# Inertial focusing of deformable particles in square capillary channel flows

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Inertial focusing of particles was first reported for circular tube flows, in which suspended particles migrate across streamlines towards an annulus, called the Segre-Silberberg (SS) annulus. Recent studies have shown that inertial particles in rectangular channel flows also initially migrate towards a ring corresponding to the SS annulus, termed the p(seudo)SS ring, and eventually focus at several discrete points in downstream cross sections. Such inertial focusing phenomena have attracted considerable attention in the field of microfluidics due to their wide range of applications, such as the separation and sorting of biological cells. Currently, most microfluidic devices for these purposes are designed to operate mainly on the basis of the difference in cell size. However, the operation based on their deformability is useful and of practical importance for improving performance.

In the present study, the inertial migration of deformable particles (human red blood cells (RBCs)[1] and hydrogel microspheres[2], Fig. 1(a)) suspended in the flow through square cross-section capillary channels was experimentally investigated and their focusing positions in the channel cross section were compared with those of rigid particles of similar size. RBCs are known to be highly deformable, and hardened RBCs (HRBCs) are prepared by immersing intact RBCs in glutaraldehyde solutions of various concentrations. The dilute suspension of RBCs, HRBCs, hydrogel microspheres or spherical polystyrene particles is injected into the square channel with 50μm width, and the positions of the particles in the cross section are detected near the outlet of the channel from the downstream side to obtain their distribution (Fig. 1(b)).

The present experiments show that at a low Reynolds number (*Re*=0.1), deformable particles (RBCs and hydrogel microspheres) are focused near the channel centreline, whereas rigid particles (HRBCs and rigid spheres with 5μm diameter) are widely dispersed in the cross section (Fig. 1(c)). At elevated *Re* (=1), deformable particles show off-centre focusing together with the centre focusing. In particular, RBCs are focused on the diagonals. In contrast, rigid particles are aligned along the pSS ring in the downstream cross section. At even higher *Re* (=10), deformable particles are focused near four points on the diagonals, whereas rigid particles are focused at four points near the centre of the channel faces. Thus, the migration behaviour of deformable and rigid particles of similar size is quite different at each *Re*, suggesting that the deformability can be used to separate suspended particles in channel flows.

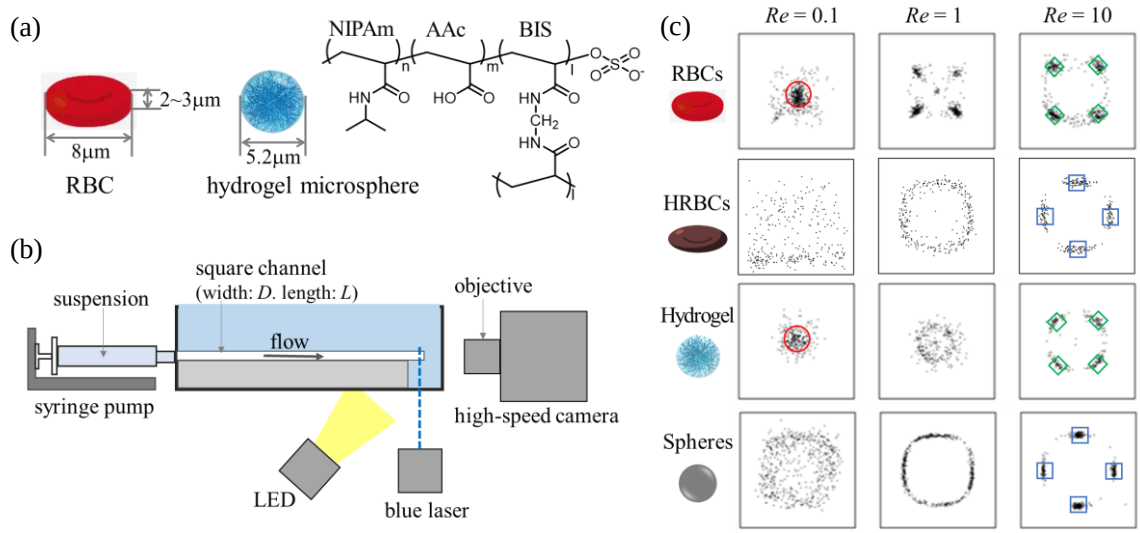


Figure 1: (a) Human red blood cells (RBCs) and hydrogel microspheres (NIPAm: *N*-isopropyl-acrylamide, BIS: *N,N'*-methylenebis(acrylamide), AAc: Acrylic acid), (b) experimental setup, and (c) experimental results of the particle distribution in the channel cross section ($D$ = 50μm, $L$ = 600mm).

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[1]Tanaka & Sugihara-Seki, *Journal of the Physical Society of Japan* **91**, 083401 (2022)
[2]Minato et al. *Chemical Communications* **54**, 932 (2018)