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Ultrasonic microsorters for dust samples handling in planetary exploratory missions

Itziar Gonzalez, National Research Council of Spain CSIC, Institute of Physical Technologies and Information ITEFI, Group of Ultrasonic Resonators,; Jessica Gomez, National Research Council of Spain CSIC, Institute of Physical Technologies and Information ITEFI, Group of Ultrasonic Resonators,;

This work presents various microfluidic devices which perform ultrasonic particle sorting in a range of sizes from 1um to more than 100microns. This is a label-free technique that can be used to concentrate or separate cells or particles based in enrichment processes generated by a radiation force acoustically induced during their flow motion along the microchannels.
NASA and ESA have conducted a number of studies of lunar and Martian dust over the years, which exemplify its on-going interest in extraterrestrial dust composition and mitigation. A small device already installed in Mars lander/rovers uses a microFAC magnetic sorter to perform the particle sorting processes on the Mars surface collected either from a drilling directly on the soil/rocks or taken from the dust storms of Mars, after which determine and characterize the terrain-particle properties. Most of these particles have a ferrous composition and are susceptible to the magnetic field applied. However, other particles with different composition that could be present there can't be handled by the magnetic microsorter.
New free-label and low-cost technologies are demanded for it.
Acoustophoresis (which means migration with sound) is based in the ability of the devices to perform differentiated collection of particles or cells at certain positions of acoustic equilibrium, depending on their specific physical properties, such as size, density and/or compressibility.
This work presents some microfluidic devices assisted by ultrasounds strategically applied to perform particle separation based on acoustophoresis. It includes also a study of the particle enrichment process in glass capillaries, main mechanism on which is based the acoustophoretic method.
They are low-cost devices of a relatively easy design selected to work at frequencies close to 1-2MHz.
Different concepts of ultrasonic microsorters are here presented, including the most single 2D resonator consisting of a glass capillary attached to a piezoelectric ceramic with an inner square cross section dimensions corresponding to a half-wavelength at f=1MHz, as well as polymeric complex 3D resonators with versatile particle collectors in short range of frequency variations around this value.
A radiation force is a steady force acoustically induced due to a nonlinear interaction between the incident acoustic wave and that one scattered by each single particle, driving it toward a certain position of acoustic equilibrium established inside the cavity. Different particle sub-populations reach different enrichment locations inside the cross section of the channel, favouring their separation at the end of the channel where they flow.
This work presents experimental results of particle enrichment and sorting in both types of ultrasonic micro-resonators.
The successful results obtained with these lab-on-chip platforms demonstrate their feasibility to carry out sorting processes on flowing samples and represent a proof of concept to handle dust samples in future exploratory missions.
This technology provides especial interest to collect micron-sized particle samples from the Moon, Mars, comets and asteroids, as well as interplanetary dust.