Poster

Nanoparticle Electrofluidization

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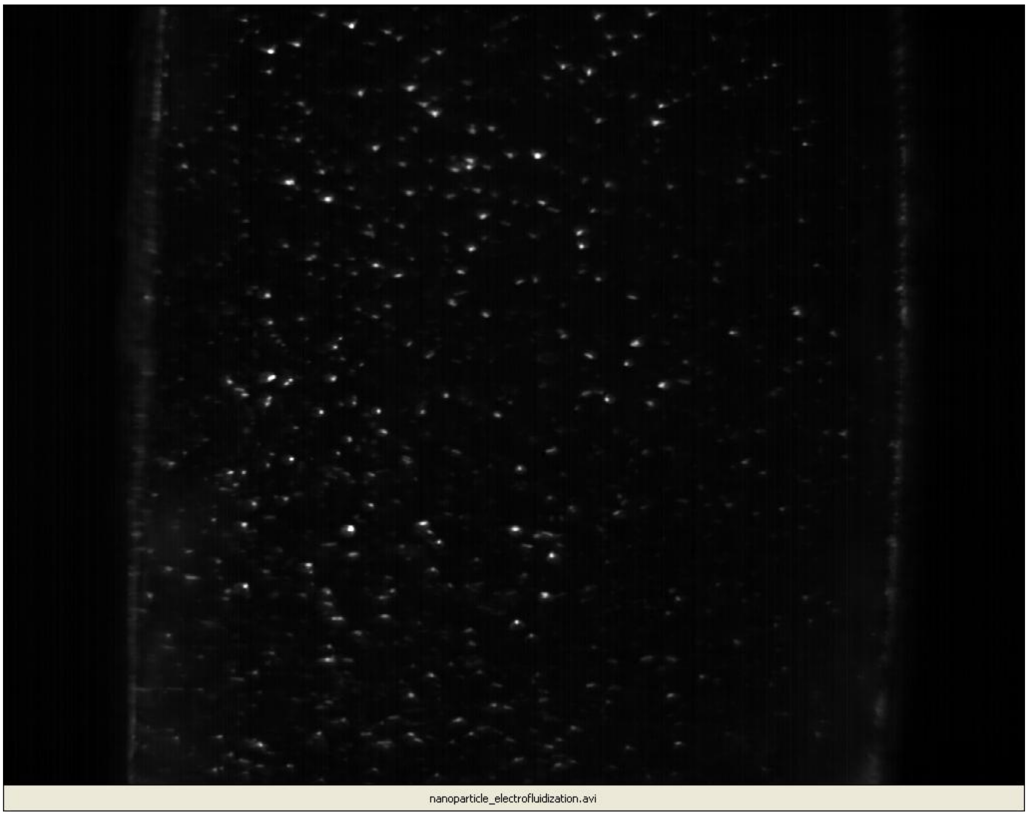
Processing and handling of granular materials in fluidized beds is widespread in industry because of their multiple advantages such as enhanced gas-solid contact and improved flowability. In a typical fluidized bed the granular material rests on a horizontal porous plate through which gas is pumped to the bed. Fluidization of functionalized nanoparticles, providing extremely high gas-solid contact efficiency, has become one of the most promising techniques for emerging industrial applications [1]. Unfortunately, most nanopowders cannot be uniformly fluidized, thus hampering the efficiency of industry processes relying on gas-solid contact efficiency. Usually, nanoparticle powders are characterized by the existence of large and hard agglomerates that impede homogeneous expansion when the powder bed is subjected to a gas flow. This is the case, for example, of unsieved silica nanopwder. Because of contact and tribo charging mechanisms, nanoparticle agglomerates naturally accumulate sufficient electrostatic charge to be appreciably excited by electric fields of strength on the order of 1 kV/cm [2]. In our work, a direct visualization technique has been developed to automatically track nanoparticle agglomerate trajectories when excited by an externally applied field (see video clip below). This technique enables us to measure nanoparticle agglomerate properties such as their size, charge, and fractal dimension. Moreover, it is shown that the application of either a cross-flow or a co-flow alternating electric field is useful to enhance fluidization of this system by forcing the oscillation of nanoparticle agglomerates, which homogenizes the flow and enhances the gas-solid contact efficiency. The most effective technique to assist fluidization is shown to consist of application of a nonuniform alternating electric field, which is weak in the vicinity of the free surface but strong close to the bottom of the bed (see figure below). Due to the wide size distribution of the nanoparticle agglomerates, especially in the case of unsieved samples ranging from tens of microns to millimetres, the conventional nanoparticle fluidized bed is highly stratified, with the larger agglomerates sinking to the bottom of the bed and the smaller agglomerates almost free floating in the free surface. These smaller agglomerates are easily elutriated if the gas flow is increased to mobilize the larger agglomerates, resulting in poor bed expansion and inhomogenenous fluidization. The alternating nonuniform field agitates strongly the larger agglomerates while has almost no effect on the smaller agglomerates, thus enhancing fluidization and at the same time avoiding excessive elutriation.

References:

[1] J. M. Valverde, A. Castellanos, 2007. Fluidization, bubbling and jamming of nanoparticle agglomerates. Chem. Eng. Sci. 62: 6947--6956.

[2] M.J. Espin,, J.M. Valverde, M.A.S. Quintanilla, A. Castellanos, 2009. Electromechanics of fluidized beds of nanoparticles. Phys. Rev. E 79, 011304.



Video clip: Fluidized bed of silica nanoparticle agglomerates excited by an externally applied alternating electric field (click twice on it for visualization)

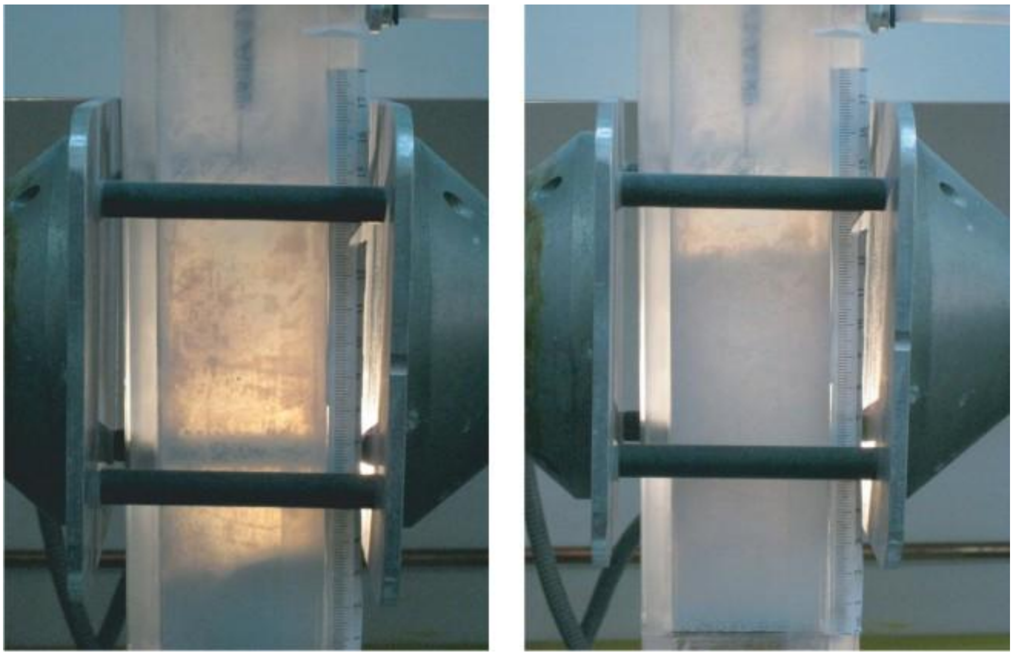


Figure: Fluidized bed if silica nanoparticle agglomerates before (left) and after (right) being excited by an alternating nonuniform electric field