

Supporting Information

Colloidal joints with Designed Motion Range and Tunable Joint Flexibility

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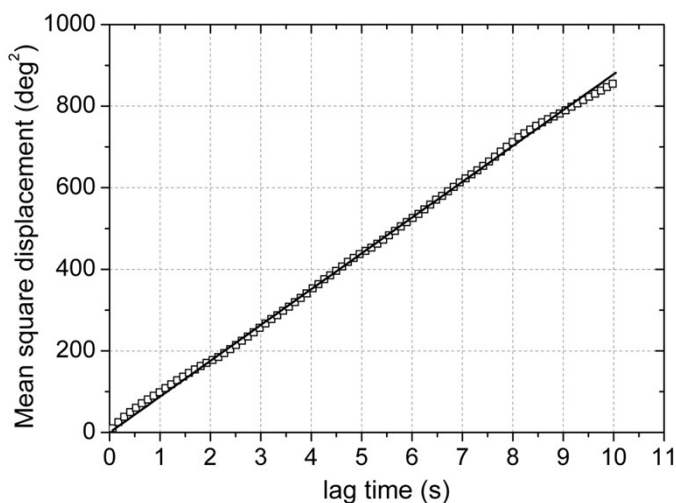


Figure S1. An exemplary plot of the Mean square displacement $\langle (\theta(t + \Delta t) - \theta(t))^2 \rangle$ vs lag time Δt for a three particle colloidal joint. The joint flexibility J in this case is given by the slope of the curve, $J = 88 \pm 23 \text{ deg}^2/\text{s}$.

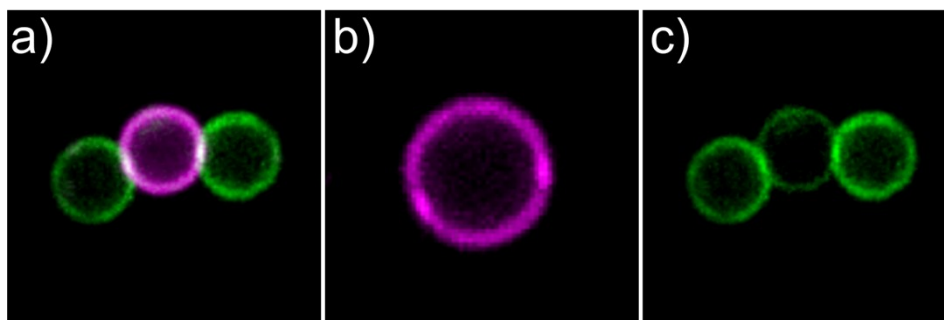


Figure S2. Confocal microscopy images of a colloidal joint bonded to two silica spheres with complementary DNA linkers. a) The superposed image from two different channels shows the patch areas as bright, white regions, same as Fig. 1b. b) and c) represent the single channel images for the magenta and green particles respectively, indicating the presence of two bright patch areas even in each single channel image.

Calculation of bond area of colloidal joints

We consider bonding of two spheres of radii r_1 and r_2 by mobile DNA linkers. We presume that the maximum distance d_{max} at which two linkers still bond is twice their length l ($l = 20$ nm). This parameter contains small corrections to the actual linker lengths to take the overlap at the sticky end and insertion into the lipid membrane into account. The maximum bond area defines a spherical cap on each sphere within which linkers can bind to their complementary linkers on the other sphere. To calculate the bond area of the colloidal joints, we express the height h in terms of the cap radius a and the radius of the sphere r .

$$h(r,a) = r - \sqrt{r^2 - a^2} \quad (1)$$

Setting $h_1+h_2=2l$, we obtain,

$$a(r_1,r_2) = 2\sqrt{\frac{l(r_1-l)(r_2-l)(r_1+r_2-l)}{(r_1+r_2-2l)}} \quad (2)$$

For equal sized spheres, $r_1 = r_2 = r$, equation 2 simplifies to:

$$a(r) = \sqrt{2lr - l^2}$$

The bond areas are therefore given by:

$$A_b(r_1) = 2\pi r_1 h_1(r_1,a) = 2\pi r_1 \left(r_1 - \sqrt{r_1^2 - \frac{4l(r_1-l)(r_2-l)(r_1+r_2-l)}{(r_1+r_2-2l)^2}} \right)$$

$$A_b(r_2) = 2\pi r_2 h_2(r_2,a) = 2\pi r_2 \left(r_2 - \sqrt{r_2^2 - \frac{4l(r_2-l)(r_1-l)(r_1+r_2-l)}{(r_1+r_2-2l)^2}} \right) \quad (3)$$

For equal sized spheres, this reduces to:

$$A_b = 2\pi r l \quad (4)$$

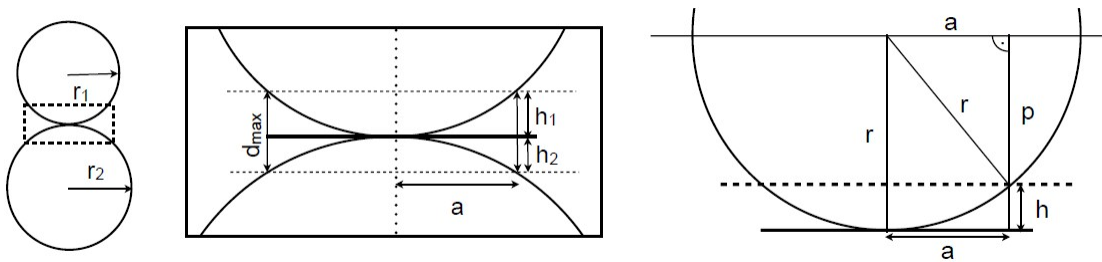


Figure S3. Geometry of two binding spheres with DNA linkers.

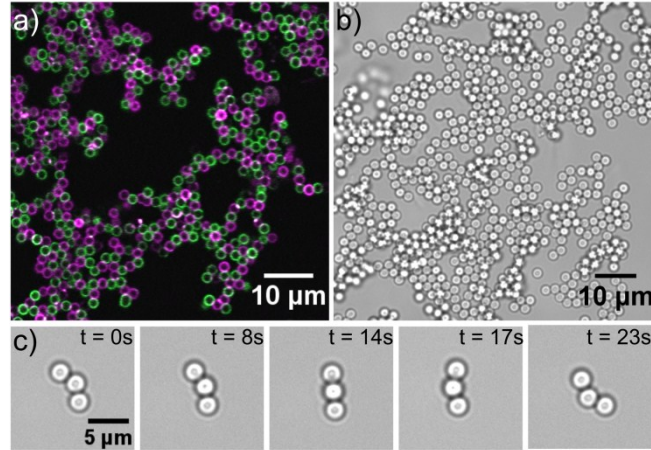


Figure S4. Colloidal joints with two different types of DNA anchors. a) Joints with a very high density of mobile DNA linkers ($>10^4 \mu\text{m}^{-2}$) containing double cholesterol anchors are immobile and form fractal aggregates at high linker density. b) Similar behaviour is shown by joints with DNA containing double stearyl (C_{18}) anchors. c) At low DNA linker densities ($\sim 10^3 \mu\text{m}^{-2}$) colloidal joints with stearyl anchored DNA show reconfigurability similar to joints containing cholesterol anchored DNA.

Video Captions

S1: A three particle colloidal string composed of colloidal joints, which consist of $2 \mu\text{m}$ silica particles functionalized with complementary DNA linkers. The video has been sped up $3.7 \times$ times for viewing convenience.

S2: A colloidal spherical joint composed of a $2 \mu\text{m}$ silica particle with mobile DNA linkers and $1 \mu\text{m}$ polystyrene particles with bound DNA linkers as joint elements.

S3: A colloidal planar slider joint composed of a $1 \mu\text{m}$ silica particle and a hollow $1 \mu\text{m}$ silica cube. Both have mobile DNA linkers. The motion of the spherical silica particle is restricted to sliding along one face of the cube.

S4: A colloidal hinge composed of two polystyrene particles with surface bound DNA linkers undergoing constrained motion along the neck of a silica dumbbell.

S5: A reconfigurable colloidal polymer composed of $2 \mu\text{m}$ silica with mobile DNA and $1 \mu\text{m}$ polystyrene with surface-bound DNA.

S6: A colloidal molecule composed of $2 \mu\text{m}$ and $1 \mu\text{m}$ silica particles with mobile DNA linkers.