Crystallisation of Sodium Dodecylsulfate (SDS) from Drying Microdroplets of Colloidal Silica Suspension

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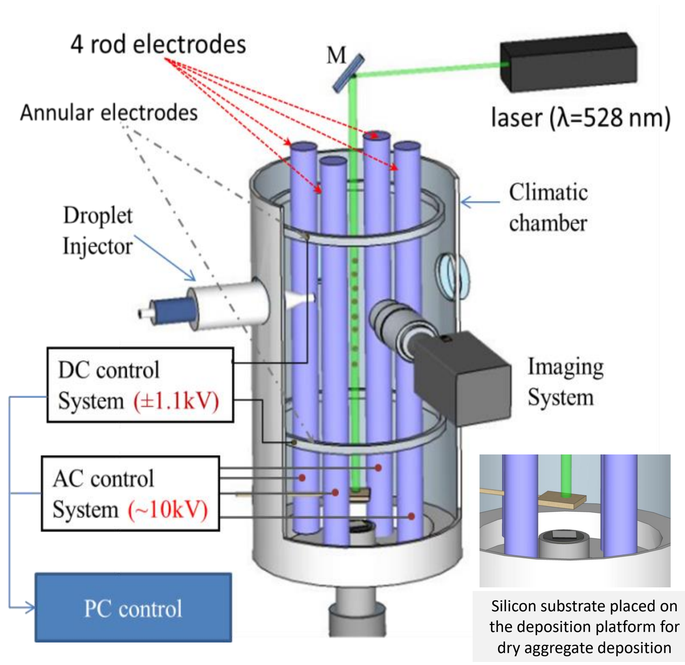
Abstract

Unsupported drying of microdroplets of colloidal suspension can lead to diverse 3D microobjects with quasi-spherical symmetry. Herein, we use electrodynamic levitation technique for drying colloidal suspension microdroplets and "soft-landing" of the dried microproducts for off-line scanning electron microscopy (SEM) study. We obtained unique microobjects created by drying microdroplets of colloidal suspension of silica nanospheres (SiO_2, 250 nm diameter) in diethylene glycol (DEG) with sodium dodecylsulfate (SDS). The final microobjects had diverse forms with variable fractions of surface coverage of crystallized SDS and aggregated SiO_2 nanospheres, dependent on the initial droplet size and composition. The smallest SDS/SiO_2 composite microobjects obtained from microdroplets of smaller initial diameter and at an SDS initial concentration of ≤ 1% had spherical forms with surface of crystallised SDS and interior filled with SiO_2 nanospheres. Larger microdroplets with higher initial SDS concentration of 1.72% formed SDS/SiO_2 microobjects with aggregated silica arranged in-between SDS crystallised flakes. Depended on the initial droplet parameters, the SDS flakes were similar to cabbage leaves (curved lobes) or resembled the so-called desert roses with radially-directed SDS crystals. Largest microdroplets with highest initial SDS concentration (2.6 %) transformed into ring-shaped (doughnuts) microcontainers filled with aggregated silica nanospheres.

Experimental Methods

Experimental Setup

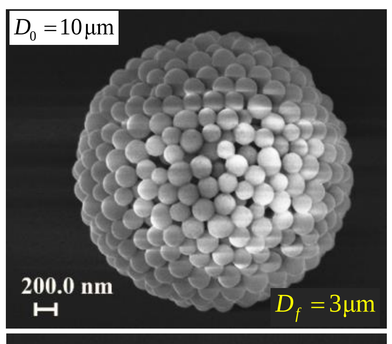


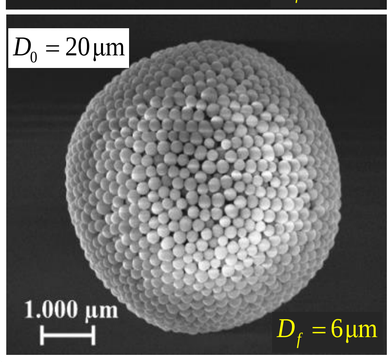
The 2D Linear electrodynamic quadrupole trap for particle tapping and deposition [1,3]

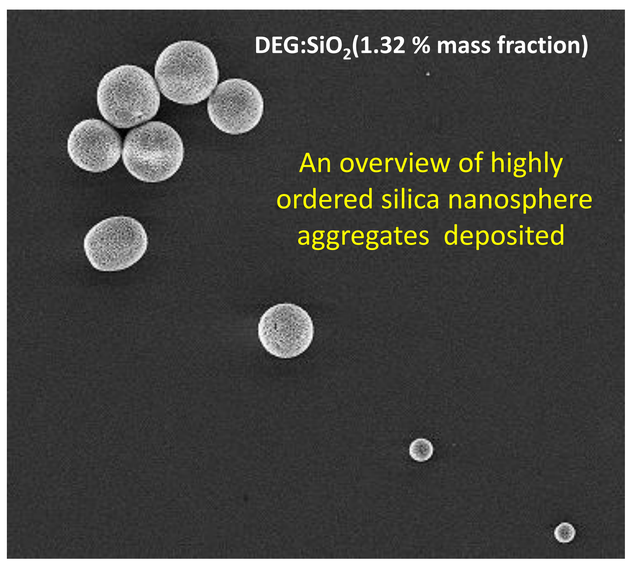
Experimental Procedure

A. Droplet generation (droplet on demand injector) and stabilization.
   - ❑ Control of droplet initial size using parameters of the injector(driving pulse width, shape , amplitude, nozzle diameter)
B. Solvent evaporation/drying of aggregate.
   - ❑ Control of vertical position of the droplet/aggregates
C. Deposition of dry aggregates and offline SEM imaging.
   - ❑ *"Soft landing"* of the dried aggregates onto the substrate

Formation of micro-aggregates from single component droplet evaporation

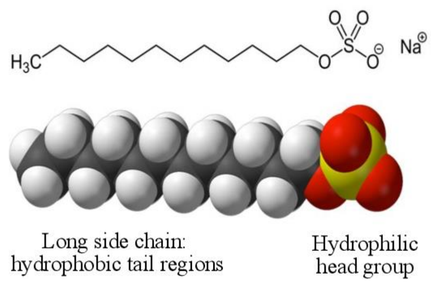






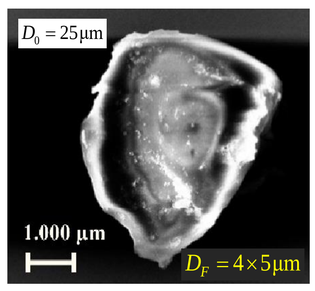
Formation of highly ordered spherical aggregates of silica nanospheres [1]

Microobjects from sodium dodecylsulfate

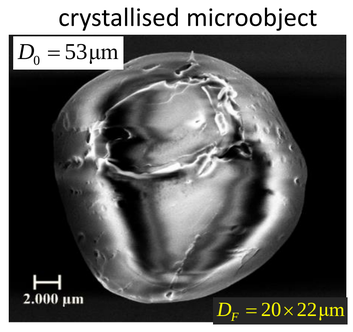


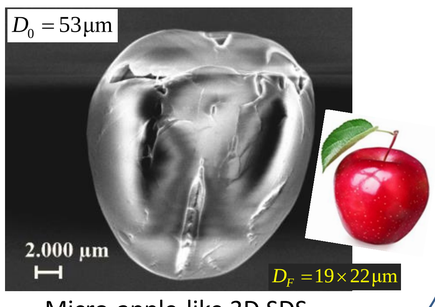
SDS is an anionic surfactant with critical micelle concentration (CMC) of 8.0 - 8.2 mM. SDS self-assembles into micelles consisting of a hydrophobic core of tail groups surrounded by a shell of hydrophilic head groups in water [2].

Unstable 2D SDS crystallised surface structure



Nearly stable 3D SDS crystallised microobject

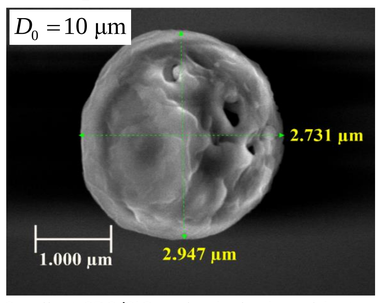




Micro-apple-like 3D SDS crystallised microobject

Microobjects of silica/SDS from mixed component droplet evaporation

DEG:SiO_2+0.5 % of SDS

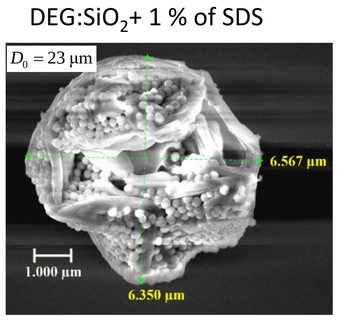


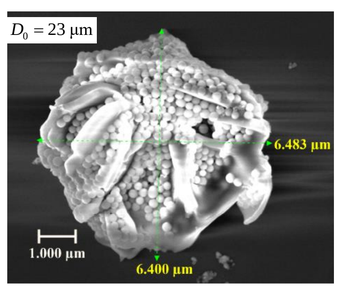
D_0 = Initial diameter of droplet

D_F = Final size of dry microobject

Smallest SDS/SiO_2 spherical microobject with interior filled with silica nanospheres and exterior with crystallised SDS surface

DEG:SiO_2+ 1 % of SDS

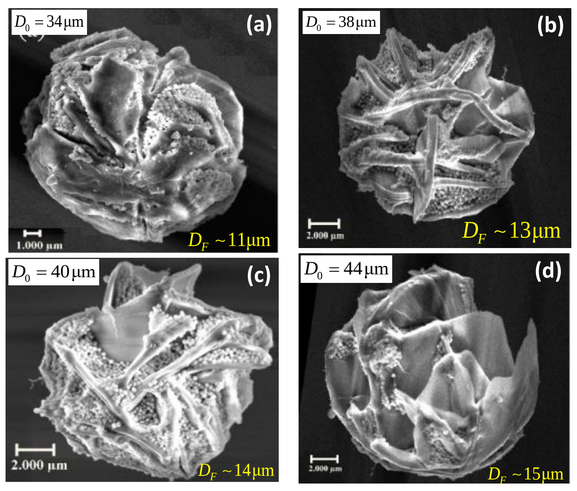




SDS/SiO_2 microobjects of nearly similar shapes from the same initial droplet size and composition

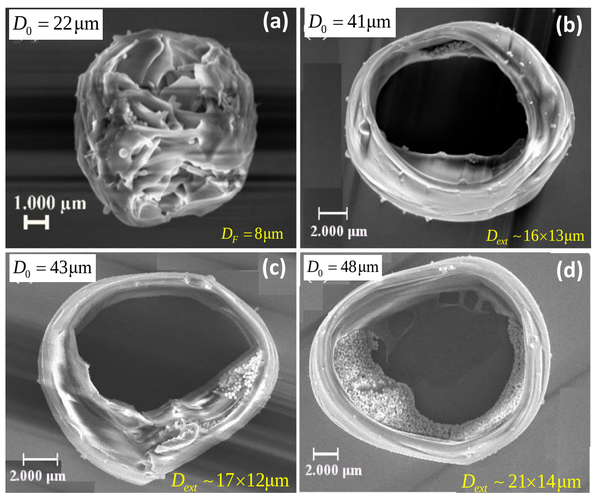
SDS/Silica microobject morphology transformations driven by Initial droplet size and SDS concentrations

DEG:SiO_2+1.72 % of SDS



Variety of SDS/SiO_2 microobjects:
(a) cabbage-like shape
(b, c) desert rose like microobjects
(d) rose-like microobject with radially–directed SDS crystallised flakes [3]

DEG:SiO_2+2.6 % of SDS



Variety of SDS/SiO_2 microobjects:
(a) spherical shape
(b) nearly circular ring and
(c, d) deformed rings [3]

Fractionalisation of surfaces due to different interaction mechanisms and surface coverage

GENERAL STATISTICS

Influence of increasing concentration of SDS on final microobjects sizes and their morphology

References

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2. *J. H. Clint, Surfactant Aggregation, Chapman and Hall, Inc, 1992.*
3. *Justice Archer, Maciej Kolwas, Mariusz Woźniak, Krystyna Kolwas, Daniel Jakubczyk, Tomasz Wojciechowski, Gennadiy Derkachov. Crystallization of Sodium Dodecylsulfate (SDS) from Drying Microdroplet of Colloidal Silica Suspension. (2017).* ***Under review***

Acknowledgement

The authors acknowledge financial support from the National Science Centre, Poland, grant number 2014/13/D/ST3/01882 and by the Ministry of Science and Higher Education, Poland