A147 Density Determination Via Magnetic Levitation

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After attending this presentation, attendees will have learned of a new method of helping to characterize trace evidence items by determining their density.

This presentation will impact the forensic science community by introducing a method of determining the density of small, irregularly shaped objects and of liquids, that is non-destructive, quick, easy, and inexpensive, is independent of instrument/operator/location, and provides values that may be entered into a searchable database.

Density is one parameter that may be used to characterize a trace object. Although the formula for density (or specific gravity) is simply mass divided by volume, this is not so easily done for tiny, irregularly-shaped objects. In the past the density of small objects has been compared/determined using the sink/float method. When the tested objects suspended in a liquid medium neither rose to the surface nor sank to the bottom, their density was the same as the liquid. This could be a slow process as the liquid medium was gradually made less or denser by the addition of drops of either a miscible heavier or lighter liquid followed by mixing. Once this equilibrium point had been reached, one could determine the density of the liquid and hence the density of the object by removing sufficient liquid to fill a previously weighed pychnometer and then weigh the now full pychnometer. One could then obtain an actual value of density that could be entered into a database.

This presentation will introduce an entirely different method of obtaining density that is quick (just a few minutes), requires no expensive instrumentation (not even a source of electrical power), does not require highly-trained operators, does not destroy the sample, is readily calibrated with a series of density standards, provides values that can be entered into a searchable database, and that can distinguish between samples whose density differs by as little as 0.0002 g/cm^3. The method is based on magnetic levitation (MagLev) and involves placing diamagnetic samples into a container filled with a paramagnetic fluid, which is then placed between two permanent magnets. The vertical position of the sample, in the presence of the magnetic field, correlates with density. The vertical position depends on mass/volume rather than mass or volume separately and thus eliminates the need for standardized sample sizes.

Additionally, the MagLev concept may be used to separate similar items that vary in density. This will be illustrated by a photomicrograph showing how a mixture of two visually-similar types of glitter (both silver in appearance, both hexagonal and the same size) is clearly separated by vertical position in the cuvette containing a paramagnetic liquid. A disposable pipette may then be inserted to draw out those particles at a given level.

For heterogeneous samples, the distribution of densities may be a distinguishing characteristic. The MagLev method could replace the density gradient columns that in the past have been used to compare various size fractions of soil samples. In the past, the preparation of the density gradients was a slow, tedious process and involved liquids that are health hazards. Then once the soil fraction was added to the prepared density gradient column it might take a day or more for the sample to reach a stable distribution. With MagLev the entire process from start to finish would take only a few minutes.

For the determination of density, is there a limitation on particle size? Particles as small as 7µm in diameter are no problem, but for those 2µm or smaller Brownian motion prevent an accurate measurement. What if your sample is water soluble? Not a problem. There are paramagnetic ions that are chelated and are not water soluble, but are soluble in various non-aqueous solvents. Have a liquid sample? Not a problem; just add a drop to an immiscible paramagnetic liquid.

Does the MagLev process alter your sample? Results will show that smokeless gunpowder samples undergo no change. Also, the density of a glitter sample was measured and then some was added to a commercial nail polish. A portion of the liquid polish was diluted in hexane and then passed through filter paper, the glitter particles removed from the filter paper and their density again was measured and was unchanged.

Results will be shown from eleven different glitter samples, six different commercial smokeless gunpowder samples, and glitter particles extracted from a brand of commercial nail polish.

Density, Magnetic Levitation, Trace Evidence

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