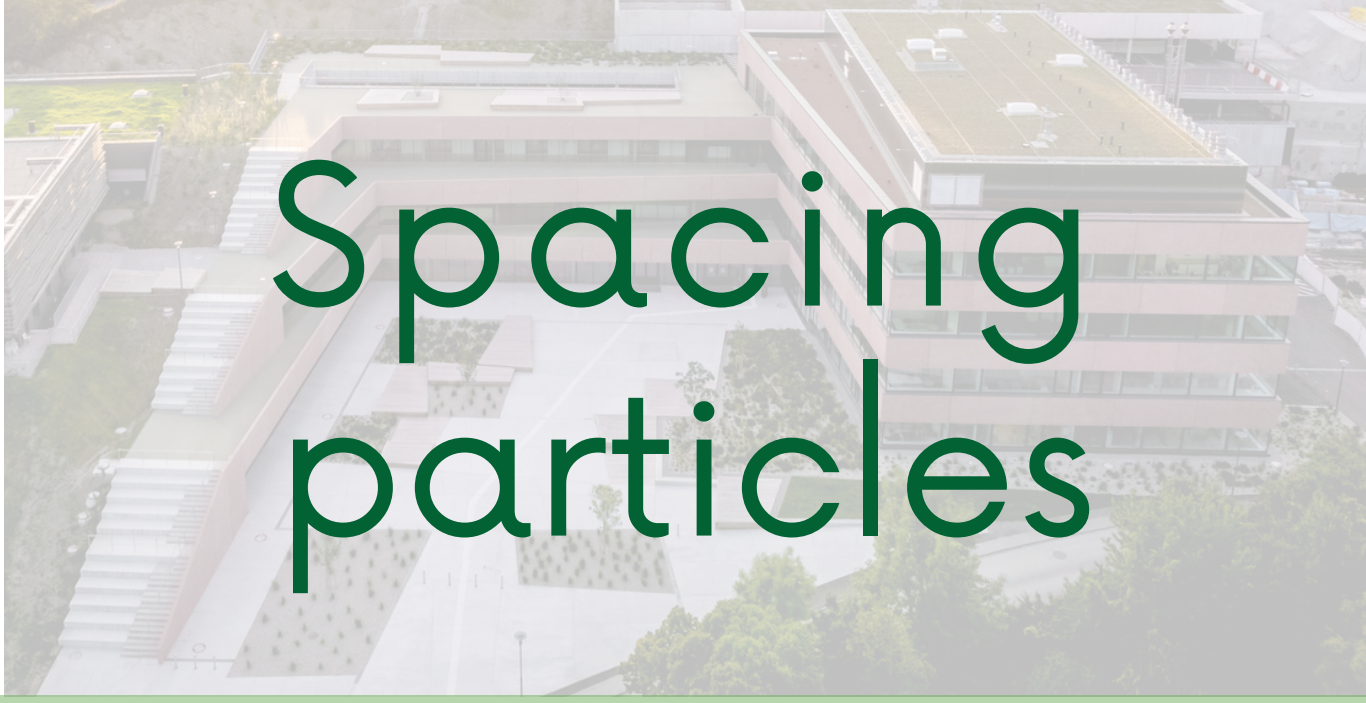
ChemISTry Colloquia



Spacing particles

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Moonstone Room G

Spacing is important: nanoparticles in dense assemblies can fuse and lose their identity. Changing particle distances in material, on the other hand, lets us tune color, electrical conductivity, or mechanical strength. In this talk, I will discuss how apolar organic ligands set the distance between nanoparticle cores.

Gold and cadmium selenide nanocrystals strongly attract each other. I will show that gold cores with diameters of 10 nm attract each other so strongly that they dominate the agglomeration of nanoparticles with hexadecanethiol shells [1]. In this “core-dominated” regime, ligand shells are compressed. Silica cores of the same diameter attract each other only weakly, and their spacing is set by the geometry of the ligand shells.

Particle geometry affects spacing, too. Ultrathin gold nanowires with oleylamine shells in alkanes spontaneously form bundles with large spacings – their ligand shells do not even touch. I will discuss how the solvent sets their spacing via an entropic mechanism [2]. Changes of the shell disrupt the mechanism and can induce nanowire gelation, as I will show.

Apparently spherical gold nanoparticles with alkylthiol ligands form superlattices with structures that depend on the polarity of the substrate. I will show that such particles can sit on different facets, which changes core-surface and, thus, interaction energies [3].

As an outlook, I will show that nanoparticle fusion at small spacings can be beneficial: we exploit the fusion of inorganic cores for the printing of transparent flexible electrodes [4] and for chemical sensors.

[1] Kister, T.; Monego, D.; Mulvaney, P.; Widmer-Cooper, A.; Kraus, T. Colloidal stability of apolar nanoparticles: The role of particle size and ligand shell structure, *ACS Nano* **2018**, *12*, 5969–5977.

[2] H. Y. Gao, S. Bettscheider, T. Kraus, M. H. Muser, Entropy can bundle nanowires in good solvents, *Nano Lett.* **2019**, *19*, 6993–6999.

[3] A. Bo, Y. W. Liu, B. Kuttich, T. Kraus, A. Widmer-Cooper, N. de Jonge, Nanoscale faceting and ligand shell structure dominate the self-assembly of nonpolar nanoparticles into superlattices, *Adv. Mater.* **2022**, *34*, 2109093.

[4] L. F. Engel, L. Gonzalez-Garcia, T. Kraus, Flexible and transparent electrodes imprinted from metal nano-structures: Morphology and opto-electronic performance, *Nanoscale Adv.* **2022**, *4*, 3370–3380.