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TECHNICAL NOTE

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Selection of an Adhesive Tape Suitable for Forensic Fiber Sampling

ABSTRACT: Five commercial adhesive tapes were tested for fiber uptake and saturation, for recovery and for ease of analysis. On the basis of the results, a high tack adhesive tape has been selected to be used for forensic fiber sampling. This adhesive tape is used as sampling material in two different micro trace kits. The first tape lifting kit is used mainly for the sampling of cars and the second is a 1:1 tape lifting kit for the collection of fibers on a corpse.

KEYWORDS: forensic science, forensic fiber examination, sampling techniques, tape lifting, adhesive tape

In forensic fiber examination, the tape lifting technique (1) is now widely accepted to sample crime-related fibers. Recovery percentages of more than 80% are mentioned in literature (2,3). Apart from its ease of application on a crime scene, the transfer of adhesive tape onto a clear plastic sheet prevents contamination after sampling and allows for easy examination in the fiber laboratory.

In this technical note, the authors wish to report on a study that was conducted to select the most suitable tape among five commercial adhesive tapes. The following tapes were used: Filmolux 609 (Neschen, AG, Bueckeburg, Germany), Hawe 9000 (Hawe Hugentobler AG, Bern, Switzerland), a 3M Scotchmark tape (3M, St. Paul, MN), Low Tack (Etilux, Liege, Belgium), and High Tack (Etilux).

A tape consists of a plastic layer which on one side is covered with a glue layer. This sheet is applied to an easily removable backing, which generally is a sort of siliconated paper.

The main composition of glue and plastic layers has been determined using Fourier transform infrared spectroscopy (FT-IR) and is described in Table 1. Both Filmolux 609 and High Tack tapes have been used in our institute and the latter has been used since 1999 in a Tape Lifting Kit. This study was performed in 2001 to verify the validity of the High Tack tape or to look for a more suitable alternative.

All tapes have been tested for their fiber uptake, saturation, recovery of target fibers, and ease of analysis.

Results

Fiber Uptake and Saturation

Fiber uptake is the amount of fibers recovered when applied only once to a surface. The back of a medium shedding cotton/polyester (80/20%) sweater was thoroughly cleaned using a standard adhesive tape (High Tack). Next, 5×15 cm samples of the five adhesive tapes were placed one by one on the surface and pressed with the palm of the hand as in a real tape lifting, removed from the sweater, and placed on a clear overhead sheet. The experiment was repeated placing the different adhesive tapes in reversed sequence to eliminate local shedding effects. The fiber uptake followed this order (from low to high uptake):

Low Tack < Hawe 9000 & High Tack < Filmolux 609 < 3M.

In another series of experiments, 50 consecutive tapings were performed on the same area of the sweater and again, a similar fiber uptake was rated:

Low Tack < Hawe 9000 < High Tack & Filmolux 609 < 3M.

Saturation of an adhesive tape occurs when a maximal fiber uptake is reached and no considerable amount of adhesive is left to ensure a proper placement of the tape on a substrate.

A pure woolen scarf was used for the saturation experiments. This scarf has a relatively high shedding ability. The scarf was thoroughly cleaned by taping it with a standard adhesive tape. Next, each adhesive tape of 5×15 cm was applied 10 times on the same area and the saturation was tested by placing the tape on a table surface and checking whether the tape still sticks to it. This was repeated for every five tapings. The saturation was evaluated as complete when the tape could readily be removed without applying any force.

The number of times the tape was applied was noted and a relative rating was given for the uptake of fibers when saturation was reached. Another tape was then tested in an area next to the previously tested surface. These experiments were repeated twice with each of the five tapes.

The saturation order found was:

Low Tack $\sim$ Hawe 9000 $\sim$ High Tack < Filmolux 609 < 3M.

This is in agreement with the adhesive tape fiber uptake which follows the same order. Because the tests were stopped after 60 tapings, no difference could be made between the Low Tack, High Tack, and Hawe 9000 tapes.

Recovery Experiments

Pink bean-shaped nondelustered acrylic fibers possessing strong orange fluorescence, when excited with blue light using excitation wavelengths between 420 and 490 nm and very strong red fluorescence when excited with green light using excitation wavelengths between 515 and 560 nm, were used as *target fibers* (Fig. 1).

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TABLE 1—*Composition of glue and plastic layers of the adhesive tapes used in this work.*

Tape	Composition of Glue Layer	Composition of Plastic Layer
Filmolux 609, Neschen	Polyacrylate	Poly(vinylchloride:phthalate)
Hawe 9000, Hawe	Polyacrylate derived	Poly(vinylchloride:phthalate)
Low Tack, Etilux	Poly(acrylate:vinyl acetate)	Cellulose acetate
High Tack, Etilux	Polyacrylate	Polyvinylchloride
3M	Polyacrylate	Polyester

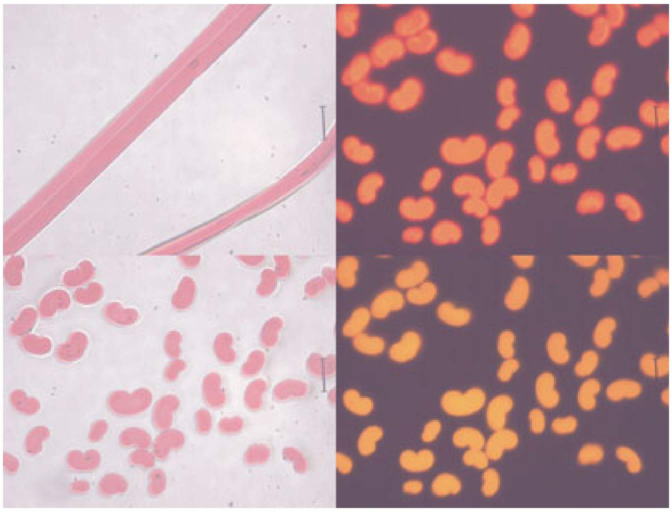

FIG. 1—*Red acrylic target fibers in bright field both longitudinal and transversal view (left) and fluorescence in transversal view with two different excitation sources (right).*

These fibers are very easy to retrieve using fluorescence stereomicroscopy and are easily recognized even with the naked eye.

The seats of 20 identical green chairs were used as acceptor material. The textile of the chairs was made up of a plain weave with a density of 4 threads/cm, in both warp and weft directions, consisting of pure wool fibers. The surface of each chair, both seat and back, was first thoroughly cleaned with a standard adhesive tape and a sampling zone somewhat greater than 5×15 cm was delimited, using the same adhesive tape which was applied onto the seats. The backs were also covered with this type of adhesive tape.

The sampling zone was protected with a small adhesive tape of 5×15 cm, thus ensuring no contamination of the sampling area. The preparation of the chairs took place in a separate room than the room where the fibers would be applied to the chair seats.

Before entering the chairs, a taping with High Tack adhesive sheets was performed on any surfaces bound to contain the target fibers, e.g., the sampling table next to which the chairs would be seeded. Furthermore, the tweezers were cleaned and checked for any remaining fibers.

Upon entering the chairs the protective adhesive tape was removed and a control taping was performed using standard adhesive tape. The taping was checked visually and the sampling area was checked using a stereomicroscope, hereby making sure that no fibers resembling the target were present in the sampling area. A small jar containing target fibers of lengths between 1 and 2 cm was opened.

Each fiber was seeded by the same person in the same way: all fibers were put under a warp thread making sure the fibers protruded no less than 2 mm and no more than 5 mm using tweezers and a stereomicroscope (Figs. 2 and 3). The 20 fibers were placed

FIG. 2—*Seeding of a chair in preparation of the recovery experiment.*

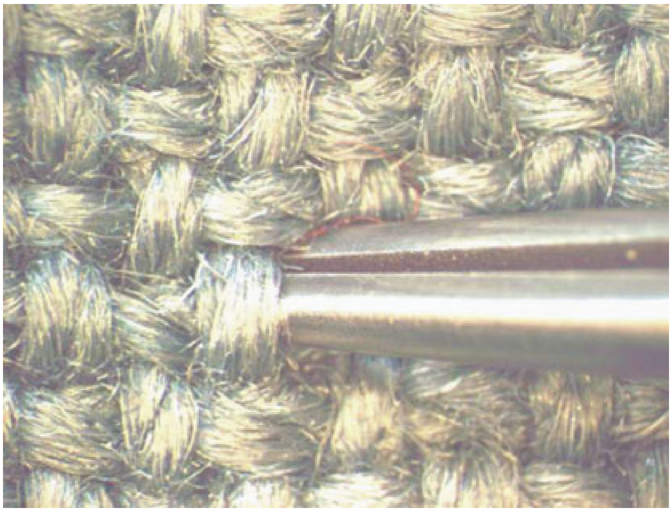

FIG. 3—*Detail of the seeding of a target fiber in the weave of the chair seat.*

into the weave in a regular pattern using five rows of four fibers and working left to right.

After this, a second person checked the sample area for the presence of this regular pattern of 20 fibers. Any loose target fibers or fiber fragments were removed from the sampling area by this person. This person also performed a tape lifting by applying the tape only once to the limited sampling area. In each experiment, the pressure exerted and the removal of the adhesive tape was done in a similar fashion.

After sampling, the adhesive tape was placed on a clear antistatic coated acetate transparency foil. The retrieved fibers were counted after the experiments using fluorescence stereomicroscopy. All fiber fragments shorter than 1 cm were not counted as retrieved fibers. The fibers which were not removed were counted by scanning the sampling area using a stereomicroscope. The amount of recovered and remaining fibers was compared. After each experiment, the sampling area was covered with High Tack adhesive tape and the chair was removed from the sampling lab. Each adhesive tape was tested four times to obtain reliable results.

The recovery tests were performed by two persons wearing Tyvek coveralls and protective gloves at every stage. The gloves

TABLE 2—*Recovery percentages for five different adhesive tapes.*

	Tapes									
	Filmolux 609, Neschen		Hawe 9000, Hawe		Low Tack, Etilux		High Tack, Etilux		3M	
Experiment	Remaining*	Recovered†	Remaining	Recovered	Remaining	Recovered	Remaining	Recovered	Remaining	Recovered
1	17	3	14	6	19	2	5	15	7	13
2	16	4	13	7	9	11	10	10	6	14
3	14	6	7	13	12	8	12	8	10	9
4	14	6	13	7	9	9	9	11	7	13
Mean	15.3	4.7	11.8	8.2	12.3	7.5	9.0	11.0	7.5	12.2
SD	1.5		3.2		4.7		2.9		1.7	
Recovery (%)‡	23.5		41.0		37.5		55.0		61.0	

*Number of target fibers detected by stereomicroscopy within the sampling area after taping.
†The total amount of fibers retrieved by taping as checked by stereomicroscopy.
‡The recovery was calculated using the recovered fiber data.

were changed between different experiments. The results of these recovery experiments are summarized in Table 2. The table shows that few errors were made in counting the amount of recovered and unrecovered target fibers. Only three times the amount of fibers counted did not correspond to the initial amount of 20 seeded fibers.

In spite of these experimental errors, an evaluation of the recovery percentage could be made and no extremely large deviations from the average were calculated. The tendency to recover the target fibers turned out to be the following:

Filmolux 609 < Hawe 9000 $\sim$ Low Tack < High Tack < 3M.

It was observed using stereomicroscopy that after tape lifting some of the target fibers were partially removed from between the chair threads. No successive taping within the sampling area was performed; so no data are available about the recovery when taping is repeated. This fact and the way the fibers were put deeply into the seat's texture can account for the low recovery rates as compared to literature.

Ease of Analysis

This test was performed to verify the ease of use of a certain type of tape in routine case work. Three different textile materials were taped with the five adhesives. These included a desk chair composed of woolen fibers, a sweater composed mainly of cotton fibers, and the collar of a coat composed of polyester fibers. From each tape, 10 fibers were removed for mounting and each time the following five criteria have been evaluated for each fiber:

the ease of cutting the tape with a scalpel;
the ease to lift the cut area of that tape;
the ease to detach the fiber without breaking it;
the absence or presence of glue on fiber and tweezers; and
the ease to deposit the fiber on a microscope slide.

Each criterion was attributed an equal amount of points. The global results for wool, cotton, and polyester fibers are represented in Table 3.

TABLE 3—*Evaluation of ease of analysis of five adhesive tapes.*

	Filmolux 609	Hawe 9000	Low Tack	High Tack	
	Neschen	Hawe	Etilux	Etilux	3M
Ease of cutting	20.0	20.0	20.0	20.0	13.3
Ease to lift cut area	19.7	20.0	16.7	17.7	16.7
Ease to detach fiber	18.9	19.8	16.9	18.2	9.0
Absence/presence of glue	17.7	18.0	18.3	16.0	11.7
Ease of deposition of fiber	17.0	17.3	16.7	10.2	10.7
Total	93.2	95.1	88.6	82.1	61.3

TABLE 4—*Overview of tape evaluation results.*

Tape	Fiber Uptake and Saturation	Recovery	Ease of Analysis
Filmolux 609, Neschen	Bad	Very bad	Very good
Hawe 9000, Hawe	Good	Mediocre	Very good
Low Tack, Etilux	Very good	Bad	Good
High Tack, Etilux	Mediocre	Good	Good
3M	Very bad	Very good	Bad

Evaluation of Criteria and Discussion

Three different parameters have been tested which are important in the sampling of transferred fibers: the fiber uptake and saturation, the recovery, and the ease of analysis. The results have been rated and are summarized in Table 4.

Despite the best recovery, the 3M adhesive tape has the highest fiber uptake and is saturated more rapidly than all other tapes, which leads to tapings with plenty of background fibers. Both the High Tack and Filmolux 609 tapes have a good fiber uptake. However, these tapes differ in two regards: High Tack tape is not so easily saturated and has a much better recovery than the Filmolux 609 tape. Hawe 9000 and Low Tack tape can be considered being comparable tapes with regard to fiber uptake/saturation and recovery.

Since 1999, the High Tack tape has been used as sampling material in a Tape Lifting Kit distributed in all laboratories of the Belgium Federal Police which are responsible for crime scene processing. This kit is mainly used for tape lifting in cars associated with crimes. Since 2001, the same tape has been used in a "1:1 Tape Lifting Kit" exclusively dedicated to crime scene processing of corpses. The results of this study confirmed the High Tack tape to be valid for forensic fiber sampling.

Since 2004, the backing material on which the tape was placed after sampling has been changed from overhead transparencies to siliconated paper backings. Because of its lesser adherence, the latter backing has the advantage of leaving less glue on fibers and hairs removed from the tapes.

Conclusion

The High Tack (Etilux) tape was selected from five commercial adhesive tapes as a good compromise to be used in every day case work. It has a good recovery, is easy to analyze, and does not saturate too quickly.

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