Shear wave reconversion in nano-fluids and the possible detection of impurities and contamination.

Michael Forrester

The mobilisation and bioavailability of contaminants in the environment of food sources such as rice, vegetables and fruit poses a health risk to the consumer. In most cases of bio-structuring, spherical silica can emerge in the polymerisation processes at different concentrations and stages. However, with the presence of a contaminant, such as arsenic that can fit into the plants transport network for silicon, integration of toxins can accrue in the edible parts of the plant[1]. Heavy metals can accumulate as they are difficult to process within an organism. Much of the biological functioning happens at the nanoscale and we have developed new methods of analysis in multiple-scattering theory, with ultrasonic fields, that demonstrate that shear-wave reconversion phenomena must be used at these scales to give an accurate measure of the attenuation[2,3]. Indeed without inclusion of shear-wave effects in nanofluid characterisation models, the attenuation can be drastically overestimated. We show that particle-size, concentration and the frequency of the applied ultrasonic field all determine the extent of the shear-effects. We compare theoretical predictions against experimental ultrasonic spectroscopy for different sizes (20-2000nm), concentrations (3-25%v/v) and frequencies (1-20MHz) of silica in aqueous media[3]. The accuracy of the theory to predict experimental results indicates that ultrasonic attenuation could be used to detect the levels of impurities in the transpiration networks in plants, to detect contamination in groundwater sources, and to ensure quality control over the food chain.

1. E. Sohn. Contamination: The toxic side of rice. Nature 514, S62–S63 (2014).
2. V. Pinfield & D. M. Forrester. Ultrasound propagation in concentrated random dispersions of spherical particles: Thermal- and shear-mediated contributions to multiple scattering. The Journal of the Acoustical Society of America 137(4), 2293-2293 (2015).
3. D. M. Forrester, J. Huang, V. Pinfield, F. Luppé, Experimental verification of nanofluid shear-wave reconversion in ultrasonic fields, Nanoscale, 8, 5497-5506. doi: 10.1039/c5nr07396k. (2016).