ABSTRACT

Microfluidics deals with the science of fluid flows over micron or sub-micron length scales, pertaining to the actuation, precise control and manipulation of small volumes of fluids through miniaturized conduits of varied geometrical shapes and practical functionalities. Flows in microscale may be actuated by several mechanisms. One such mechanism deals with the employment of forces in rotational platform, by spinning a disc containing microfluidic networks. The disc in many ways may resemble the Compact Discs (CD) used for external data storage, and hence this type of flow actuation is also known as CD-based microfluidics. CD based microfluidics has gained considerable attention owing to its utility in bio-microfluidic analysis. It can act as a relatively inexpensive platform for chemical analysis and biomedical diagnostics, exploiting the advantageous features of portability and rapidity of this analytic platform. Its prime advantages lie in handling wide variety of sample types, the ability to gate the flow of liquids, simple rotational motor requirements, economized fabrication methods, large ranges of flow rates attainable, and the possibility of performing simultaneous and identical fluidic operations.

The present study focuses on four important and inter-related facets of interfacial transport in rotationally actuated microfluidic devices. First, we characterize capillary filling dynamics on a CD as a simultaneous function of surface roughness and wettability conditions, as well as the rotational speed of the fluidic platform. Secondly, we exploit the rotational forces for microbubble generation on a CD. We demonstrate that an explicit control over the frequency and dimensions of the bubbles may be imposed by programming the rotational speeds in a dynamical environment. Thirdly, we exemplify the use of CD as an efficient mixing platform. In effect, we demonstrate that there exists a critical regime of the rotational speeds in which the mixing performance deteriorates instead of improving, with further increase in rotation speed, bearing far-ranging scientific and technological consequences. Finally, we investigate the deployment of CD as a particle separation platform and delineate the effects of Coriolis force on the same. We characterize the resolution of separation as a function of two significant parameters, namely, the particle size and rotation speed.