FLOW-INDUCED MARGINATION OF ELASTIC MICROCAPSULES

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Abstract: *Blood is a multiphasic fluid compound by particles of different shapes, sizes and rigidity. Under physiologic conditions, these differences between particles (red blood cells, leukocytes and platelets, for example) results in a phenomenon known as margination. In order to study the margination mechanism, microcapsules with tunable flexibility could be employed to mimic theses blood compounds. The present work aims to visualize and study the flow-induced margination process of these microcapsules obtained with microfluidics. These microcapsules have specific mechanical properties, which are extremely useful for this kind of application.*

Key-Words: *microcapsules; microfluidics; margination*

Introduction: Microcapsules with tunable membrane flexibility can be used to mimic of blood compounds in order to study the margination effect [1]. Microfluidics could be employed to understand better the margination effect, then it could be possible to separate the different particles present in the circulatory system. The development of this technique may lead to several applications in medical area, such as physiological responses to inflammation and thrombosis, or application as diagnostic tests, in which it would be possible to separate malaria infected red blood cells (rigid) from the health ones (more flexible). The microfluidic technology applied into the production of these microcapsules deals with discreet capsules with precise volume and composition control; with restricted dispersion and limited cross contamination, which provides ideal models to fabricate complex systems with the necessary microscale parameters. The aim of this work is to study the margination process by visualizing the interaction, between microcapsules with different mechanical properties, induced by a flow through a circular pipe.

Experimental: In order to mimic blood components with different rigidities, we used microfluidics glass made capillary devices to fabricate microcapsules with tunable flexibility. The microcapsule's membranes were constituted by a commercialized elastomer (Sylgard 184® from Dow Corning), which composition is based on a type of poly(dimethylsiloxane) (PDMS). In order to distinguish the rigid microcapsules from the flexible ones, a green dye and sulforhodamine were added into the internal phase of the capsules, respectively. To obtain different membrane rigidities, the proportions of the polymer and the crosslinker were modified resulting in variations of the crosslink degree. The polymer to reticulate agent proportion used in the rigid microcapsules was 5:1, while for the flexible ones was 17.5:1.

Aiming to represent blood flow, a mixture containing similar concentrations of both type of microcapsules was injected into a glass circular pipe with internal diameter of 5mm in the vertical position. Into the inferior part of the tube, it was injected a solution composed by 55% m/m of dimethylsulfoxide (DMSO), 31% m/m of sucrose and 14% m/m of water. This composition was in order to mimics the blood viscosity and match the refractive index, which was 1.473. A 11 Elite Plus Harvard Apparatus syringe pump was used to inject the solution with a flow rate of 5 mL/min. A rectangular acrylic visualization box (60 x 35 x 200 mm) with orifices on the bottom and on the superior parts was used to avoid images distortions.

The visualization was acquired with a laser, a Photron Fastcam SAE3 high-speed camera (HSC) and Nikon (50mm) lens. The region of interest was placed into the visualization box. In order to reduce angular incident light beam deflection caused by the difference between the refractive indexes of the mediums, the

acrylic box was filled up with the same solution used at the inner flow. With this refractive index matching technique, it was possible to reduce even more the image distortions, which improved the acquisition and image processing (Figure 1).

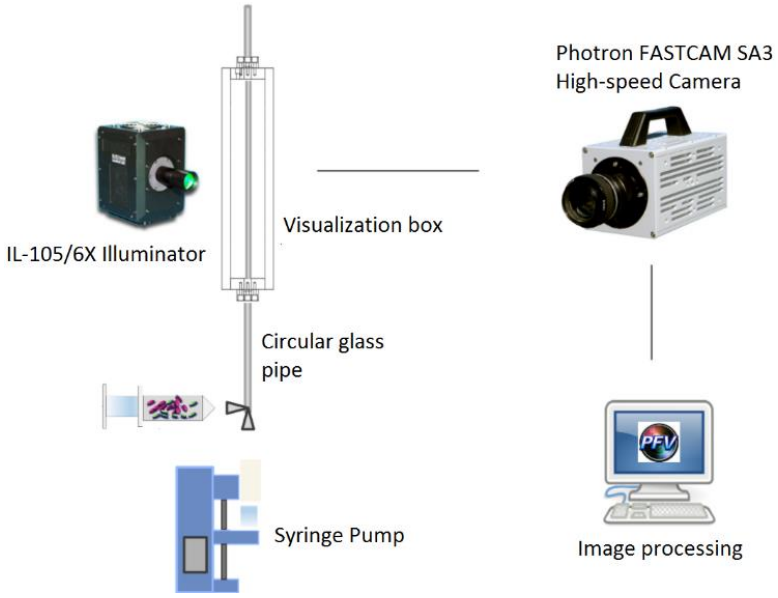

Figure 1– Schematic illustration of the experimental setup for the visualization of the microcapsules' margination effect

Results and discussion: The preliminary acquired images (Figure 2) have shown the possibilities we have to evaluate the margination, segregation in terms not only of rigidity, but it could also be possible in the future evaluate it in terms of size, concentration and forms. Therefore, several improvements must be introduced into the experimental setup, such as the focal plane, the illumination setup and the image processing method, in order to obtain better quantitative and qualitative results.

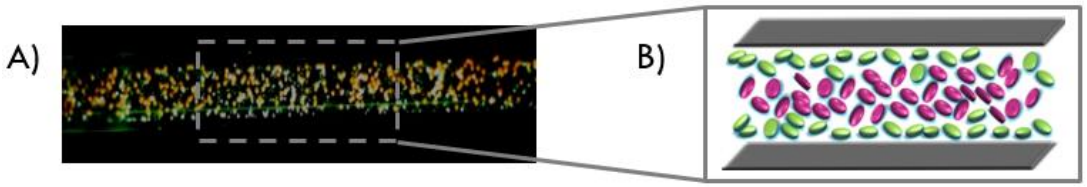

Figure 2 – A) Experimental image of microcapsules flow; B) Schematic illustration of the flow-induced margination

Conclusions: The production of microcapsules with different membrane rigidity assembled with microfluidics is well developed. On the other hand, the visualization and illumination's techniques must be improved. A thinner and uniform light plane must be guaranteed and a smaller focal plane has to be achieved in order to eliminate the superposition of microcapsules images. The results obtained were promising, and a variation of parameter such as size, shape, membrane thickness and microcapsules concentration will be placed in the future to acquire a more detailed study of the margination phenomenon.

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