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The Pabst's method: An effective and low-budget tool for the forensic comparison of opaque thermoplastics - Part 1: Additional discrimination of black electrical tapes

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On the occasion of Dr. Herbert Pabst's 79th birthday.

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ABSTRACT

For many years now, Pabst's micro-press has been used in German forensic science laboratories as a valuable addition to methods of comparative analysis of plastic trace evidence. However, it is as yet hardly known in laboratories outside of Germany. The principal reproducibility is demonstrated by a homogeneity check of a raw backing material of defined origin. The illustrated results of a proficiency test emphasise the applicability of the Pabst method for forensic comparisons. The discrimination power of the Pabst method was tested by taking 90 black PVC-backings provided by the FBI Laboratory, i.e. those that could not be discriminated by standard methods. In this way further discriminations could be achieved. In the following, the Pabst method is therefore introduced as a straightforward, inexpensive and useful tool.

1. Introduction

Opaque thermoplastics frequently play an important role as trace evidence. To name just a few examples, there are tapes, cable ties, hot melts, residues from wire insulation or from garbage bags, or small fragments of all kinds of household articles. A lot of literature is available which provides advice on ways of analysing these products with different methods in a forensic context. Sometimes the focus lies on the method(s), sometimes on certain products such as adhesive tapes and frequently information regarding the discrimination power is also provided [1]. In particular, facile and effective microscopic methods are generally appreciated. The Pabst method is a microscopic method which is rarely mentioned in the international forensic community [2–4] and never mentioned in the context of PVC-backings. This matrix, however, is especially interesting because there is a lot of further information available regarding manufacturing process, distribution, quality grades and narrowing down date of production [5,6].

The Pabst method is characterised by the fact that the analysed samples are heated up to the required processing temperature under pressure to produce the real microscopic preparation. The melting range can be estimated with the knowledge of the polymer base available for example by IR-spectroscopy. Thereby the samples are moulded in the exact same manner to obtain adjacent layers of identical thickness. These are compared under different contrast modes (e.g. bright field, dark field, polarised light): variation perceived is mostly caused by different micromorphology formed by fillers and additives.

Originally, this method was utilised by its inventor Herbert Pabst in comparing samples of a limited set of material sources, namely plastics and fibres. These were mostly involved in motor vehicle accidents in the form of fibre-plastic fusions (FPFs) [7,8]. In such cases the populations were assumed to be clear: only plastics from the seized vehicles were considered to be relevant. Soon, many more polymer-based articles were tested. However, systematic studies regarding the limitations of the method have as yet not been published.

In forensic comparison casework the Pabst method is used in addition to other methods as a quick and reliable pre-examination for opaque thermoplastics. In the case of slight differences or consistency further sampling and further methods sensitive to specific ingredients (polymer, additive package, fillers, elemental composition) are applied, in particular nuclear magnetic resonance spectroscopy (NMR) [9] and/or X-ray fluorescence (XRF) and X-ray

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Fig. 1. Heatable micro-press with power supply, side views.

diffraction (XRD) techniques. Thus, in very few cases, differences can be explained by heterogeneity or ageing effects, respectively. In most cases, however, the results of the Pabst method are confirmed by other methods. From a different perspective, significant differences in all contrast modes represent strong support for elimination. As yet, not a single case of chemically different plastics with matching Pabst-preparations can be recalled. There can, however, be considerable differences when comparing samples of the same origin but from different areas due to heterogeneity, i.e. the fillers are not distributed uniformly during the manufacturing process.

In this paper, the outcome of a homogeneity study is presented. It was performed with a raw backing material of a PVC insulation tape delivered by Coroplast®, a major German manufacturer.

The results of a recent proficiency test for PVC tapes are also presented. The comparison of the Pabst preparations already enables a clear decision.

By courtesy of the FBI laboratory the Pabst method was tested by taking the set of 90 well-examined black PVC electrical tapes [10,11]. The focus in these already published studies was set on further discrimination of tapes which could not be distinguished by standard methods, such as visual examination, stereo microscopy, infrared spectroscopy, pyrolysis gas chromatography/mass spectrometry, and scanning electron microscope/energy dispersive spectroscopy (SEM/EDS).

2. Materials and methods

2.1. The Pabst micro-press

The two main devices of the press are the power supply and the hot stage press. The power supply contains the power control unit and the digital thermometer for the surface temperature of the hot stage.

The hot stage press components are the rack and the hot-stage in the centre of the desktop with illumination and heating lamp. A small glass window in the metal frame allows the observation of the melting process of the preparations between slides and cover slip (Fig. 1).

2.2. Using the micro-press to prepare adhesive tape backings

The materials used correspond to those listed in Table 1 of Ref. [10]. Only pure backing samples were used for the Pabst preparation, each adhesive layer was removed by using n-heptane. With the aid of a heatable micro press, the backing samples were melted under stereomicroscopic control in order to prepare a microscopic preparation of adjacent samples with a uniform thickness. The complete procedure generally comprises two cycles and was performed as follows:

A tiny piece of the backing (approx. 1–2 mm^2) was cut and brought into the middle of a slide. The comparison material was placed no closer than approximately 4 mm beside it. Strips of aluminium foil (thickness 12 μm) were added on both sides. Preparations and strips were carefully covered with a cover slip. Then the prepared slide was transferred under the glass plate of the heatable micro press. The round nuts were turned slightly and the tungsten lamp was switched on to start raising the temperature while observing the preparations with a stereomicroscope. When the temperature reached 100 °C, the nuts were tightened until the material started to flow. The heating was switched off at 180 °C. The nuts were fastened finger tight. After cooling down to approx. 30 °C, the nuts were loosened, the slide was lifted off, and the cover slip was carefully removed with a scalpel. A piece of 2 mm × 1 mm was cut with a razor blade from each prepared film and transferred (with forceps) to a second slide. These were placed almost adjacently and prepared for moulding as described, but this time without using strips of aluminium foil. The temperature was increased to 80 °C under low pressure until the edges merged with each other. After cooling, the slide was removed from the micro-press. The preparation was examined by microscope.

2.3. Sample preparation for homogeneity check

The homogeneity check for the Pabst method was performed with a raw backing material of black PVC electric insulation tape without adhesive layer. The material was made available by courtesy of Coroplast®. Samples of 1 cm^2 were taken every 10 cm (see Fig. 2). 8 samples were prepared together on a glass slide. The multi-sample preparation was observed under a microscope with 10-fold magnification and with different types of illumination (bright field, dark field and polarisation).

2.4. Assessment

The protocol for differentiation complies with a three value scale (1 = significant differences, 2 = inconclusive, 3 = no difference) applied for each contrast mode and referring to pigmentation,

Fig. 2. Raw backing PVC-material with sampling points.