# Surface Forces Across Inorganic Nanoparticle Dispersions and Frictional Properties under Confinement

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**Introduction**: We have investigated the properties of ceria nanocrystals under confinement since it is known that nanosystems and molecules confined in very thin films between two solid substrates can form ordered structures and present interesting lubricant properties. Ceria cubic nanocrystals with a size lower than 10 nm and coated with decanoic acid were produced by a simple approach using organic-ligand-assisted supercritical water as the medium (see Fig. 1). The particular effects of nanomaterials under confinement are well accessible by surface force and resonance shear measurements.

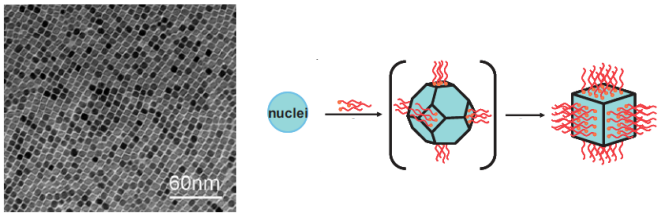


Fig 1. a) TEM image of the nanocubes. b) Synthesis process [1].

**Experimental**: The surface used was muscovite mica with a thickness within the range 2-4 µm. The surface-to-surface distance is determined optically by the fringes of equal chromatic order (FECO) obtained when light is traversing the surfaces whose back side was previously silvered (see Fig 2). The samples consisted in the ceria nanoparticles dissolved in the solvent decalin at various concentrations including 0.04 mg•mL$^{-1}$ and 0.2 mg•mL$^{-1}$.

**Results**: The main observation is the existence of a long-range repulsive force during the first approach. A hard wall was observed, which means that particles remained between the layers after compression, probably forming an ordered structure.

For the study of the tribology of the system, the shear force apparatus was used [2]. With the nanoparticle solution, the resonance peak observed far from contact generally disappeared at a distance around 100 nm due to the increase in viscosity. At the hard wall, a small peak was observed, which shifted gradually towards higher frequencies as the load was increased, pointing out to a higher friction. Those experiments thus enabled us to obtain important information on the lubricant properties of the nanoparticles.

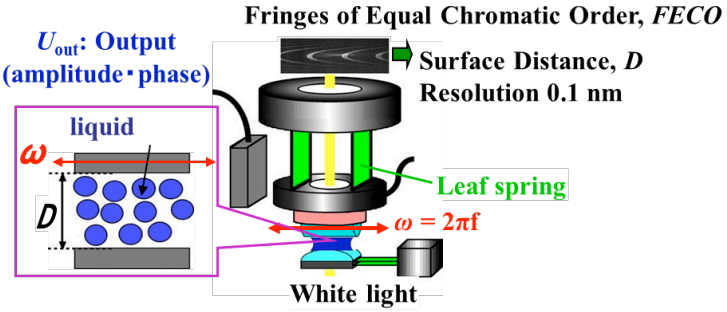


Fig 2. Experimental setup for resonance shear measurements based on a surface force apparatus (SFA).

[1] Zhang et al., *Adv. Mater.* **2007**, 19, 203–206
[2] Dushkin and Kurihara, *Colloids and Surf. A* **1997**, 129-130, 131-139