TECHNICAL NOTE

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Collection of Fiber Evidence Using Water-Soluble Cellophane Tape

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ABSTRACT: The collection and preservation of microtraces, such as fibers, using cellophane tape is generally accepted as being very practical and efficient. At the scene of a crime, for example, this means of sample collection is both easy and rapid, which explains in part its popularity. However, in addition to a very low specificity (high background), this technique suffers from one major disadvantage: the microtraces must undergo a long and tedious pretreatment before any detailed analysis is possible. This pretreatment involves the isolation and separation of the microtrace from the tape, followed by a solvent wash (usually with xylene) to remove all trace of the adhesive.

A recently commercialized product alleviates some of the problems associated with sample collection by this means: "Mask Plus II" (No. 5414, Scotch™, St-Paul, MN) is a new cellophane tape that is completely soluble in water. Microtrace collection can be performed with this tape by the conventional lifting procedure. In the laboratory, the microtraces may then be conveniently released from the tape by immersion in warm water (60°C) with continual agitation. After solubilization of the cellophane tape, the microtraces are isolated by membrane filtration then allowed to air dry.

The described technique has been thoroughly evaluated for fiber collection with comparison of the results with those obtained using conventional cellophane tape. Particular attention has been paid to operating conditions (temperature, humidity, conservation, etc.), collection efficiency, as well as possible alterations to the fibers themselves.

KEYWORDS: criminalistics, fiber evidence, microtrace collection, water-soluble cellophane tape, Mask Plus II, Cellux

The method of collecting and preserving microscopic trace evidence using cellophane tape, as proposed by Frei-Sulzer in 1951 [*1*], is widely employed in forensic science. The technique permits an optimum, rapid, and easy means of collecting invisible traces that may go undetected by other collection procedures. Unfortunately, with the use of cellophane tape, the recuperation of microtraces is time-consuming and tedious. The time saved during

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the collection of evidence at the scene is rapidly lost in the laboratory. This is one of the major disadvantages of the technique. A practical solution has never really been found, despite the presentation of several refined procedures [*2–4*].

However, in 1992, Wickenheiser proposed a method for recuperating textile fibers from tape lifts by dissolving the cellophane tape in an appropriate solvent (xylene, toluene, or carbon tetrachloride) followed by vacuum filtration [*5*]. The principle is interesting, but the use of relatively large volumes of organic solvents is a major disadvantage. In addition, the organic solvent does not always successfully dissolve the plastic support of the tape. These problems may be potentially overcome with the arrival on the market of a cellophane tape composed of a PVA (polyvinyl alcohol) support and a synthetic adhesive; both completely soluble in water: *Mask Plus II* (Scotch™ 3M, N° 5414, St-Paul, MN).

The purpose of this project was to evaluate this new cellophane tape by comparing its characteristics with a tape currently used for microtrace collection by police services in Switzerland.

Material and Methods

Fiber Evidence Collection

Fiber evidence collection is performed with *Mask Plus II* in the same fashion as for conventional cellophane tape. On returning to the laboratory, the tape lift is immersed in a beaker of distilled (or deionized) water and heated to 60°C with stirring in order to totally dissolve the tape support and adhesive (2 to 3 minutes required). The resulting suspension of trace evidence is then filtered using a vacuum filtration system (GV 050/0 glass holder and ME27 cellulose acetate/cellulose nitrate filter membranes, 47 mm diameter, 0.8 mm pore size; Schleicher & Schuell, Feldbach, Switzerland) (Fig. 1). Once dried (at room temperature and pressure, or preferably in a vacuum desiccator), the trace evidence may be readily subjected to the conventional sequence of analyses without any additional treatment.

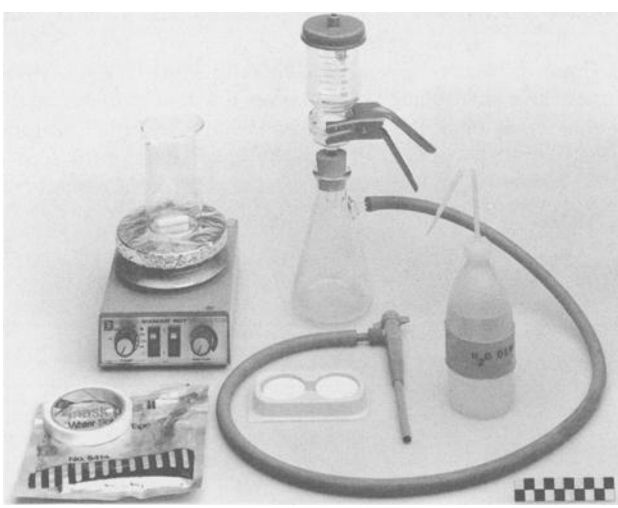

FIG. 1—*Mask Plus II water-soluble cellophane tape and vacuum filtration system.*

Evaluation of Mask Plus II

In order to be successfully applied to the collection of fibers, or other microtraces, *Mask Plus II* must respond to certain requirements relative to its support and adhesive. These requirements have already been defined for traditional cellophane tape by Martin in 1966 [*6*]. Several characteristics, however, become redundant as the trace evidence is neither observed nor conserved while in contact with this new tape (this is notably the case for conditions defining the transparency and the stability of the product with time). In the end, this new tape must meet the requirements indicated in Table 1. These characteristics were examined in detail, and the results compared to those obtained using *Cellux 760* (Cellux AG, Rorschach, Switzerland) cellophane tape.

Adhesive Efficiency—The efficiency of *Mask Plus II* was evaluated for the collection of textile fibers transferred onto two different car seats (100% wool and 100% polyester, respectively). One person took the driver's seat and mimicked standard gestures of driving for a period of 4 minutes. Different types of clothing were worn: a woolen sweater (100% wool), a cotton sweater (100% cotton), and a blouse composed of a mixture of polyester (70%), rayon (20%) and flax (10%). All clothing was marked with the luminescent stain rhodamine 6G (resistant to washing at 60°C). Fiber collections were successively performed with the two cellophane tapes on two different zones of the car seats. A filtered light source (Polilight®, Rofin, Australia) operating at 530 nm was used to count luminescent fibers remaining on the car seat after the tape lifts had been performed (observation wavelength = 590 nm). The luminescent fibers collected by each tape were counted under the same conditions, before and after isolation of the fibers by filtration. The percentage of fibers collected divided by the total number of fibers transferred gives the collection efficiency of the cellophane tape [*7*].

Temperature and Humidity Effects—Samples of the two different cellophane tapes, *Mask Plus II* and *Cellux 760*, were placed on a glass support, without being stuck down, for a period of thirty minutes at the following temperatures: −67°C (freezer), 6°C (refrigerator), and from 30 to 100°C in 10° steps (laboratory oven). Samples were also stored in a container for a period of 30 minutes under controlled conditions: 22°C and relative humidity levels from 30 to 95%. Fiber lifts were then performed on a piece of cotton cloth in order to compare the adhesive efficiency at different temperature and humidity conditions.

Alteration of Trace Evidence—Given the generally short length of time between fiber collection on the adhesive and isolation by filtration, it would be expected that no significant modification or contamination of the fibers would occur. Nevertheless, this possibility was investigated by leaving fibers in contact with the tape adhesive for a period of 24 hours (this corresponding to a reasonable delay). Different samples of natural (wool, cotton, and

TABLE 1—*Characteristics required in a water-soluble cellophane tape in order to be applied to the collection of microtraces.*

Support	Adhesive
≥2.5 cm wide	Efficient for trace evidence collection
Resistant	Not aggressive towards trace evidence
Flexible	Soluble in water
Easy to break with the hands	Efficient over a large range of temperatures
Not sensitive to temperature changes	Efficient over a large range of relative humidity
Packaging to avoid contamination	

flax) and synthetic fibers (polyester and acrylic) were collected using both tweezers (control samples) and cellophane tape (*Mask Plus II* and *Cellux 760*). The samples were then analyzed by microscopy (Laborlux S microscope fitted with 25x and 40x objectives, Leitz) and two common instrumental methods, Fourier transform infrared microspectrometry (micro-FTIR) and pyrolysis gas chromatography (Py-GC), under the conditions indicated in Table 2.

Results

General Characteristics

Mask Plus II, as for *Cellux 760,* is sold as a 2.5 cm wide tape, which is considered as the minimum width required in order to be efficient and practical.

At ambient temperature, both tapes show good resistance and flexibility. *Mask Plus II* not only has an equivalent resistance to *Cellux 760,* but it may also be stretched up to one and a half times its original length, which is an advantage for reaching places where access is difficult and for lifting traces off uneven surfaces.

As for *Cellux 760, Mask Plus II* may be readily broken with the hands. It is therefore, in this regard, easy to use.

Efficiency

The results (Table 3) show that the collection efficiency remains nearly constant for each combination of clothing/seat and for both types of cellophane tape (*Mask Plus II* or *Cellux 760*). The results also agree with those reported by Pounds for tape with strong adhesive power [7].

TABLE 2—*Experimental conditions of the instrumental analyses performed in this study.*

Technique	Experimental conditions
Micro-FTIR:	Galaxy 4020 FTIR spectrometer, Mattson, coupled to a Spectra-Tech Analytical FTIR microscope (15× Cassegrain); measurement in the transmission mode, spectral range 4000–700 cm^{-1}, resolution 8 cm^{-1}, 200 background and sample scans, MCT detector, moving mirror velocity 0.8 cm/s.
Py-GC:	CDS Pyroprobe 190 pyrolysis unit connected to a Perkin Elmer 8500 gas chromatograph; 30 m DB-5 capillary column, FID detector; sample pyrolysis at 750°C for 20 sec; GC program: 60°C for 1 min, heating at 7°C/min to 250°C, held at 250°C for 15 min.

TABLE 3—*Collection efficiency of Mask Plus II compared with Cellux 760.*

	Mask Plus II (before filtration)	Mask Plus II (after filtration)	Cellux 760
Adhesive efficiency	93 ± 3%	92 ± 3%	94 ± 2%

Temperature and Humidity Effects

Extremes of temperature generally degrade the performance of *Mask Plus II* tape at the level of its PVA support. On the other hand, an increase in relative humidity tends to attack the adhesive layer of the tape.

At low temperatures (6°C and below), the support for the *Mask Plus II* tape is not practical; all flexibility and elasticity is lost. The tape must therefore be manipulated with care at these temperatures. By contrast, *Cellux 760* performs well and shows no significant alteration. At temperatures above 50°C, the support for the *Mask Plus II* tape shrinks and becomes soft. The degree of shrinkage increases as the temperature is increased. By contrast, *Cellux 760* remains unaltered up to 100°C.

From 40% relative humidity, a softening of the adhesive layer was noted for the *Mask Plus II* tape. At 50% relative humidity, the adhesive tended to separate from its support and remain on the cloth. At 70% relative humidity, the adhesive layer retracts making trace evidence collection practically impossible. For *Cellux 760,* fiber collection remained possible up to 80% relative humidity, became difficult at 90% humidity, and was impossible at levels above 90%.

In summary, the efficiency of *Mask Plus II* under extreme conditions is clearly inferior to that observed for traditional cellophane tape such as *Cellux 760* (Fig. 2).

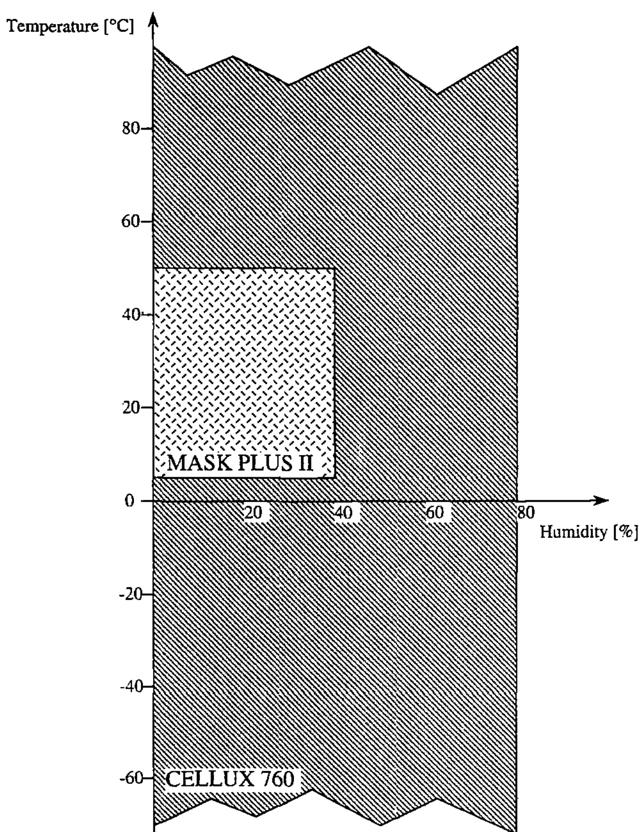

FIG. 2—*Application range of Mask Plus II compared with Cellux 760.*

Alteration of Trace Evidence

After 24 hours in contact with the adhesive, the fibers from the tape lifts showed no morphological modifications compared to the control fibers (collected with tweezers). Likewise, the instrumental analyses did not detect any contamination due to adhesive residues. No chemical modification was detected as the infrared spectra and pyrograms obtained were identical for both groups of fibers (tape lifts vs. collection with tweezers).

Packaging

Mask Plus II is packaged in a very practical manner; the tape is not rolled directly around onto itself but is stuck down on a strip of wax paper. The end of the cellophane tape is therefore very easy to find. On the other hand, the adhesive layer is not evenly distributed over the PVA support and has the tendency to overpass the support. Precautions must therefore be taken to prevent the roll being inadvertently laid down on a contaminated surface. In addition, the fingers become rapidly covered with excess adhesive thus complicating the work.

It must be emphasized that *Mask Plus II* cannot be employed under all circumstances due to its sensitivity to humidity. When not in use, the tape must be keep in a sealed container, in the presence of a drying agent, to prevent exposure to humidity.

Cellux 760 is sold in hermetically sealed packaging to avoid contamination.

Solubility in Water

The *Mask Plus II* cellophane tape is readily soluble in water; 2 to 3 minutes in water at 60°C is sufficient to completely dissolve the adhesive layer and its PVA support. This is far more efficient and more practical than the use of xylene to dissolve the adhesive in the case of *Cellux 760* tape. In addition, given that the instrumental analyses did not detect any adhesive residue, it can be considered that the water solubility of the *Mask Plus II* tape is complete.

Discussion

The new cellophane tape *Mask Plus II* is certainly, in many respects, a product of particular interest. It is more flexible and more elastic than *Cellux 760*, its packaging is more practical, and its adhesive power is virtually identical. The solubility of *Mask Plus II* in water is remarkable and largely fulfills all of its promise. Coupled with an efficient filtration method, this cellophane tape permits the recovery of over 90% of fiber transferred during a contact. Once dried, the recovered fibers are immediately available for analysis, without any remaining adhesive residue. Due to the use of a particularly mild solvent (water), there is no risk of contamination or chemical modification of the collected fibers. Microscopic trace evidence isolated in this fashion may be conveniently stored in hermetically sealed Petri dishes and thus be protected from environmental contamination.

Unfortunately, the high solubility of *Mask Plus II* in water is not only an advantage, but also leads to major inconveniences. Firstly, due to its hygroscopic nature, use of the tape outdoors is difficult under humid conditions. Storage of the tape is also a delicate problem. For this reason, *Mask Plus II* is sold in an hermetically sealed sachet containing a drying agent. During its use, it must be kept in a desiccator, making its transport between crime scenes more difficult. Collected evidence should not be stored under cellophane tape but rather isolated using the filtration technique described.

The user of *Mask Plus II* should be more attentive and take special care. The tape is sensitive to variations in temperature and should not be placed near a heat source or kept

TABLE 4—*Characteristics of Mask Plus II compared with Cellux 760.*

Characteristics	Mask Plus II	Cellux 760
Dimensions	++	++
Resistance	++	++
Flexibility	+++	++
Ease of breakage with the hands	++	++
Adhesive efficiency	++	++
Behavior at different temperatures	−−	++
Behavior at different humidity levels	−	++
Packaging (to avoid contamination)	++	+
Aggressive towards trace evidence	No	No
Solvent required	Water	Xylene
Adhesive solubility	+++	++

NOTE: −− poor
− unsatisfactory
+ satisfactory
++ good
+++ excellent

for long periods in the car, for example. In addition, as the adhesive is not evenly distributed over the PVA support, the roll should not be placed on any surface that may be contaminated.

In summary, compared with traditional cellophane tape, *Mask Plus II* has a similar performance under normal conditions but is more practical for the recovery of collected particles. It constitutes a valuable tool for laboratory work or any case where conditions are favorable (indoors, for example). Unfortunately, operating conditions are strict and make the use of this tape generally difficult for outdoor crime scenes (Fig. 2; Table 4).

In this study, *Mask Plus II* has been tested for the collection of textile fiber evidence. Its use may, however, be extended to the collection of other types of trace evidence including paint and glass fragments, for example. The application of *Mask Plus II* to the recovery of biological traces, such as head and body hair or dandruff, is presently under investigation.

Conclusion

This study has permitted the evaluation of *Mask Plus II*, a cellophane tape completely soluble in water, as a means of collecting forensic trace evidence. This new product has been compared to the cellophane tape currently being employed by police forensic services within Switzerland (*Cellux 760*). Particular attention has been paid to operating conditions (temperature, humidity, storage, etc.), collection efficiency, and possible modification of the microtraces in question.

The results show that *Mask Plus II* is a valuable tool for indoor crime scenes and in the laboratory. Under these conditions, its performance is equal if not superior to that of *Cellux 760*. Unfortunately, strict operating conditions must be respected with regard to temperature and humidity, thus limiting the use of *Mask Plus II* in outdoor situations. Better resistance to temperature variations and a more even distribution of adhesive over the tape support would be welcomed improvements. The evolution of such products should be closely followed as they can make significant and unique contributions to the problem of microscopic evidence collection.

Acknowledgments

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