Supporting Information for:

Release of Colloids from Primary Minimum Contact Under Unfavorable Conditions by Perturbations in Ionic Strength and Flow Rate

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Fluid flow fields of loading jet velocity and 5x and 25x perturbations

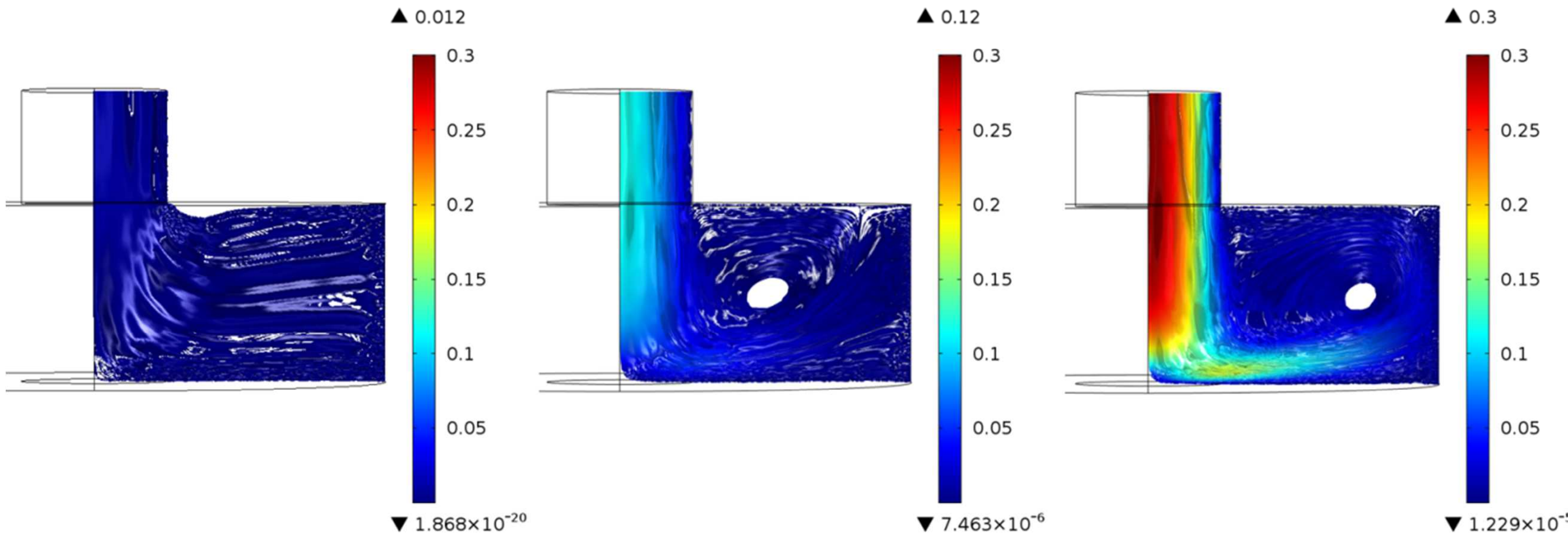

Figure SI-1. Velocity flow field streamlines under laminar conditions. Left: nominal loading jet velocity ($v_{jet} = 5.94x10^{-3}$ ms^{-1}). Center: 10x flow relative to loading. Right: 25x flow relative to loading. Color map shows velocity values in ms^{-1}. Up arrow and down arrow values on legend indicate maximum and minimum velocities in each flow field. The numerical flow fields were solved via the Navier-Stokes equations for a single phase laminar flow model using finite-element computational software.[4]

Distribution of fractional areas occupied by heterodomains interacting with immobilized colloids

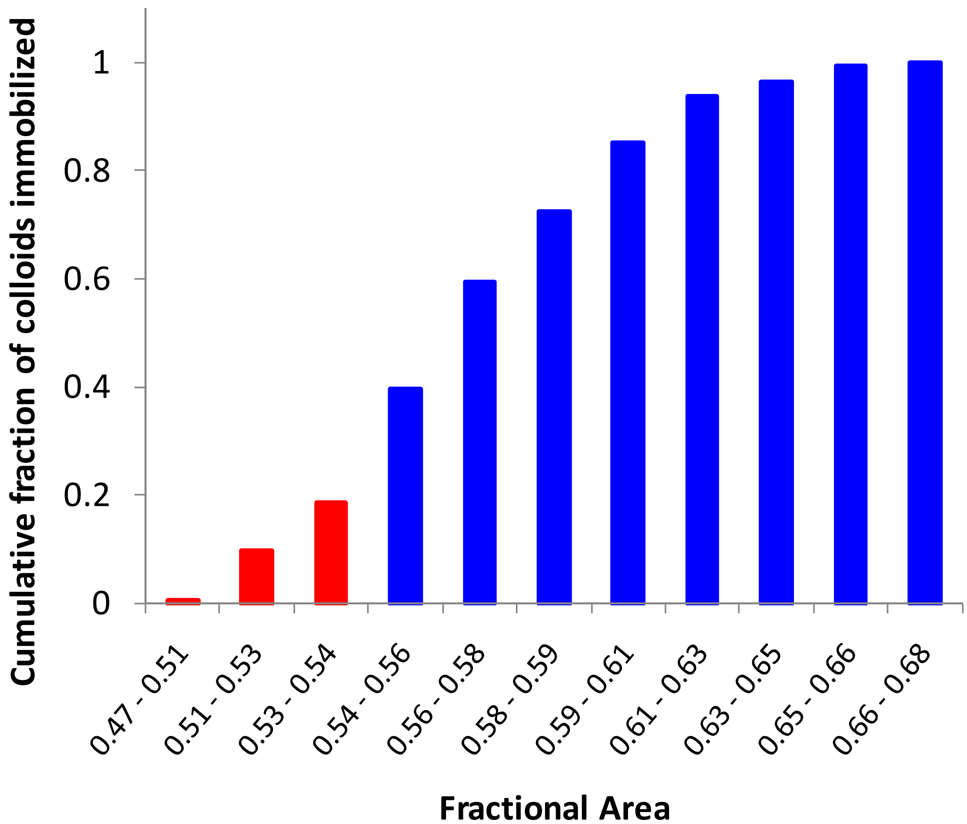

Figure SI-2. Cumulative distribution of fractional areas occupied by heterodomains in the zone of influence (ZOI) for 1.95 µm immobilized colloids loaded at 20 mM IS, 1.7×10^{-3} ms-1 average jet velocity. Red denotes the fraction of the colloids prone to release in response to IS reduction (20 to 1 mM). Blue denotes the fraction of the colloids that remains attached. Simulated heterogeneity involved 120 and 60 nm radii heterodomains at 1 to 4 number ratio, respectively, at surface coverage 0.04%.

Electric double layer interaction

The electric double layer force between colloid-collector was calculated from the energy expression developed by Lin and Weisner[1] for a sphere-plate geometry:

$$W_{sphere-plate} = \frac{64\pi\varepsilon}{\kappa}\left(\frac{k_B T}{ze}\right)\tanh\left(\frac{ze\psi_c}{4k_B T}\right)\tanh\left(\frac{ze\psi_p}{4k_B T}\right)\left[\left(\kappa a_p - 1\right)e^{-kH} + \left(\kappa a_p + 1\right)e^{-k\left(H+2a_p\right)}\right]$$

where ε is the absolute electric permittivity of water, κ is the inverse Debye length, k_B is the Boltzmann constant, T the absolute temperature, e the elementary charge, z the electrolyte valance ψ_c and ψ_p the zeta potentials of collector and colloid, a_p is the colloid radius and H is the separation distance. The electric double layer force corresponds to the derivative of the above expression with respect to H:

$$F_{sphere-plate} = 64\pi\varepsilon\left(\frac{k_B T}{ze}\right)\tanh\left(\frac{ze\psi_c}{4k_B T}\right)\tanh\left(\frac{ze\psi_p}{4k_B T}\right)\left[\left(\kappa a_p - 1\right)e^{-kH} + \left(\kappa a_p + 1\right)e^{-k\left(H+2a_p\right)}\right]$$

Van der Waals interaction

The retarded van der Waals force was calculated from the energy expression provided by Gregory[2] for a sphere plate geometry:

$$W_{sphere-plate} = -\frac{A_{132}a_p}{6H}\left[1 - \frac{5.32H}{\lambda} ln\left(1 + \frac{\lambda}{5.32H}\right)\right]$$

where A_{132} is the Hamaker constant and λ is the characteristic wavelength. The van der Waals force corresponds to the derivative of the above expression with respect to H:

$$F_{sphere-plate} = -\frac{A_{132}a_p}{6H}\left[6H^2\left(1 + \frac{5.32H}{\lambda}\right)\right]$$

Steric interaction

The steric force was calculated from the expression provided by Israelavichli[3] which corresponds to the energy per unit area between two plates:

$$w_{plate-plate} = W_0 e^{-\frac{H}{\lambda_0}}$$

The steric force was calculated via the Derjaguin approximation yielding:

$$F_{sphere-plate} = 2\pi a_p W_0 e^{-\frac{H}{\lambda_0}}$$

where λ_0 is the decay length and W_0 the maximum repulsive energy per unit area.

Time-lapse images

A time-lapse image acquisition is provided as a movie: "*Colloid reentrainment 1.7e-3 ms-1 1.95 um 20mM to 1 mM.avi"*, which shows release of 1.95 µm colloids in response to reduced ionic strength (20 to 1 mM). This material is available free of charge via the Internet at http://pubs.acs.org.

References:

(1) Lin, S.; Wiesner, M. R., Paradox of Stability of Nanoparticles at Very Low Ionic Strength. *Langmuir* **2012**, *28* (30), 11032-11041.
(2) Gregory, J., Approximate expressions for retarded van der Waals interaction. *Journal of Colloid and Interface Science* **1981,** *83* (1), 138-45.
(3) Israelachvili, J. N., *Intermolecular and Surface Forces: Revised Third Edition*. Elsevier Science: **2011**; pp 342-370.
(4) COMSOL Multiphysics™, http://www.comsol.com.