# DYSSEE

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## Product Design

## Overview

Aiming to make ODYSSEE an easy-to-use and safe to implement product, we proposed the "2 tubes philosophy". However, thinking about the future we aim to incorporate all the features of our "2tubes philosophy" into a paper based diagnostic test that is compatible with the needs of a POC test. Paper-based diagnostics have already revolutionized point-of-care approaches for health and environmental applications, by providing low-cost, disposable tools that can be utilized in remote settings. Below we are discussing our ideas for scaling up our product's design and the main characteristics that our paper kit should meet.

## Design

The most suitable design for out kit in order to include all the desired characteristics is the 3D μPAD origami paper-based kit that makes the diagnostic procedure a lot easier. Origami, (from *ori* meaning "folding", and *kami* meaning "paper") is the art of paper folding. The word "origami" is used as an inclusive term for all folding practices, regardless of their culture of origin. The origami technique can change the diagnostic tests for ever.

The structure of our kit will be the following:

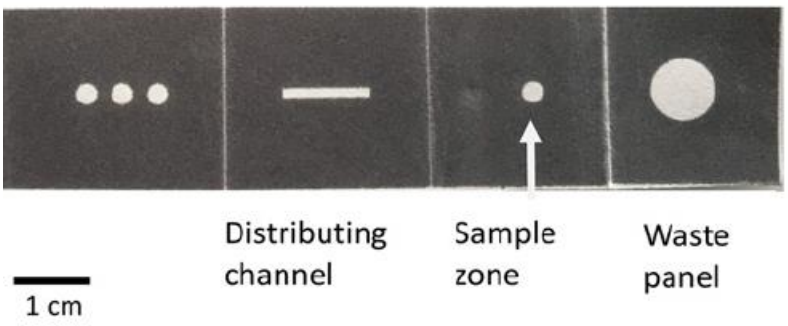


**Figure 1** An idea of an origami paper-based diagnostic kit according to Reboud, Julien, et al. (2019)

The rightmost fold is the waste panel, the sample panel to its left shows where the urine sample is loaded, and the distributing channel is where DNA is eluted for RPA DNA testing. The final (leftmost) fold sits on top of the three (or two) RPA testing chambers. In these three chambers we would like to incorporate the detection of Tuberculosis, Hepatitis B Virus (HBV) and a positive control, respectively.

## Considerations

According to Lucas- Washburn Law, the flow speed decreases as the inverse of the square root of time. This means that liquids rapidly imbibe the paper at short times, i.e in the first few seconds, and slow down as

time increases. In practice, because of Lucas-Wasburn law, the extent to which samples or reagents propagate on a paper sheet is limited to a 3-4 centimeters. This limitation represents a constraint for the design of paper devices. When the test line/zone is placed furthest from the inlet, the analyte will be slower as it passes through the capture line. The case where viscosity does not raise issues is urine, since its viscosity is 8 mPa.s. Therefore, the choice of urine as a sample becomes ideal for a paper-based kit.

The **paper** that aim to use in our kit is the Whatman Chromatography Paper grade 1. This type of paper is really cheap and because of its low cost it can increased the shelf life of our kit. In addition, it increases the efficiency of the hydrolysis of the nitrocefin due to its slow and controlled flow. Slow and controlled flow allows the sample to rehydrate more nitrocefin to react with ß-lactamase in the detection zone, resulting in a more noticeable color change.

In order to stop the **degradation** of our reagents we thought of using BSA. Basically, BSA binds to the paper thereby decreasing the loss of enzyme to adsorption in an inactive form. According to Boehle, Katherine E., et al., 2018, when BSA was used to stabilize ß-lactamase on Whatman 1 filter paper, the enzyme showed no decrease in activity over three months at room temperature and retained >80% of its activity after one year of storage.

The **color** of our paper is important because it plays a role in image analysis. Our paper will be white, with no tinge or hue. Paper tends to turn yellowish to brownish upon prolonged storage due to exposure to humidity, high temperatures and sunlight. Acceptable limits of color decay must be identified and compensated for during the readout.

## Application Considerations

Below we are indicating the background information for implementing our paper-based kit, considering the use of a cell lysate and freeze-dried components.

**Cell lysate:** Bacterial cell-free protein synthesis system (CFPS) is a robust tool for synthetic biology. The bacteria lysate, the DNA, and the energy module, which are the three optimized sub-systems for *in vitro* protein synthesis, compose the integrated system. The resulting extract contains all the molecular machineries required for coupling transcription-translation processes, while the obtained protein is encoded by the addition of a DNA template. One of its major advantages is its low cost compared to TX-TL systems that are on the market. Protein synthesis can be done at 37 – 42°C optimally.

**Freeze-drying:** Freeze-drying is a dehydration process especially suited to the conservation of biological products. In comparison with other drying processes, freeze-drying is considered as a reference for manufacturing high-quality dehydrated product. The direct transition of water from solid to vapor (sublimation), without a liquid phase, helps to preserve most of the initial raw material's properties such as appearance, shape, taste, color, and flavor. As an important functional property, the freeze-dried product has a high rehydration capacity.

## References


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