

## Supplementary information

A commercial colloidal silica suspension (Ludox TM-50, Sigma-Aldrich) with uniform particle size of ca. 36 nm was diluted to 2 wt% concentration in a volume of 2.5 L. An 1.1 M KNO<sub>3</sub> solution (Sigma-Aldrich) was prepared in a volume of 2.5 L. Addition of the salt solution to the silica sol caused diffusion limited aggregation. Aggregate growth was allowed to proceed to an aggregate size which could still reliably be investigated using dynamic light scattering (DLS). An aggregate size of around 1,000 nm was found to be suitable. The aggregated sol was treated in an experimental setup with an internal closed liquid volume of 3.5 L. The setup consisted of stainless steel tubes, a double membrane pump (Model XLB 25.50 MMA 123 F ZC2, Flowtec Iwaki) with pulsation damper, on-off temperature control, ultrasonic flow meter and proportional flow control. A piston-cylinder system was implemented to compensate for the decrease of liquid volume upon sampling. A dispersing device made of stycast was mounted in the circuit. The dispersing device had an internal cylindrical channel with inner free diameter of 8 mm. The Reynolds number of the suspension could be adjusted by altering the flow rate or else by insertion of stainless steel tubes with a wall thickness of 1 mm in the cylindrical restriction. The free diameter of the dispersing device could be varied from 2 to 8 mm. Special care was taken to avoid flow resistances at the in- and outlet of the dispersion device. For generating the static magnetic field two permanent NdFeB block magnets (grade N50, ChenYang Technologies) with dimensions of 50x20x5 mm were mounted on the outside of the dispersing device (Figure 1B of the manuscript). The distance between the attracting magnetic blocks was 10.5 mm. The magnetic field strength in the middle of the channel was 0.31 T, as measured with a Hall probe, the field of which was calibrated by electron spin resonance. DLS measurements were performed on an ALV CGS-3 instrument, equipped with a goniometer. The laser wavelength was 632.8 nm. The index matching fluid was toluene. The samples were measured without dilution during 30 s within 5 min after dispersion treatment.

$\gamma$ -Alumina (CR125, Baikowski) with a primary particle size of 20 nm as determined by scanning electron microscopy (Philips XL 30 FEG SEM at 10 kV) was suspended at a concentration of 0.5 wt% in deionized water. The original aggregate size determined using Laser diffraction (LS100, Beckman Coulter) reached several microns. A volume of 100 mL of  $\gamma$ -alumina suspension was circulated in a closed loop of an 9.5 mm inner-diameter Tygon Lab tubing (Masterflex, IP70, R-3603, Cole-Palmer) using a peristaltic pump (Masterflex I/P High Performance Pump, Model 77600-62, Cole-Palmer) (Figure 3B). The dispersing device was mounted into the loop. The treated suspension was poured into a beaker. Three drops were sampled under gentle stirring and diluted in 3 mL of distilled water. The particle size determination was done as quickly as possible and always within 5 min after dispersion treatment. Aggregate sizes were determined by photon correlation spectroscopy (PCS) using an ALV-NIBS HPPS particle size analyzer (ALV-GmbH) equipped with a 3 mW He-Ne laser ( $\lambda = 632.8$  nm) and operating in back scattering mode (detector at an angle of 173° with respect to the laser). The particle size distribution was estimated from the field autocorrelation function using an inverse Laplace transformation algorithm and Stokes-Einstein equation.<sup>1</sup> Average particle size was calculated as the geometric logarithmic intensity-based mean value of the particle size distribution. The mean particle size in a series of experiments performed under the same conditions was the average of the average particle sizes.

The circulation system for in-situ SAXS measurements (DUBBLE beamline, Grenoble) was essentially the setup used for the experiments with  $\gamma$ -alumina. An additional flow cell with mica plates to allow X-rays to pass through the flowing suspension was integrated in the loop together with a degassing device for elimination of air bubbles using helium stripping before starting circulation. The SAXS patterns of parent  $\gamma$ -alumina suspension (circulated at low flow rate for a few minutes) and magnetically treated suspension at Reynolds numbers of 16,000 and 32,000 were indistinguishable (Figure 1).

The planetary ball mill was a Fritsch Planetary Micro Mill "Pulverisette 7" classic line with an input power of 880 W. The milling was applied during 1 hour in two separate bowls each with a sample quantity of 20 mL. A number of seven zirconia milling balls ( $\rho = 5.7$  g cm<sup>-3</sup>) with 10 mm diameter were used. The Ultraturrax instrument IKA-Ultra-Turax T25 Basic had a power input and output of 600 and 350 W, respectively. A volume of 500 ml was treated during 2 min. Ultrasonic treatment was performed using Hielscher UP400S equipment with a power input of 300 W and an amplitude of 70 %. A volume of 100 mL was treated during 2 min. The entrance section of the home-made jet-milling device had a diameter of 2.5 mm. The suspension collided on a plate and was split in two opposite directions. Through a few orifices the two streams were recombined. The data used for estimating the energy consumption of treatments with the different dispersion techniques is provided in Table 1.

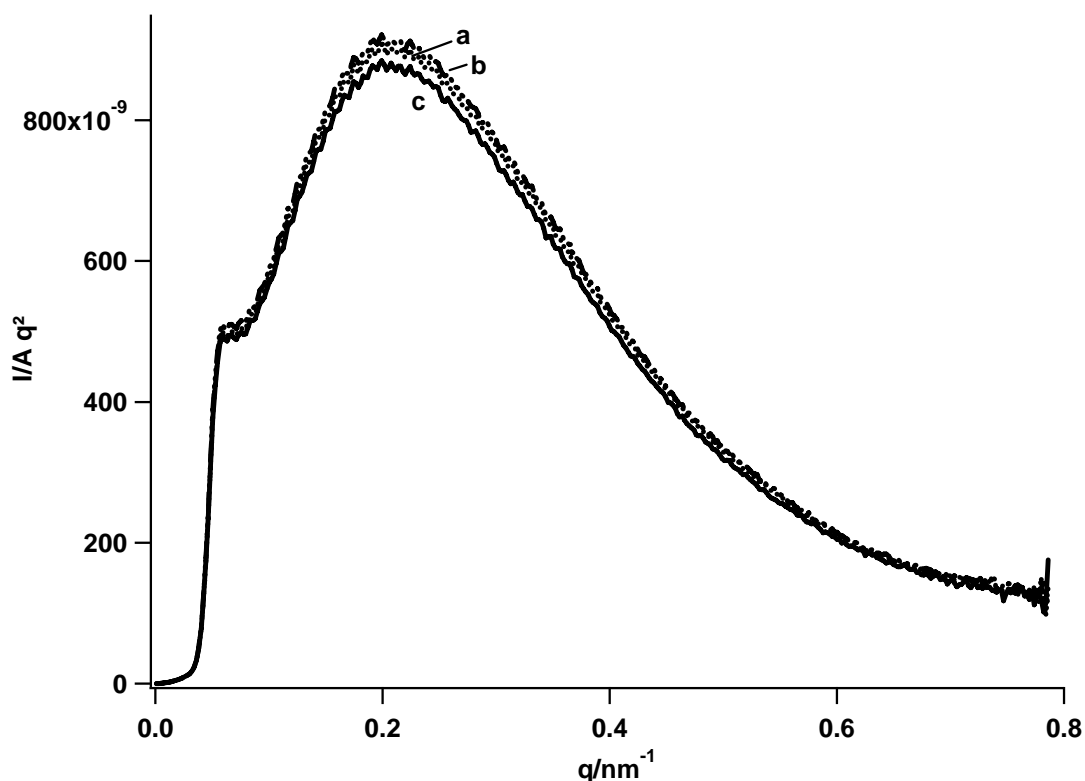


Figure 1: SAXS patterns of  $\gamma$ -alumina suspension circulated at  $Re = 5,000$  for 5 min without magnetic field (a), at  $Re = 16,000$  for 50 min with magnetic field (b) and at  $Re = 32,000$  for 1 h with magnetic field (c);  $I/A$  is measured intensity, corrected with the intensity of the ion chamber;  $q$  is the scattering wave vector.

**Table 1** Energy consumption and mean particle size after treatment with different dispersion technologies.

	Magnetic milling				Jet-Milling			Ultrasonic	Ultraturrax
	1.5	3.0	5.0	7.0	3.0	5.0	7.0		
Flow rate /Lmin-1	1.5	3.0	5.0	7.0	3.0	5.0	7.0	/	/
Reynolds number /-	7942	15884	26473	37062	25414	42357	59299	/	/
Pressure drop /Pa	1758	7031	19531	38281	50000	210000	450000	/	/
Maximum power /W	535	535	535	535	535	535	535	400	600
Output power /W	0.044	0.352	1.63	4.47	2.5	17.5	52.5	210	350
Time /s	3600	3600	3600	3600	3600	3600	3600	120	120
Energy /J	158	1266	5859	16078	9000	63000	189000	25200	42000
Volume /L	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0.1	0.5
Energy/Volume /JL-1	45	362	1674	4594	2571	18000	54000	252000	84000
Radius after treatment /nm	262	236	169	150	158	105	77	80	92

## References

- 1 M. Delsuc, T. Malliavin, *Anal. Chem.*, 1998, **70**, 2146.