Assembling Patchy Particles into Colloidal Superstructures

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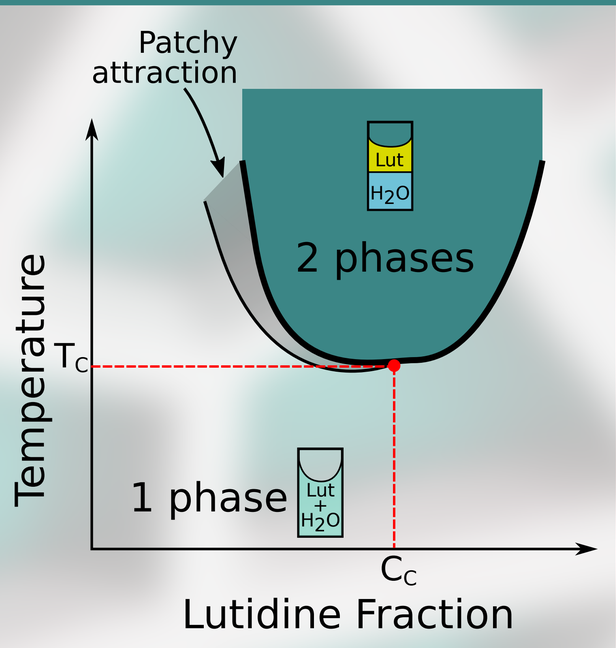
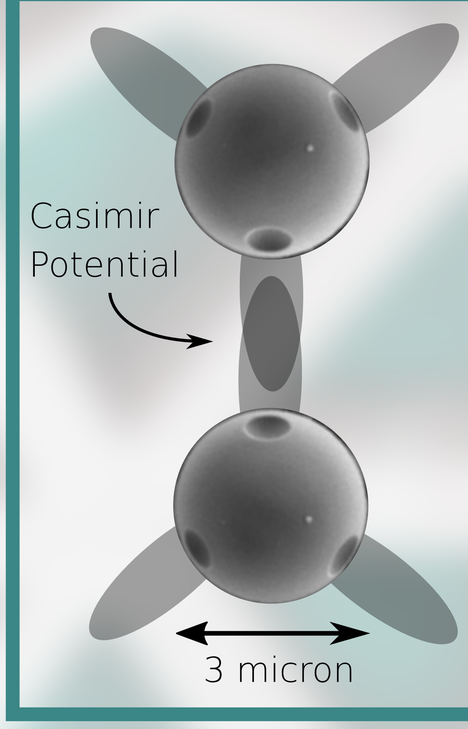
Molecular assembly is a good inspiration for the design of colloids for complex superstructures. From simple atomic properties, like direction, valency and reversibility, atoms can spontaneously form many different structures, from rings to polymers, and from diamond crystals to glasses. The reverse is also true: the assembly of colloids with atom-like properties may grant us new insight into the behaviour of molecules.

The Critical Casimir Effect

Critical Casimir Forces are solvent-induced between surfaces in binary solvents close to the solvent critical point. They have several benefits over other types of interactions, among them being reversible, highly tuneable and surface specific.

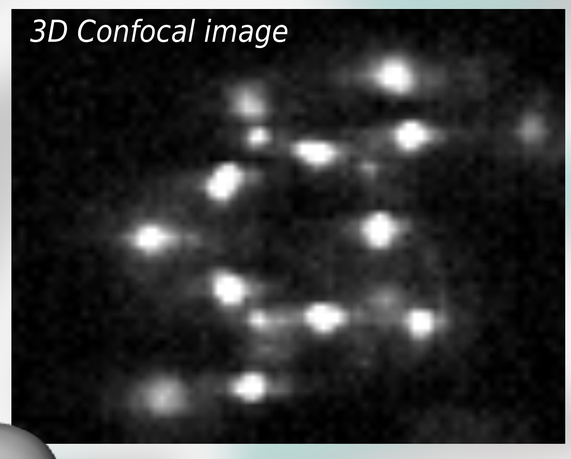


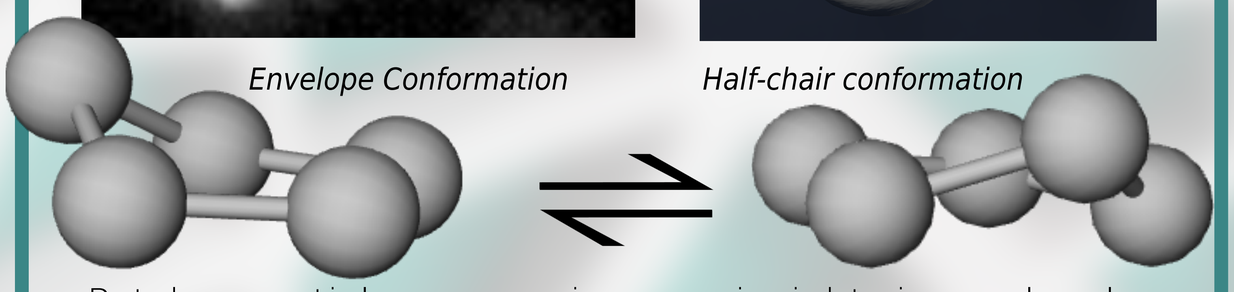
Patchy Particles



The group of Sacanna (NYU) has perfected the synthesis of monodisperse anisotropic colloidal particles with discrete patches. Using critical casimir forces, we make patches on the particles attractive. Computer simulations have revealed a wealth of structures that result from the assembly of patchy particles as a function of the main tuning parameters – the number of patches per particle, the patch size, and the particle geometry.

Cyclic Molecules

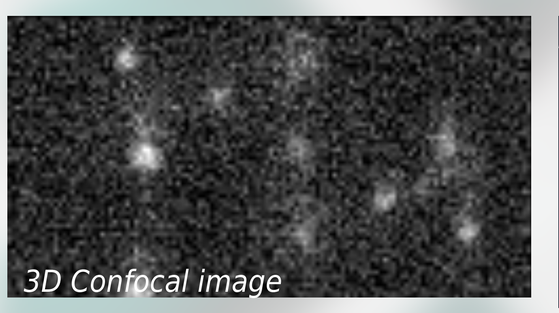


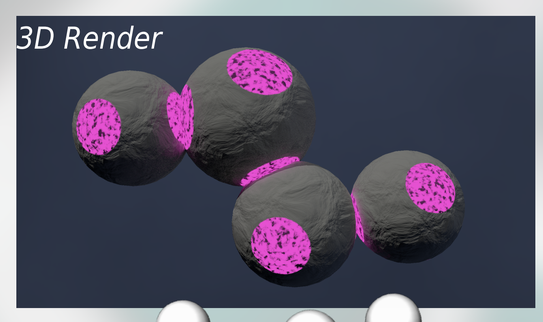


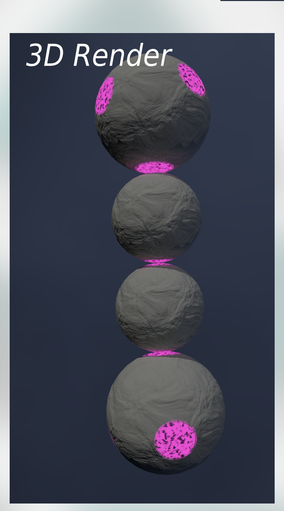
Patchy particles can give us insight in molecular behaviour. For instance, we observe 'envelope' conformations in 5-rings. This in agreement with a molecular 5-ring - cyclopentane, which also forms envelope conformations. Studying vibrational modes of 'colloidal' cyclopentane will give us fundamental insight into its molecular counterpart.

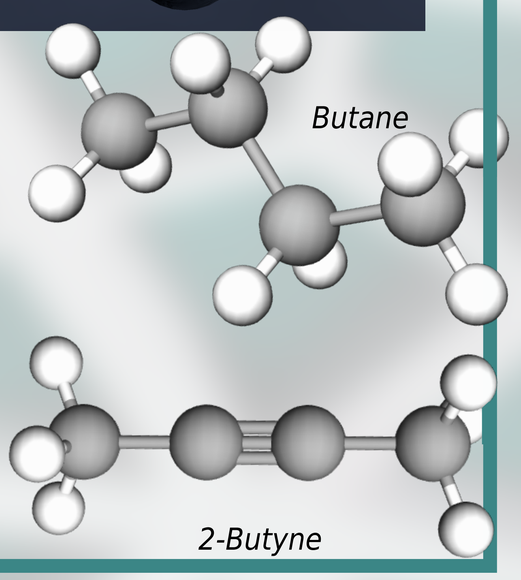
Linear Molecules

By combining particles with different numbers of patches, we obtain a range of structures, analogues of molecular species.









Polymers

We can use patchy particles to form a polymer chain. These chains are a model for molecular polymers. Properties like stiffness can be tuned by changing the attractive strength between particles. We can study the 'polymerization' by studying the dynamics of formation of these chains. In a weaker bonding regime, chains are constantly building up and breaking down, reminiscent of biological processes like actin ligament buildup.

Conclusion

Patchy particles are a powerful tool for gaining understanding in the chemical world. By using atomic geometry as a blueprint for patchy colloids, we can assemble 'colloidal molecules'. Thus, we unlock easy access to a generally inaccessible domain. We can study the assembly, structure, and behaviour by direct microscopic observation. This will yield fundamental insight into chemical sciences.

Further Reading

1. Gong *et al*., Nature 2017
2. Nguyen *et al*., Adv. Mat. 2017
3. Nguyen *et al*., Materials 2017
4. Stuij *et al.*, Soft Matter 2017

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