B54 Forensic Examination of Oriented Polymer Films: Polarized Light Examinations of Packaging and Shipping Tapes

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After attending this presentation, attendees will understand the nature of mon-axially and bi-axially oriented polypropylene polymer films, which are widely used in the manufacture of packaging, shipping, mailing, and moving tapes. Attendees will also understand the role that polarized light microscopy can play in the forensic analysis of such polymer films. Attendees will understand the potential for the application of digital photomicrography and digital image analysis to the forensic analysis of polymer films in commercial products such as packaging, shipping, mailing, or moving tapes.

This presentation will impact the forensic science community by emphasizing the continuing value of simple analytical tools such as polarized light microscopy, particularly when this tool is enhanced with digital photography and digital image analysis.

Because polymer films produced commercially are typically composed of polyethylene, polypropylene, or polyesters, Infrared Spectrometry (IR) has limited utility for making brand identifications. The physical characteristics of these films may be more useful in making such identifications. Amorphous polymer films are optically isotropic and appear dark at all orientations between crossed polarizing filters. On the other hand, crystalline films may have up to three indices of refraction: one parallel to the direction of extrusion of the film (sometimes called the machine direction), one perpendicular to the machine direction in the plane of the film, and a third perpendicular to the film plane. Crystalline films are birefringent; they will also show classic bi-axial interference figures.

Commercial tape products variously designated packaging, shipping, mailing or moving tapes are frequently made of polypropylene films. During manufacture, the film may be stretched only in the machine direction, resulting in a Mono-Axially Oriented Polypropylene (MOPP) film; if the film is also stretched perpendicular to the machine direction, the result is a Bi-Axially Oriented Polypropylene (BOPP) film. Both MOPP and BOPP tapes are birefringent; however, when specimens of BOPP tapes are examined with a polarizing microscope and are rotated slightly away from extinction, they display crosshatched patterns.

This research explored the application of digital photomicrography and digital image processing to the forensic examination of packaging tapes. Seventeen samples of 5cm (two inch) nominal width clear packaging tape, representing seven different brands, were examined. Small strips were cut from each tape sample and mounted on microscope slides directly, using the tapes' adhesives. Care was taken to retain at least one machine edge. Slide mounts were also prepared by stripping the adhesive from the tape backing using a mixture of xylenes. Again, small strips were cut from each tape sample, care being taken again to keep one machine edge intact. The adhesive layers were removed to facilitate thickness measurements of the tape backing. Thickness measurements were made in triplicate on each cleaned strip of tape using a calibrated digital caliper. Finally, the cleaned strips of tape backing were mounted in a medium having n_D=1.54. Each slide was viewed under a polarized light microscope equipped with a ten-megapixel digital camera. Digital photomicrographs of the tape samples were taken: (1) at maximum birefringence; (2) at extinction; and, (3) just past extinction to display the crosshatched patterns characteristic of BOPP polymer films. The tapes' extinction angles (defined as the smallest angle between the machine edge of the tape when it is at extinction and an analyzer or polarizer direction) were measured using the camera's software. The discrete 2D Fourier transform was applied to the digital images of the crosshatched patterns of the BOPP tapes.

The thicknesses of the tape backings provided little discrimination among samples; however, different brands of tape often showed different interference colors, even when the thicknesses of the backings were the same. Rolls of the same brand and type of tape could sometimes be differentiated by differences in interference colors. The extinction angles of the tapes varied from 0° (parallel extinction) to 13.5°. There were differences between brands but also between rolls of the same brand and type of tape. The crosshatched patterns of the BOPP tapes consisted of mosaics of diamond shapes. The diamonds differed in size and in the angles made by their sides. Several different types of crosshatched patterns were found. The discrete 2D Fourier transforms of the crosshatched patterns provided a simple method for comparing the crosshatched patterns.

Polarized Light Microscopy, Polymer Films, Fourier Transform