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Playing Lego at the nanoscale: Nanoparticles as building blocks for hierarchical structures

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Nanoscience has deeply explored the synthesis of nanoparticles (NPs) and their application in devices. Still two main challenges remain open: the intrinsic material's performance limits at the nanoscale, and the low performance of NPs when integrated into devices. Producing or assembling NPs into more complex hierarchical structures has become a novel strategy to overcome such limitations. The inter-particle interactions that appear when NPs are assembled into large structures can increase the overall performance of the pristine NP building blocks while improving their integration into devices. The complexity of the structures can range from a simple assembly of two NPs (dimers) up to assemblies of an Avogadro number of them (*i.e.* gels). For instance, iron ferrite NPs show outstanding heating performance or relaxation times for MRI if produced as nanocubes. The latter can be improved by developing more complex structures such as dimers or magnetic nanobeads. Similar, anisotropic ceria NPs can be assembled into 3D aerogels boosting their performance for gas purification applications. Assembly strategies can be also exploited for the integration of NPs into devices. For instance, the integration of indium sulfide NPs into a xerogel thin-film increases the photocurrent in a factor of 2 if compared to standard integration techniques. All the above examples represent novel strategies to push the current limits of nanotechnology. *(Are you ready to play?)*

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