Popular summary

High-throughput testing of drugs or drug combinations is currently carried out by trial and error. Therefore, from a statistical point of view, it is important to perform as many of these as possible. However, current methods using mainly 96-well reaction plates significantly limit the number of tests that can be performed and also take a relatively long time. Furthermore, operations on liquid samples - such as pipetting - are usually performed by fully automated industrial robots, which are extremely expensive and large machines.

New tools developed in recent decades such as droplet microfluidics may be the answer to these problems. Microfluidic operations are not only performed on miniature systems that are easy to produce and extremely cheap compared to pipetting robots, but are also much more efficient compared to standard plates. Where from 1 mL of sample on a single 96-well plate we can obtain 96 experimental samples, on a microfluidic device we can obtain as much as 10^5!

Thanks to these properties, microfluidic devices can easily be used in small laboratories or hospitals, for example, but can also be used to test tens of thousands of molecules at once. This is extremely important, for example in cancer therapy, where the combination and administration of drugs, often expensive and/or toxic, must be optimally tailored to the individual patient to reduce costs and minimize harmful side effects.

Microfluidics offers a personalized solution for high-throughput drug testing using very small sample volumes, such as a few grams of tissue from a biopsy. The sample, introduced into the microfluidic chip, is dispersed into thousands of droplets, each with a volume of single nanolitres (one billionth of a liter) and then combined with droplets containing the drug sample - usually a mixture of drugs at different concentrations. Observation of the cells' response to the drug combination, which is different in each droplet, allows the most effective drug combination to be identified.

However, microfluidic methods have a major limitation – this is the identification of individual droplets. This topic has been intensively studied in recent years and we can find several solutions. One method is to stain the droplets to identify them. However, this method has a low resolution, a major drawback if we want to identify tens of thousands of droplets.

Our proposed approach is to produce droplets from hydrogel precursors, which would be applied to a substrate after encapsulation of cells in them and cross-linking. Complete control of the printing process would enable the automatic observation of individual droplets - with precise knowledge of where a particular bead has been applied, individual droplets could be identified to act as bioreactors.

In this project, we will develop an understanding of the mechanics and flow properties of densely packed soft hydrogel pellets through a print head with a tapered geometry. We will investigate what phenomena affect the flow regularity necessary to achieve prism in their printing onto the substrate.

The technology developed under the project will provide a non-invasive (i.e. dye-free) and relatively low-cost alternative to existing droplet marking methods, potentially breaking new ground in areas such as drug testing and personalized medicine and diagnostics.