B7 Rapid and Reliable Validation of Body Fluids Using Paper Microfluidic Device (µPAD) Chips

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After attending this presentation, attendees will understand the development of a new procedure for the determination of the presence of body fluids at crime scenes using µPADs. Paper microfluidics permit the simultaneous analysis of multiple sources of body fluids from a variety of substrates using multiplexed colorimetric detection. The result is a fast, simple, and reliable analytical tool for screening body fluids found at a crime scene.

This presentation will impact the forensic science community by demonstrating the practical application of µPADs in forensic serology. The design and developmental validation of the system will be discussed, including sensitivity, specificity, and long-term stability.

In recent years, there have been a number of new developments in the field of forensic serology; however, these methods involve lengthy laboratory testing (genomics, proteomics) and are not applicable to direct measurements at the crime scene. In contrast, field tests are simple, fast, and presumptive. Unfortunately, these analyses generally involve multiple testing procedures for each body fluid and are inherently destructive (with the exception of Raman and alternate light sources), wasting precious samples. With the advent of genetic testing, it becomes critical to determine all potential sources of human DNA at the scene to assist collection and sample analysis. These include blood, semen, saliva, vaginal fluids, urine, and sweat. To test each suspected body fluid with all these different procedures clearly would be uneconomical. Thus, a multiplexed presumptive body fluid screening procedure was proposed using paper microfluidics.

The µPADs utilize sheets of chromatographic paper and thermal wax to create hydrophilic channels that are bounded by hydrophobic barriers that direct a liquid sample to multiple test wells, each with a different sensor. In this project, various bodily fluids have been detected through the development of a µPAD chip. The device is designed like a tree. A single sample is placed at the base of the device and the sample flow is divided into several branches. A different colorimetric reagent is placed at the terminus end of each branch, each of which is capable of detecting a different body fluid. Currently, four different fluids can be simultaneously detected on a single device.

In this project, a variety of colorimetric sensing systems have been developed and modified for the presumptive determination of blood, urine, saliva, and semen. Reagents for detecting blood were prepared using sodium perborate as a longer-lasting oxidizing agent for the phenolphthalein-based Kastle-Meyer test. This compound becomes oxidized when sodium perborate comes in contact with water, generating hydrogen peroxide. A colorimetric change is produced in a minimum of ten seconds. To detect urine, a second test site utilizes the hydrolysis of urea via urease. The ammonia that is released interacts with the Nessler's reagent (mercuric iodide) and produces a color change in less than a minute. The reagents used for saliva detection utilize the amylase-based hydrolysis of the a-1,4 glyosidic linkages in starch/iodine, resulting in the loss of the initial colored complex. Reagents used for semen involve the reaction of sodium a- naphthyl phosphate with acid phosphatase. Upon analysis, the paper microfluidic chip permits the determination of sub-microliter volumes of samples.

Test results with mixtures and single-source samples demonstrate clear and distinct signals for the presence of each body fluid type. Further interference testing and validation is currently underway. Overall, this paper microfluidic presumptive testing method can serve as a cost-effective and field-able analytical method for screening unknown fluids found at crime scenes.

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