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Concentration dependent aerosol substrates: UV-vis attenuation measurement

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Abstract

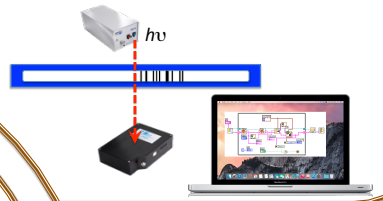
Ultraviolet and visible (UV/vis) light were used to determine the composition of aerosol samples taken from several military bases located in the Middle East. The aerosols were collected using a cascade impactor placing time resolved aerosols on strips of Mylar. These strips were then fed into a fiber optic UV/vis spectrometer which passes light through the Mylar strip and detects the amount of transmitted light relative to a blank standard. By measuring the light transmitted, the amount of aerosol on the Mylar strip was determined proportional to a calibration curve of standard mass depositions. The UV/vis tests were then compared to results from **β**-gauge analysis performed on the same samples to determine the validity of optical transparency as a substitute for electron attenuation studies. It was determined that the UV/vis data is largely comparable to the **β**-gauge data showing that UV/vis is a viable alternative to the **β**-gauge method as well as being more convenient, expedient, and easier to perform.

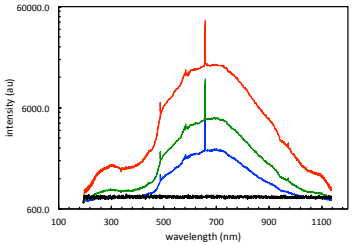
Experimental

- Aerosols comprise any lofted particulates of varying size.
- These partucluates range from carbon to lead with other diverse elements or compounds depending on the source.
- May originate from pollution from vehicles or industry or even simply from wind blowing up particles from the ground.
- Aerosols pose a health risk, especially smaller particulates.
- Aerosol samples from military bases in the middle east are being studied with eight unique size fractions.
- Significant aerosol sources sources include natural dust from (natural) winds and loose soil as well as (anthropogenic) combustion of leaded gasoline still used in the Middle East.

Data collection

- Samples areplaced into the automated translation apparatus
- The slide is moved stepwise through the light beam to measure all the aerosol depositions along the slide.
- The aerosols block a proportional amount of light at specific wavelengths through absorption and scattering.
- The attenuated signal is recorded with against the number of steps (0.53 mm/step) the slide has moved for a visual representation of the mass of the aerosols distributed on the slide .





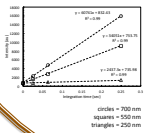


Figure
Detector sensitivity for the diode array can be seen in green (0.25 s), red (0.0625 s), blue (0.025 s) and black (dark current) for varying integration times. Sensitivity is non-linear across the wavelength range.

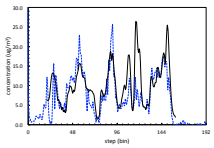


Figure
Scaled **β**-gauge (solid black) placed over the data collected through UV-vis spectroscopy (dashed blue) for 10-5 um particulates from Kuwait in February of 2012. UV-vis spectra is linearly scaled using a weighted sum of squares routine.

Discussions

Sodium benzoate depositions display a non-uniform (donut) deposition density which is confirmed by the large attenuation at the start of the deposited spot and then lower attenuation in the middle of the deposition. To increase uniformity of spot deposition new deposition solutions were developed to create a more consistent deposition density over the entire spot size. Iron oxide deposits are shown in three deposition densities on a mylar substrate. The first three attenuation spikes are for a high deposition density and display the same non-uniform deposition as seen with sodium benzoate. The second and third lower deposition densities display more uniform mass density.

Conclusion

- Linear scaling factors are not representative of heavily deposited substrates

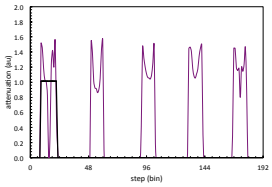


Figure
UV-vis spectroscopy (solid purple) of sodium benzoate depositions in thin film standard sample preparation with average deposition calculated over spot size (black line)

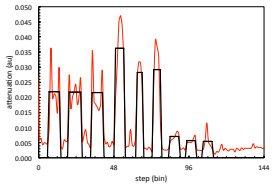
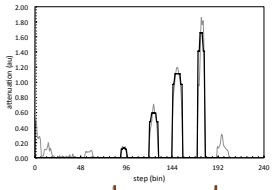


Figure
UV-vis spectroscopy (solid red) of iron oxide depositions in thin film standard sample preparation with average deposition calculated over spot size (black line)



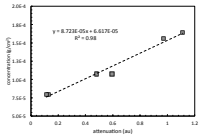


Figure
Graphite thin film deposits of varying areal density show linear response to attenuated flux for deposited samples.

Future work

In comparing the UV-vis attenuated signal of the aerosol samples to the **β**-gauge signal, a qualitative scaling factor can be found to represent the main features in the data. However due to non-linear flux sensitivity this linear relationship is not valid. A non-linear calibration curve must be developed to scale the attenuated signal consistently over the spectral attenuation range and deposition densities. Further work will include continued method development to create uniform mass density depositions, non-linear calibration, and more chemically unique mass standards.

Acknowledgements

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