Granular and colloidal 1D structures: Physics and applications

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Abstract:

The fabrication of 1D granular and colloidal materials is of considerable interest as they offer opportunities for a variety of electronic applications, including granular conductors, flexible electronics for wearable devices, electromagnetic energy transport, etc. These particle structures can be assembled either from particle groups or from individual particles. In this talk I will show structures composed of individual microparticles.

There are several methods for fabricating particle structures, including lithography, cluster-assisted assembly and colloidal polymerization, pore-assisted assembly, and field-directed assembly in electro- or magneto-rheological fluids. The latter is generally considered to be a simple and effective approach to form particle structures. Thou fast and efficient, the external field-driven approach suffers from three major limitations to its applications, for example in electronic-device manufacturing. First, the assembly often takes place in a bulk liquid; it is difficult to remove the bulk liquid and maintain the assembled structure intact. Second, in principal only linear 1D structures can be formed along the field lines and positioning of the formed structure is greatly limited. Third, maintaining the formed structures normally requires a continuous energy supply; once the external field is turned off, the structures disintegrate. Within this talk, I will present novel routes to overcoming these limitations, making it possible to easily fabricate self-sustained 1D structures outside of a dispersion, as demonstrated in the figure below.

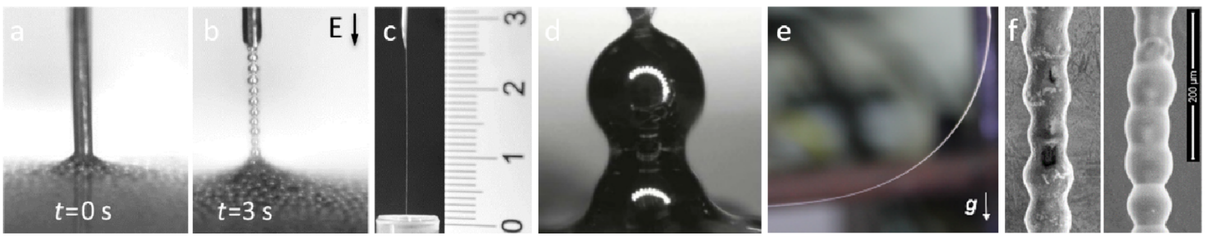

Figure 1. Experiments on fabricating 1D particle structure and its properties: (a,b) Pulling a chain from a container filled with a dispersion of Ag-coated silica microspheres in silicone oil. The electrode is brought up after application of an E-field (t>0), and a chain is pulled out from the dispersion. (c) A nearly 3 cm long chain comprising hundreds of particles can be formed within several seconds. (d) A well-resolved capillary liquid bridge is formed between two particles. (e) Capillary bridges lend flexibility to the particle chain. (f) SEM images of a particle chain embedded in solidified paraffin wax and in solidified resin.

For more details, see the following article:

Formation of printable granular and colloidal chains through capillary effects and dielectrophoresis, Nature Communications 2017, 8, 15255, https://www.nature.com/articles/ncomms15255