Toward Portable Instrumentation for Quantitative Cocaine Detection with Lab-on-a-Paper and Hybrid Optical Readout

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Abstract

Detection of cocaine on the level of a few ng/ml by the use of lab-on-a-paper test co-working with OLED light source as excitation light source and CCD-based detection unit is described in this paper. The new method enables not only yes or now answer of drug presence in a tested sample but also concentration of the drug in the sample. Presented here results opens a new way toward portable instrumentation for point-of-care detection of cocaine (and in the future other drugs) in sweat of for example professional drivers. This device will be a drug-tester similar to widely now used alcohol testers.

Keywords: cocaine, OLED, CCD, detection

1. Introduction

In this paper we present for the first time a first approach toward portable instrumentation for cheap and rapid quantitative detection of cocaine in a sweat sample. This will be a new standard of drugs detection comparable to existing now test for alcohol presence with accurate indication of the stimulant quantity. Applicability of such instrumentation is very wide - for example tests for professional drivers where it is estimated that 1 of 10 drivers may be working under the influence of drugs.

The instrumentation is developed under EU 7. FP LABONFOIL project. The lab-on-paper will be based on immunochromatographic method with fluorescence detection. It will integrate OLED as excitation light source and co-work with external CCD-based optical readout system. The detection limit of cocaine will be significantly improved to level of at least 30 ng/ml in comparison to existing strip tests where 300 ng/ml limit is now a standard [1]. What more, quantitative detection of cocaine, in spite of only indication of presence of cocaine in a sample as it is now, will be possible.

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2. Instrumentation

The configuration of measurement set up for preliminary tests is shown on figure 1. It contains of a paper-based detection strip placed between OLED with proper filter playing as fluorescence excitation source. The filtered OLED light excites fluorescence test and control lines of the strip. The fluorescence light is collected by a highly sensitive CCD-based detection system co-working with personal computer and specialized software is applied to determine cocaine quantity in the tested sample on the base of fluorescence intensity of control/test lines.

2.1. OLED

The OLED is placed at the bottom of the semi-transparent patch. By emission of light, fluorescence within the test and control lines of the strip is excited. The brightness of fluorescent light is a direct indicator for the amount of cocaine in the sweat of the tested person. Because of the rather wide spectral characteristic of OLEDs in general and a Stokes shift of about 20 nm for the fluorescent marker (Dylight 649) used in the test strip, the integration of an excitation filter is required that cuts off all light generated by OLED that has larger wavelength than maximum absorbance of Dylight 649. In the experiment a short-pass 650 nm interference (ThorLabs, USA) placed on the top of the OLED was used. The OLED material itself will be an emitter with maximum brightness in the orange (Fig. 2). At operation voltages of about 4V and current density of 100mA/cm², it features a luminance of more than 10000 cd/m². Current efficiency is at about 16 cd/A (at 10000 cd/m²). First samples of OLEDs will be manufactured on rigid substrates like glass. In parallel to the device development inside LABONFOIL, efforts are undertaken to be able to produce OLED on flexible substrates which are of course much better suited for a skin patch application. This will be realized using a innovative roll-to-roll manufacturing equipment for OLEDs currently under development.

2.2. Immunochromatographic strip

The strip is a immunochromatographic paper-based strip with cocaine capturing areas. The detection areas were deposited onto nitrocellulose membrane. Test and control lines were deposited onto the strip with 5 mm spacing. The lines contained Dylight649 fluorochrome with maximal excitation wavelength of 649 nm and emission at 670 nm. Negative, 15 ng/ml, 30 ng/ml and 60 ng/ml cocaine concentration samples diluted in proper buffer were used.
2.3. Optical readout

The optical readout is based on a CCD minicamera equipped with band-pass 670 nm filter (Thorlabs, USA). The architecture of the optical readout was based on the solution developed for OPTOLABCARD project [2] but some improvements have been implemented. The fluorescence images were collected by the minicamera and send to the computer equipped with video card and specialized software. The software selected the areas of control/test lines, calculated fluorescence intensity and calculated ratio of fluorescence intensity of the test to control lines.

Fig. 4. Measurement set up for cocaine quantitative detection: a) view of the instrumentation, b) fluorescence excitation OLED with 650 short-pass filter and nitrocellulose strip placed on it - view during tests as seen by a human eye.

3. Results

Views of strips as seen by the optical readout system are shown on figure 5. According to expectations, two fluorescing lines – test (green outline) and control (red outline) – were observed. The specialized software determined the fluorescence intensity of these two lines and calculated ratio of test line fluorescence intensity to control line.

Fig. 5. Views of the detection areas of the strips, as seen by CCD-based detection unit, for different cocaine concentrations
Fluorescence intensity ratio as function of cocaine concentration (an average values of 5 strips for each concentration) is shown on figure 6. The lower the fluorescence intensity of test line, the higher cocaine concentration in the sample. The lowest detection limit was 5 ng/ml of cocaine what is over an order of magnitude better than for commercially available tests.

![Fig. 6. Normalized fluorescence ratio (test line fluorescence/control line fluorescence) as function of cocaine concentration](image)

4. Conclusions

We presented a first approach toward cheap and highly sensitive instrumentation for quantitative cocaine detection with very low detection limit. Further works will be focused on integration of developed now flexible OLEDs with interference filter and paper-based cocaine test to form disposable strip for sweat collection and cocaine detection. The strip will co-work with hand-held detection device connected to a portable minicomputer for fluorescence signals conditioning and presentation of the test result.

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References
