SPECIAL ISSUE “Micro and Nano Flows 2016 (MNF2016) – Biomedical Stream”

EDITORIAL

The 5th run of the Micro and Nano Flows conference series, MNF2016, was held at the Politecnico di Milano, Italy, from 10–14 September. The conference series provides a forum for scientists and engineers working in the area of small scale flows, both in the biomedical and thermofluids engineering fields, to enable presentation of recent research findings as well as discussion of remaining issues to aid improved understanding and future progress. The MNF2016 Conference attracted in excess of 160 delegates with representation from all five continents.

In biomedical engineering the drive to increase understanding of biomedical flows, particularly blood related, and to develop associated technology at small scales keeps persevering. At the tissue and organ level these may be experimental or numerical studies related to health and disease. Whilst lab-on-a-chip technology aids screening and treatment, organ-on-a-chip devices are set to improve disease modelling and aid dosage optimisation to path the way for increasing personalised drug treatments as well as to benefit drug development. Advances in each of these areas are reflected in the articles that appear in this Special Issue, which were invited following oral presentation at MNF2016, and having been subject to expert re- view according to the Journal’s peer review process.

The use of cell coating in clinical treatments involving allogenic cellular transplantation poses several issues. In particular the immunoisolation through encapsulation has to be balanced with the preservation of cell factor secretion and nutrient adsorption. At the Diabetes Research Institute of Miami a novel encapsulation process based on microfluidic principles named conformal coating has been developed, which allows to obtain a thin layer of polymer not interfering with the normal cell function. The method has been applied to human renal endothelial cells as models for showing the feasibility of a cell engineering approach while maintaining immune-isolation for an effective treatment of kidney diseases. Manzoli et al. encapsulated human renal endothelial cells and clusters demonstrating that the conformal coating encapsulation do not affect, and in certain cases even ameliorates, the proliferative potential and the secretory properties of the cells.

Von Willebrand factor is a key protein in hemostasis as it mediates adhesion of blood platelets to a site of vascular injury. A suitable length distribution of the protein is necessary to ensure normal functioning of hemostatic processes. While a diminished number of long Von Willebrand factor chains may significantly limit blood clotting and lead to bleeding, an abundant number of long ones may result in undesired thrombotic events. As the protein’s size distribution is controlled by ADAMTS13 protease Huisman *et al* modelled the cleavage of von Willebrand factor by ADAMTS13 protease in shear flow. Red blood cell aggregation is known to play a key role in microcirculatory flows. As little is known about the transport characteristics of red blood cell aggregates in branching geometries, Kaliviotis *et al* investigated the fluxes of red blood cell aggregates of various sizes in a T-shaped microchannel with the aim to clarify the effects of different flow conditions in the outlet branches of the channel. Their results show that the flow of larger aggregates is not suppressed downstream of a bifurcation, and that blood flow is maintained, for physiological levels of red blood cell aggregation.

As thrombus formation is a major adverse event affecting patients implanted with ventricular assist devices (VADs), despite anti-thrombotic drug administration, Dimasi *et al* evaluated anti-platelet agent efficacy under hyper-shear conditions using microfluidic platforms. Their study demonstrates the potential use of microfluidic platforms as a means of testing platelet responsiveness and AP drug efficacy under complex and realistic VAD-like shear stress conditions.

To control fluid volumes in microfluidic devices for medical applications, where flow adjustments often occur (generated e.g. by valves or infusion pumps), suitable actuators and corresponding sensors are required. Schroeter *et al* present two optical flow metering methods which are appropriate to characterise the dynamic behaviour of clinical or medical devices. They apply their methods for the characterisation of flowmeters and piezoelectrical micropumps.

Microcirculation issues related to red blood cell resuspension used to simulate microcirculation conditions in lab on chips are discussed in the work by Sznitman and colleagues. The paper compares two different buffer compositions and evaluate the different behaviours emanating between buffers. Convective/diffusive mass transport phenomena are a critical issue in microfluidic devices where the laminar flow regime limits not only the fluid mixing but also the concentration gradients within the fluid. This is particularly relevant when dealing with immobilization and adsorption of molecules, in solution, onto a dedicated surface within a microchannel. In the work by Bianchi and coworkers this issue is elegantly investigated thanks to a numerical approach simulating the effects of herringbone like structures, which allow for tuning the concentration gradients and to adapt the adsorption pattern to the specific assay requirements.

Biomedical applications often require to sort cells according to their physical properties, such as size, density or deformability. Le Goff *et al* present a simple microfluidic device consisting of a channel containing an obstacle against which capsules are squeezed by the flow, followed by a diverging chamber. They demonstrate that this basic system is capable of sorting elastic microcapsules according to their size at low flows, and according to the stiffness of their membrane at high flows.

Capillary microsystems are used not only in the scientific domains of biotechnology, medicine and biology (with application in portable diagnostic systems, smart bandages and tissue engineering), but also in chemistry, energy and space engineering. A general condition for the establishment of a spontaneous capillary flow in a uniform cross section channel has already been derived from Gibbs free energy. Spontaneous capillary flows in diverging open U-grooves and suspended channels are investigated by Berthier *et al*. Their study shows that they do not flow indefinitely but come to a halt at some location in the channel. When moving to technological applications, however, the flow pattern inside the bundle remains hardly predictable, depending on the internal structure and material of the bundle. In another paper Berthier *et al* present a theoretical and numerical analysis of the different flow regimes for homogenous and heterogeneous fibre bundles. They show that heterogeneous bundles with controlled properties can be obtained by comprising sub-yarns of different wettabilities.

Single-cell analysis tools are rising interest in medicine and life science applications, to non-invasively probe cell function at the single-cell level, in order discriminate between cell types, or to investigate cell growth, activation and cell-cycle progression. In this scenario, Caselli et al provide an in silico study on a novel high-throughput microfluidic impedance cytometer conjugating high accuracy and easy-to-realize features.

We would like to thank the Editorial Board and the Editor-in-Chief, Dr Richard Black, for giving us the opportunity to assemble another Special Issue, this being the fourth one in connection with the MNF conference series. We would also like to thank all the contributors who accepted our invitation to submit their work for this issue. As the area of biomedical fluid flow at small scale continues to be a greatly active research field we are very much looking forward to the 6th International Conference on Micro and Nano Flows which will be taking place at the Georgia Institute of Technology, Atlanta, USA from 9-12 September 2018 (http://www.mnf2018.com/) for new developments in the field.

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