surface modification treatment (some type of fluorocarbon applied by a wet process but different than 3M's).

All elements except hydrogen and helium may be detected and measured by XPS. Low resolution survey spectra identify all the elements in the surface layer and their relative abundances, while separately for each element high resolution spectra show the different bonding states and the relative amounts for each state for a particular element. Because carbon can exist in so many different bonding states, XPS is particularly effective in characterizing different types of polymers that exist as thin surface layers.

Additionally, the thickness of a very thin surface layer, as well as the change in composition below it, may be determined by angle-resolved XPS. As with hammering in a nail at an acute angle compared to the normal, the penetration of the x-ray beam into (perpendicular) the sample is decreased as the angle become more acute.

Also, through XPS Imaging the coverage in the x,y plane of a given element may be mapped. It will be shown that by mapping for F the extent of coverage of a thin fluorocarbon surface layer may be determined on a single fiber.

This presentation will show how, from just a single fiber x-ray, photoelectron spectroscopy (XPS) can nondestructively distinguish these surface modifications.

Fibers, Surface Modifications, X-Ray Photoelectron Spectroscopy

