# Two-level ordering in nano-rattles for optical properties

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Yolk-shell nano-particles (also named nano-rattles), are in the center of many studies thanks to their interesting properties in multiple fields ranging from medicine to physics.[1] These properties come from both, the non-homogeneous composition of the nano-rattles, and also from the particular environment around the core, as it behaves like a nano-reactor. Synthesizing such nano-objects is challenging,[2] but we decided to take it one step further by organizing them in different ways and levels for optical effects.

In a first part we focused on obtaining a controllable and reversible way of aggregating the nano-particles, using silica spheres as model. The second part focused on the development of anisotropic and magnetic nano-particles and on how to use these as starting point for the synthesis of the desired nano-rattles. Having such a high control over the organization of nano-materials might allow to control opalescent properties of the aggregates.

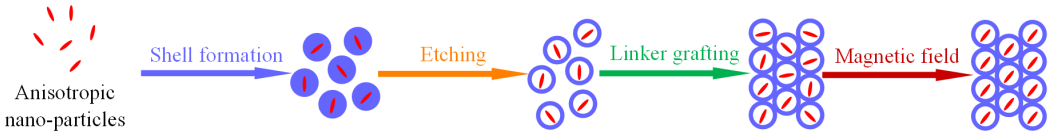


**Figure 1.** Schematic representation of the different synthesis and organization steps

[1] A. M. El-Toni, M. A. Habila, J. P. Labis, Z. A. ALOthman, M. Alhoshan, A. A. Elzatahry and F. Zhang, *Nanoscale*, 2016, **8**, 2510–2531.
[2] L.-S. Lin, J. Song, H.-H. Yang and X. Chen, *Adv. Mater.*, 2018, **30**, 1704639.