Structure Library of Magnetically Levitated Self-Assemblies

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Regenerative medicine addresses the significant imbalance between the supply of organs and the need for transplants. A novel method for scaffold- and label-free biofabrication is the use of levitational assembly in magnetic fields. Parfenov *et al.* used this method to assemble living cells into a spheroid [1], but more advanced shapes are required to allow for applications in regenerative medicine.

For weakly diamagnetic materials such as living cells or plastics suspended in a paramagnetic medium, the gravitational force and the magnetic force can be balanced so that the material levitates. In a table-top setup consisting of two neodymium permanent magnets in an anti-Helmholtz configuration, a low magnetic field gradient can be compensated by high paramagnetic salt concentrations. Although the paramagnetic salt, gadolinium, is approved by the FDA for MRI studies, high concentrations of it are toxic to cells. To compensate for lower paramagnetic salt concentrations, Florida-Bitter magnets can be used to generate a stronger magnetic field gradient. Here, we demonstrate that in such an environment the shape of the self-assembly can be varied by choosing the actual position in the so-called stable levitation zone, which is defined by vertical and horizontal stability parameters of the field gradient [2]. We show that tuning the magnetic field strength and the height of the sample in the Florida-Bitter magnet allow the self-assembly of polystyrene beads to form oblate spheroids, spheroids and prolate spheroids (see Fig. 1). We will also present the technical layout allowing for optical imaging during the levitation process.

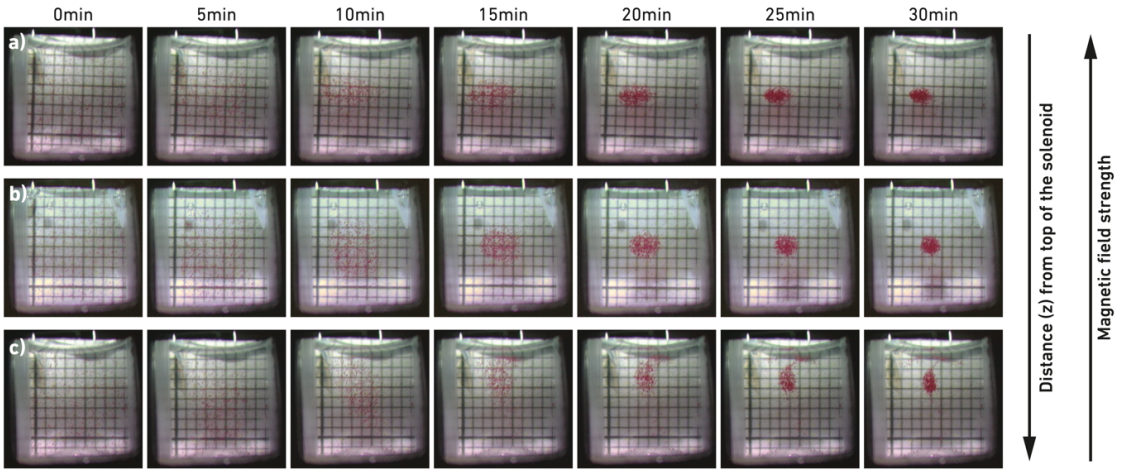

Figure 1: Snapshots of polystyrene beads (100µm) in 25mM $MnCl_2$ solution, levitated at various distances from the top of the Bitter magnet and magnetic field strengths showing the accumulation of beads in the shape of (a) an oblate spheroid, (b) a spheroid and (c) a prolate spheroid.

[1] V. A. Parfenov *et al.* Biofabrication. 12 (2020).

[2] M. V. Berry and A. K. Geim Eur. J. Phys. 18 (1997).