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Test strips for examining reactivity of fingerprints visualization methods on absorptive surfaces with amino acids

Summary

This article provides the results of research on the uniformity of amino acid test strips used with fluorescent DFO method. Ready to use amino acid test strips made of the absorptive material containing four reactive fields of exponentially decreasing amino acid concentrations, designed for DFO, ninhydrin, 1,2-indanedione methods were used in the study. The test strips were treated with DFO solution in order to measure the fluorescence emission level of DFO-amino acid reaction product for respective reaction fields. Based on the obtained results, the repeatability of emitted fluorescence measurements was observed, thus confirming the usability of test strips in DFO method verification of newly prepared reagents as well as the use of this method in routine laboratory work. Based on the findings, it should be assumed that test strips are also effective and suitable for verification of correctness of preparation of working solutions for the remaining amino acid based fingerprint visualization methods such as: ninhydrin, 1,2-indanedione, and 1,2-indanedione with zinc chloride.

Keywords DFO, test strips, amino acids, absorptive surfaces

Introduction

Since many years, fingerprint examination has been considered as one of the most effective methods of identification of criminal offenders [1]. The area of fingerprint examination had been clearly divided into activities related to the detection and visualization of fingerprints referred to as visualization examinations, and those related to fingerprint identification, defined as comparative examinations. The above division has been reflected in many publications [2]. Furthermore, distinguishing these two types of forensic specialist areas accelerated the growth of new fingerprint development technologies, most often adapted from other disciplines of science, such as fluorescence methods involving the use of DFO, 1,2-indanedione, Basic Yellow 40, and others. A breakthrough in the field of detection of latent fingerprints is also related to the advanced instrumental methods, such as hyperspectral, time-resolved and up-conversion imaging or reflection techniques in long-range ultraviolet spectrum [3, 4, 5, 6, 7, 8, 9, 10].

The use of chemical methods for detection of fingerprints needs the control over the reactivity and effectiveness of chemical reagents under preparation. The examiner must make sure that the ready to use or laboratory prepared reagent solution reacts with traceable substance components and facilitates effective visualization of fingerprint. The easiest way to verify the effectiveness of prepared reagents are the so-called test traces left on the surface similar to the one being examined. The ideal model of a test trace approach assumes applying identical conditions, such as composition of traceable substance, type of surface, dynamics of trace deposition. In practice, however, it is not possible to fulfill these assumptions. While

selecting the similar surface is relatively manageable (e.g. a sheet of office paper), the problem arises with finding a traceable substance of similar composition. It is commonly known that the composition of traceable substance directly depends on many factors, such as age, sex, diet, [lite]. Furthermore, the composition is variable in time and expected to change within one week, or even one day.

The effectiveness of chemical compounds reacting with amino acids can be tested by performing reaction of amino acids naturally present in traceable substance on the test surfaces. In order to do that, amino acid aqueous solutions with exponentially changing concentration are prepared and applied onto the selected test surface, at specific locations. The exponentially changing concentration of the amino acid solution allows for subsequent determination of sensitivity of prepared developing solution. The use of ink jet printers with cartridges filled with amino acid aqueous solutions for test surface preparation has been reported [11]. Several studies on the preparation of homogeneous research material were also conducted at CFLP. For this purpose, HP710C ink jet printer equipped with brand new cartridges was used (courtesy of Hewlett-Packard Polska Sp. z o.o.). After initial success with effective "printing" with amino acids on paper sheets, several problems were encountered, related to the printing nozzles drying up and insufficient pressure inside the cartridges. The above problems disabled the preparation of larger batches of surfaces.

Currently, ready to use amino acid test strips by SEMA GmbH[1] intended for the following methods: DFO, ninhydrin, 1,2-indanedione are available on the European market. They are made of absorptive surface resembling filter paper with printed information. The strips contain four reaction fields with exponentially changing concentration of amino acids (Fig. 1).

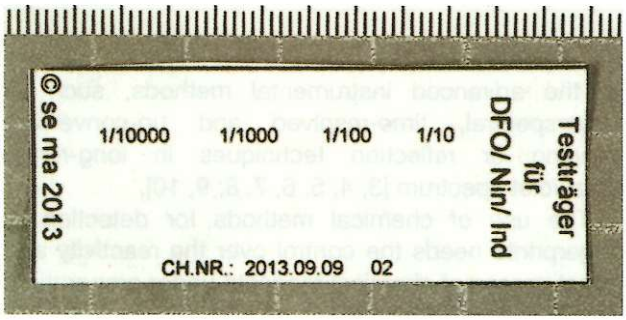

Fig. 1. SEMA GmbH Amino acid test strip.

The goal of the study was to determine the uniformity of amino acid test strips for fluorescent DFO method. Assuming that the reaction fields of particular strips contain similar amino acid concentrations, their measured fluorescence emission level of DFO-amino acids reaction product should be comparable. If the uniformity of test samples is confirmed, the strips may be used in every day laboratory practice to verify the effectiveness of DFO, ninhydrin or 1,2-indanedione solutions. The study included the fluorescence emission measurements of four fields containing exponentially increasing amino acid concentration.

Materials and methods

Test strips and chemical reagents

Test strips were obtained from SEMA GmbH (Germany). DFO (1,8-diazafluoren-9-on) was obtained from BVDA (the Netherlands). Acetic acid and methanol were obtained from POCH (Poland). HFE7100, HFE71DE were purchased from Sigma Aldrich (Poland). All chemical reagents used in this study were of analytical grade, used without subsequent purification.

Preparation of DFO solution

DFO solution was prepared according to the formulation recommended by CAST[2] [Home Office Centre for Applied Science and Technology]. First, 0.25 g DFO was added to the mixture of 30 ml methanol and 20 ml acetic acid and mixed on a magnetic stirrer until DFO was completely dissolved. Subsequently, 275 ml HFE71DE and 725 ml HFE7100 were added and mixed for 15 min on a magnetic stirrer.

Conditions for performing test reactions between test strips and DFO

100 test strips selected for examinations were exposed to DFO solution using the immersion method. The strips were heated at approximately 90°C for 20 minutes. The positive reaction result was visualized during observation through OG590 filter, after excitation at 505nm, as fluorescence emission of the reaction fields (Fig. 2).

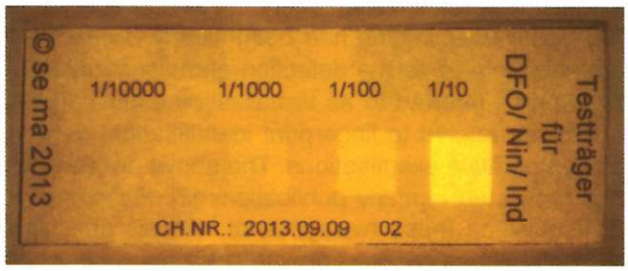

Fig. 2. SEMA Gmbh amino acid test strip reacted with DFO – 505nm excitation wavelength, OG590.

1 www.sema-gmbh.de

2 Home Office Centre for Applied Science and Technology (CAST), Fingermark Visualisation Manual, UK, 2014.

Measurements of fluorescence emission spectra and data analysis

The intensity of fluorescence emitted from reaction fields of the test strips was measured by hyperspectral imaging, using a CONDOR Macroscopic Chemical Imaging System™ (ChemImage, USA).

The measurements of fluorescence emission were taken from four square-shaped reaction fields on each strip. The surfaces were visualized and analyzed using ChemXpert software (Fig. 3). The data were collected within the range between 550 nm and 720 nm, at spectral resolution of 7 nm, concurrent with fluorescence excitation at 515 nm, using a Mini Crimescope light source (Ybon, USA).

The spectra of 100 reaction fields for each of four exponentially increasing concentrations were analyzed. The fields were marked as follows: ROI1, ROI2, ROI3, ROI4. The numerical data corresponding to the areas measured were imported into Microsoft Excel spreadsheet, where the arithmetic mean was calculated for every point of measurement, followed by data verification by calculation of standard deviation.

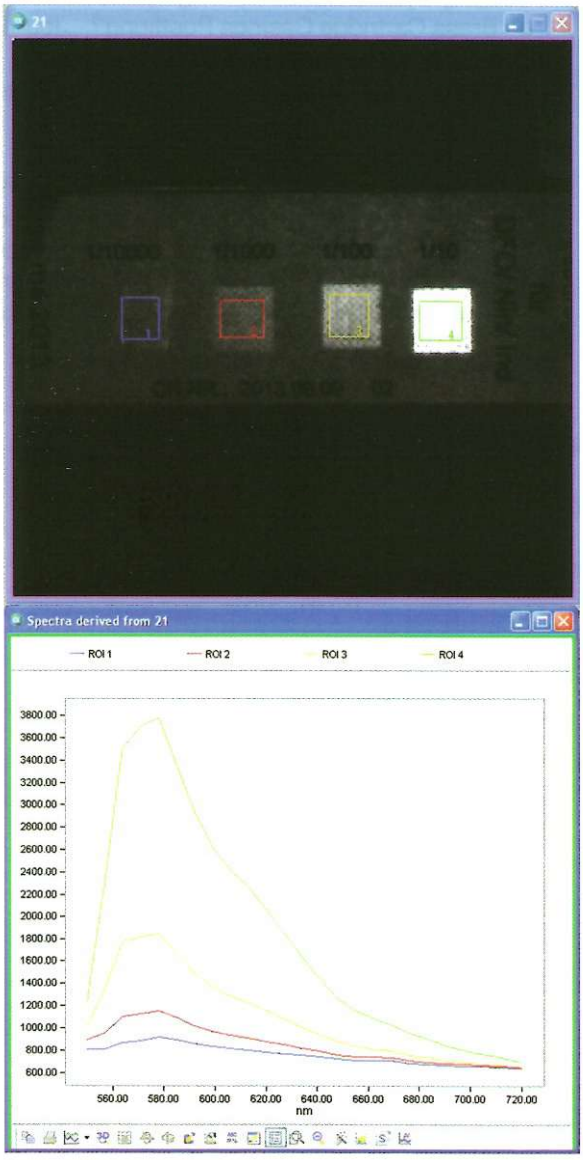

Fig. 3. An example of outlined measurement areas: ROI1, ROI2, ROI3, ROI4 in reaction fields of test strips after visualization along with emission spectra.

Discussion

Obtained results point to the repeatability of emitted fluorescence measurements. The increased amino acid concentration in ROI1-ROI4 fields declared by the manufacturer was confirmed by the respective increase of measured emission, particularly near the maximum emission level (578 nm) (Fig. 4). The measured standard deviation reached maximum values for reaction field with the highest amino acid concentration (ROI4) - 25% near the maximum emission level. Obtained fluorescence emission spectra of DFO-amino acids reaction products were comparable to those observed in earlier studies. While only the DFO method was tested in the current study, it may be expected that test strips will prove suitable for other amino acid-based methods such as: 1,2-indanedione and 1,2-indanedione with zinc chloride.

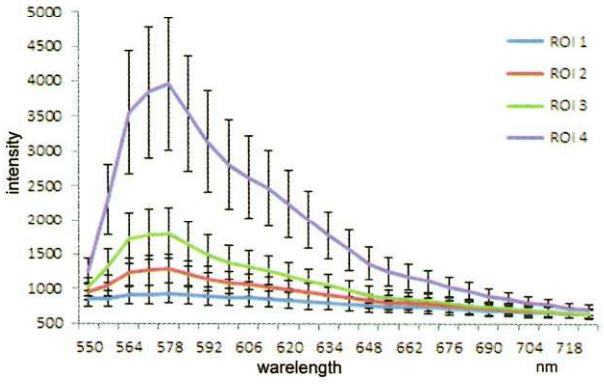

Fig. 4. Fluorescence emission spectra measured within the measurement areas: ROI1, ROI2, ROI3, ROI4 with corresponding standard deviations.

Conclusions

The conducted studies confirmed usability of test strips in the verification of DFO method with newly prepared reagents and also each time the method was used in operational conditions. It should be assumed that the strips are also suitable for checking the effectiveness of prepared working solutions for remaining amino acid-based methods, i.e., 1,2-indanedione and 1,2-indanedione with zinc chloride. The uniformity observed throughout the studies allows for performing initial test of new formulations of presently used compounds and new substances, provided that

they will be chemically reactive with amino acids. Furthermore, it should be underlined that strip testing of new formulations should not completely replace the tests performed in operational conditions on real latent fingermarks.

Obtained emission spectra corresponded to those observed in previous studies in showing the maximum emission of DFO-amino acids reaction at around 578 nm, at the excitation wavelength 530 nm [12].

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Source

Figs. 1–4: authors

Translation Rafał Wierzchosławski