Abstract

Drying of complex fluids (viz. whole blood, plasma, urine) on both porous and non-porous substrates has received significant attention owing to its potential to be used as a biomarker in determining the health status of a subject. The focus of this thesis is to understand the interfacial facets of complex bio-fluid systems and explore their applications in the broad realm of bio-microfluidics. In the first objective, the crucial roles of hardness, material compositions and surface charges of a substrate in relation to the morphological alterations of erythrocytes have been investigated to formulate an error-free protocol for the baseline peripheral smear test of haematological diagnosis. Experimental results and supporting theoretical analysis unambiguously justify the surface potential of the solid substrate to be the most influential parameter in the process of morphological alterations. In the second objective, the exclusive effects of some commonly available salts on the final dried patterns of model solutions have been explored to further aid in disease detection. The physics associated with the interfacial interactions between the cells and the substrate (owing to the differences in physicochemical properties of the healthy and diseased red blood cells), have been probed in the third objective, taking Thalassaemia as a test case. The efficacy and potential of the unique study have been established for rapid, accurate and direct screening of a large number of samples in areas with low resource settings. Porous media systems have been explored in the fourth objective of the thesis, where two paper-based devices have been designed and created on Whatman® filter papers, using a commercial laser printer, for self-monitoring of glucose and ketone contents in urine. The devices have been tested for wide ranges of glucose and ketone contents in real urine samples, resulting in successful detection of the biomarkers' contents with zero false negatives. The studies conducted in this thesis can be instrumental in developing rapid, less laborious, and cost-effective point-of-care devices for applications leading to accurate and affordable healthcare monitoring.

Keywords: erythrocyte, peripheral smear, morphological alteration, model solutions, complex fluids, blood droplet drying, cell-substrate interactions, cell-cell interactions, drying patterns, red blood cells, interfacial energy, thalassaemia, paper device, glucose detection, ketone detection, Richards' equation, laser printing, colorimetry.