Supplementary material for the article:

Tuning finely the packing density of heavy microparticles in a microfluidic channel.

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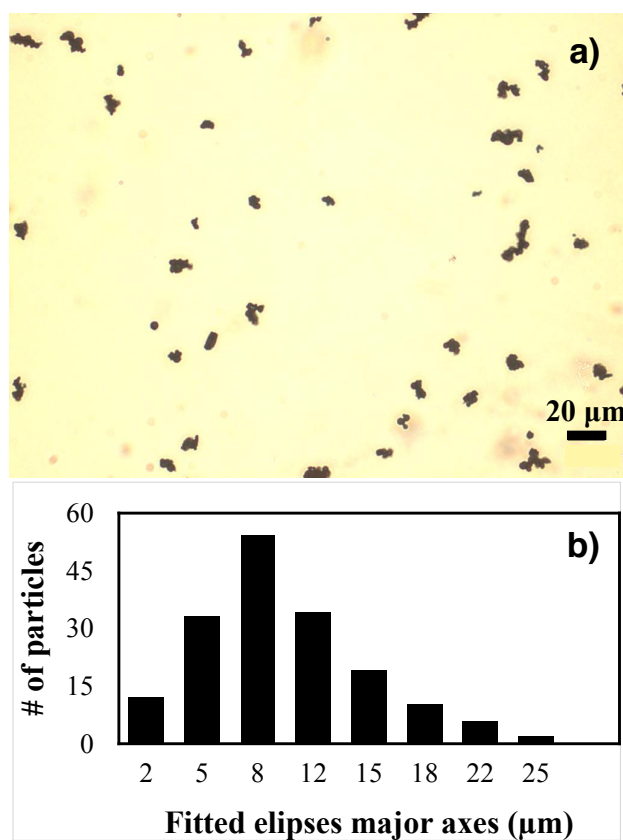
1   Microparticles characterisation

Fig. 1 Visualisation of particles. a) Carbonyl-Iron powder (puriss. p.a. 44890 ALDRICH) dispersed in 1,2,3-Triacetoxypropane observed in an inverted microscope. b) Distribution of sizes of the major axes of ellipses fitted to particles through image analysis. The ellipses have the same area, orientation and centroid as the particles. The average major axis size is 9.82 *μm* and the average aspect ratio (major axis/minor axis) is 1.6.

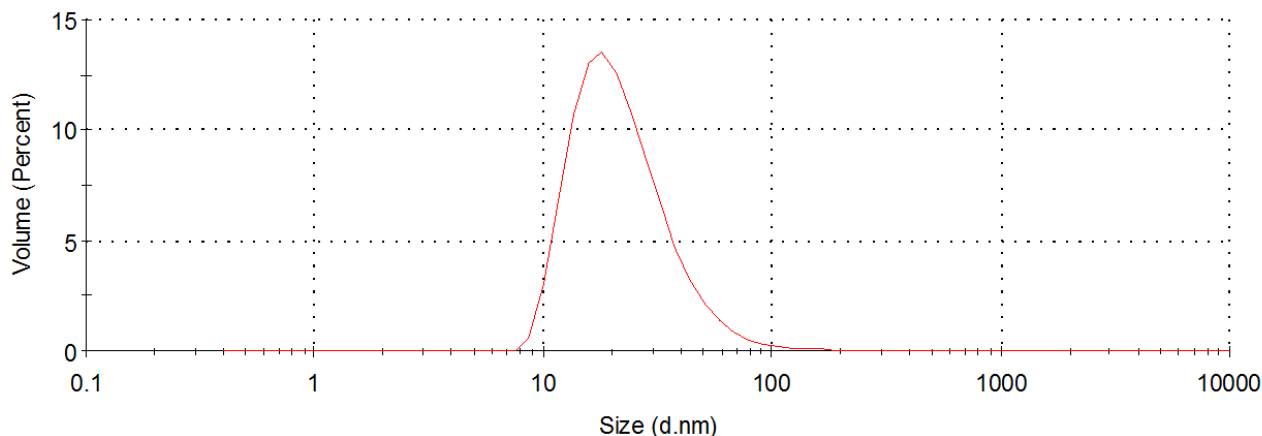## 2   Nanoparticles synthesis and characterisation

Fig. 2 Dynamic Light Scattering analysis of the non functionalized magnetic nanoparticles. The average size measured was 24 *nm*.

The magnetic trap was tested by trapping Fluorescent Magnetic Core Shell Nanoparticles (FMCSNPs) that we synthesised following closely the procedure used by B. Teste et al. (ref. 5 in the article). First, we prepared maghemite-magnetite nanoparticles by co-precipitation of Fe^{+2} and Fe^{+3} ions under alkaline conditions following the procedure described by Bacri et al.[1]. The nanoparticles were coated with citric acid to make them colloidal and stable in water. The average size of these particles was found to be 24 *nm* by Dynamic Light Scattering (Fig. 2).
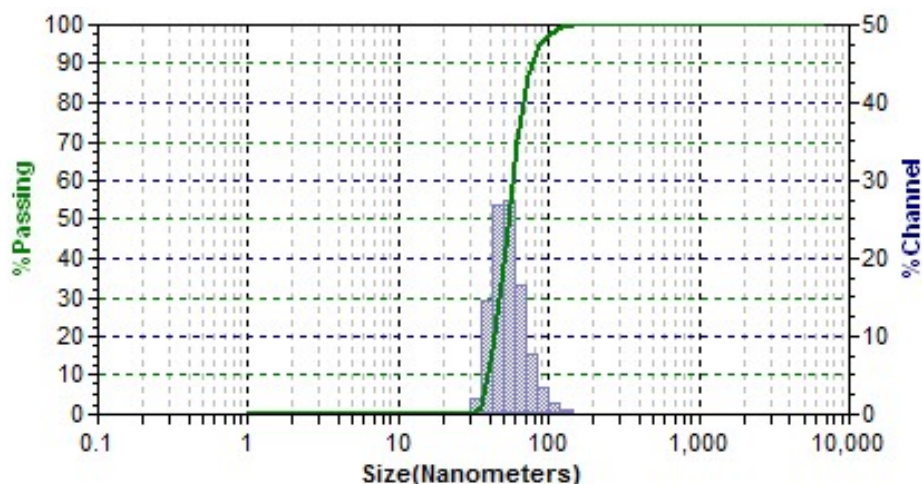

Fig. 3 Dynamic Light Scattering analysis of the Fluorescent Magnetic Core Shell Nanoparticles (FMCSNPs). The average size measured was 53 *nm*.

The magnetic nanoparticles were functionalized to make them fluorescent. The functionalization was based on the hydrolysis and condensation of tetraethoxyorthosilicate (TEOS) through a sol-gel process. We followed the procedure described by Y. Lu et al.[2], which is also followed by B. Teste et al. (ref. 5 in the article). This method coats the nanoparticles with a uniform silica shell whose thickness can be

controlled by simply changing the concentration of TEOS. Fluorescent dyes can be added to the silica shell by coupling the dye and the precursor covalently. We prepared the complex Fluorescein isothiocynate- 3-Amino propyltriethoxysilane (FITC-APTS) through an addition reaction and then incorporated to the silica shell by co-hydrolyzing with TEOS. The resulting FMCSNPs were analysed with Dynamic Light Scattering showing to have an average size of 53 *nm* (see Fig. 3).

3   Nanoparticles trapping

The Fluorescent Magnetic Core Shell Nanoparticles (FMCSNPs) are trapped by approaching a $6 \times 3 \times 25$ *mm* neodymium magnet to the iron beads packed against the restriction while flowing a solution of nanoparticles in water at a concentration of approximately 60 nanoparticles per μm^3 and a flow rate of 100 $\mu L/h$. The magnetic field applied to the restriction is 150 *mT*. Fig. 4 shows snapshots of a movie showing the liberation of trapped nanoparticles. From these kind of movies is possible to estimate the amount of nanoparticles trapped in the restriction.
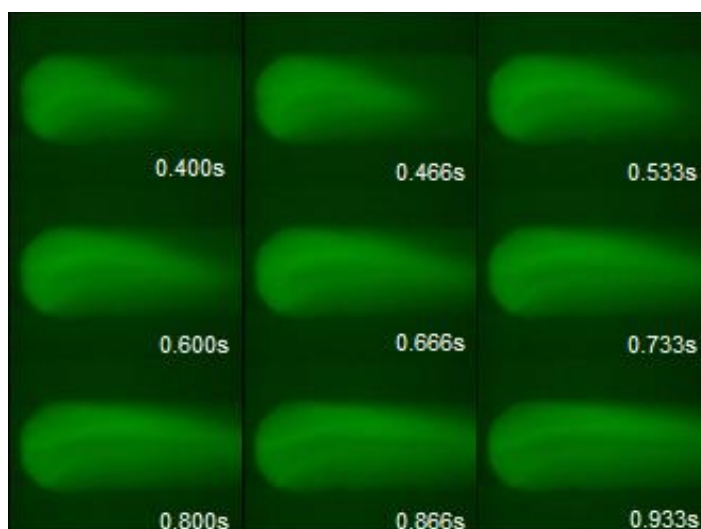

Fig. 4 Snapshots of a movie showing the liberation of trapped fluorescent nanoparticles. The images are showing the channel right after the restriction; the leftmost part of the images correspond to the restriction. Time zero corresponds to the moment of removing the magnet. The movies are made using a fluorescent inverted microscope.

The trapping experiments were performed as follows: 1) the packing was shaken for 10 *s* to prepare the packing into its most expanded configuration or into the desire density; 2) the packing was allowed to settle down for 10 *s* without shaking; 3) a flow of FMCSNPs in water at a rate of 100 $\mu L/h$ was imposed into the channel and the flow was allowed to stabilise for 5 minutes; 4) the height of the packing was measured; 5) the magnet was approached to the trap for ten seconds; 6) the magnet was released and the liberation movie was made.

When the packing density of the microparticles is low the packing is not strong and it compacts easily. Therefore, the process of approaching and removing the magnet in the presence of flow causes some compaction. For this reason, steps 4 to 6 of the protocol were repeated several times until the packing reached a density where no more compaction was caused by the magnet. Then, the protocol was repeated from step 1 but preparing the packing in more compact states until the maximum compaction was reached.

Once the microparticles had been exposed to the magnet, the most expanded configuration reached with the shaking was much lower than before the magnetisation. That is why the values of ρ/ρ_0 can be smaller than one in Fig. 5 in the article. Interestingly, the nanoparticle trapping increases considerably for these hyper expanded packings.

For the moment we are not able to know the mass of microparticles introduced to the channel. This makes difficult to compare trapping experiments done with different chips. That is why we present here the trapping data only for one chip as preliminary results.

The estimation of the number of trapped nanoparticles was made by knowing the fluorescence intensity measured in a movie of the input solution of FMCSNPs in water at a concentration of 60 nanoparticles per μm^3 and assuming that the fluorescence intensity is proportional to the number of nanoparticles. Each frame of the movies, like those in fig. 4, were analysed applying a mask with the shape of the velocity profile of the flow in the channel to be sure that the fluorescence intensity measured in the region of the mask in each frame captured all the nanoparticles, and no more, that passed through the cross section of the channel where the analysis was made.

References

1 J.-C. Bacri, R. Perzynski, D. Salin, V. Cabuil and R. Massart, *Journal of Magnetism and Magnetic Materials*, 1986, **62**, 36 – 46.

2 Y. Lu, Y. Yin, B. T. Mayers and Y. Xia, *Nano Letters*, 2002, **2**, 183–186.