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Physical characterization of red blood cell aggregation

Abstract

In this work, five aspects of the red blood cell aggregation induced by macromolecules are investigated. A rheological approach focused on the normalization of viscosity as a function of the macromolecular adsorption rates using a commercial rheometer is proposed. Derived from that approach, the yield stress of aggregating red blood cell suspensions is investigated. The sedimentation rates of the utilized biological system are then studied. Microscopical investigations, including measurements of the microscopical aggregation index, lead to the conclusion that the C-reactive protein, a plasma protein, does not influence the aggregation behavior of red blood cells. Detailed microscopical studies on the morphology of the interaction zones of aggregated red blood cells show that these strongly depend on the macromolecular concentration in good agreement with numerical simulations that allow to derive an approximation of the interaction energies. The latter are also directly measured with single cell force spectroscopy using an atomic force microscope with the additional result that the viscosity of the surrounding medium can influence the results significantly.

Finally, the physical origin of aggregation is discussed and supported by several additional measurements. This allows to combine two existing theories and explain the bell-shape of interaction energy versus macromolecular concentration curve in a new way.