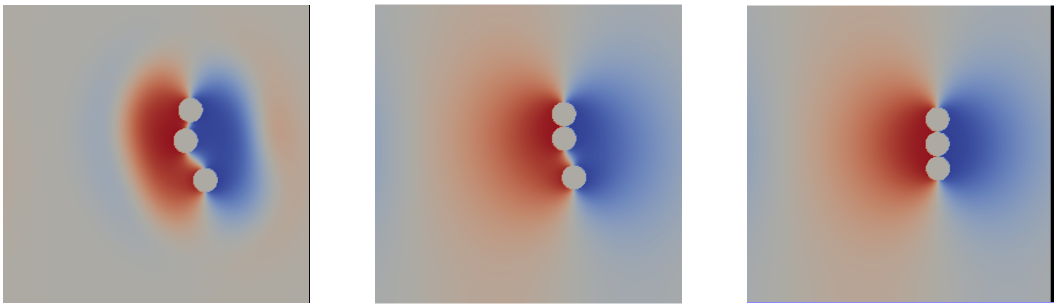
Supplementary Material

0.1 Discussion on many-body effects

For the system we investigated, the magnetic dipoles align perpendicular to the interface normal in equilibrium and we then apply a horizontal magnetic field. The particles will have similar tilt angles. To a first approximation, we can consider the particles having only 2 degrees of freedom (in plane translation). This is different from magnetic ellipsoidal particles interacting with a vertical magnetic field [David et al., Soft Matter 11:7969, 2016.], where the ellipsoidal particles have at least 3 degrees of freedom (in plane rotation and in plane translation).

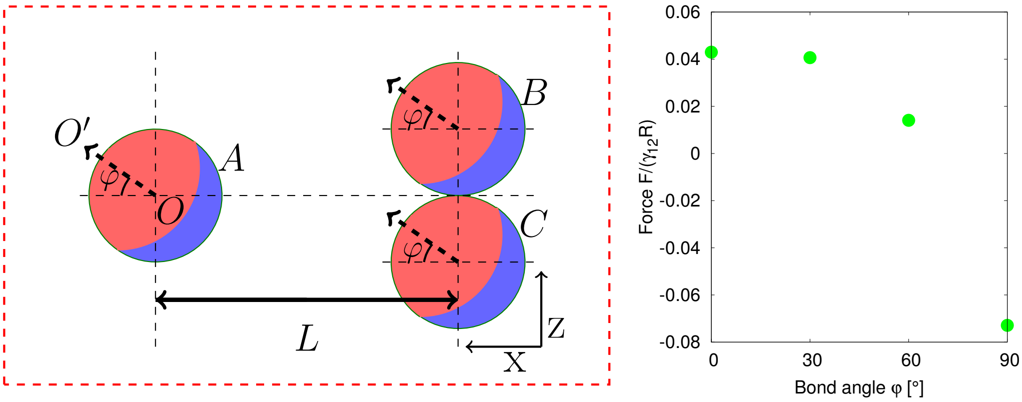
Therefore, the theoretical prediction can be used directly to explain straight chains formed by multiple particles. In Fig. 1 we show the assembly process of 3 particles at an interface using our simulations. The colours represent the relative height of the interface. The particles are randomly distributed at a fluid interface and the tilt angle increases due to presence of an external magnetic field. Each of them produces a dipolar interface deformation due to this tilting, and therefore interacts with its neighbours via dipolar capillary interactions. The two neighbouring particles form a pair. This pair deforms the interface in a dipolar fashion as well. Thus, we can treat this pair as a capillary dipole interacting with a third particle. Finally they then join into one longer chain (bond angle $\varphi = 90°$), which corresponds to free energy minimum.



(a) (b) (c)

Figure 1: Snapshots of the assembly process of 3 Janus particles adsorbed at a fluid-fluid interface. The colours show the relative height of the interface. The interface is depressed on one side of the particle (blue) and raised on the other side (red).

Additionally, we provide a quantitative analysis. We fix the positions and orientations of three particles, as illustrated in Fig. 2(a). We then let system equilibrate and measure the lateral capillary force on particle A as the bond angle varies. Fig. 2(b) shows that the capillary force is repulsive for bond angles $\varphi < 65°$ and attractive for bond angles $\varphi > 65°$. This is consistent with the results of two particles (Fig.4 in the manuscript).



(a) (b)

Figure 2: a) planar view of the particles and b) lateral capillary force on particle A as a function of bond angle φ.

0.2 Movies for assembling process of multiple Janus particles

- Movie $S1$ shows the assembling process of 8 randomly distributed particles under given dipole-field strength $\bar{B} = 1.31$.
- Movie $S2$ shows the assembling process of 80 randomly distributed particles under given dipole-field strength $\bar{B} = 0.30$.
- Movie $S3$ shows the assembling process of 80 randomly distributed particles under given dipole-field strength $\bar{B} = 0.65$.