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Optical Properties of Secondary Organic Aerosols

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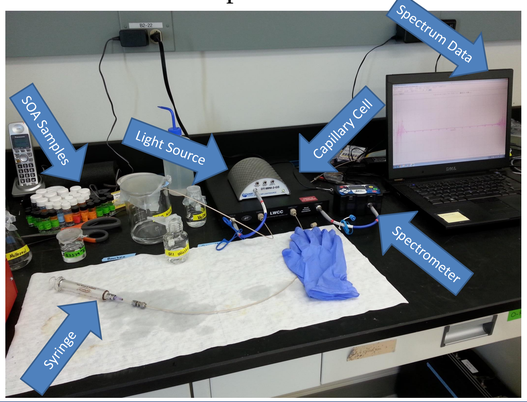
Abstract

It is well known that the increased warming effect due to greenhouse gases is a major environmental concern. While the amount of solar radiation absorbed by greenhouse gases is known to a high certainty, the amount absorbed by secondary organic aerosols (SOA) is not. The experimental procedure used to measure the amount of radiation absorbed by SOA was optimized using fulvic acid. The optimized method was then used to measure how much radiation SOA absorb between ~200 and 800 nm. Using this data, mass absorption coefficient (MAC) values at 405 nm and imaginary refractive indexes (k) were calculated. These values will be used to help improve climate models developed at PNNL that currently do not take into account radiation absorbed by SOA.

Methods

SOA were created in the PNNL environmental chamber and collected on Teflon filters. The filters were sonicated in water or methanol to dissolved the SOA. Using a syringe, the aqueous SOA samples were injected the samples into a liquid flow capillary cell (100-cm path length) coupled with a UV/Vis light source. The light absorbed was measured by the high resolution UV/Vis spectrometer.



UV/Vis Calibration

Two calibration curves using fulvic acid in water or methanol were created to validate the UV/Vis procedure. Water and methanol were used to determine if SOA solubility was affected by different solvent systems. Stock solutions of fulvic acid in each solvent were created and then diluted to desired concentrations. The absorbance of light (between ~200 and 800 nm) by each solution was measured. The calculated MAC values matched the literature value[1] of 0.17 m^2/g.

Concentration of FA Stock Solutions
120 mg/L FA in Water
110 mg/L FA in MeOH

Table 1. Stock solutions of fulvic acid (FA) in two solvents: water and methanol (MeOH).

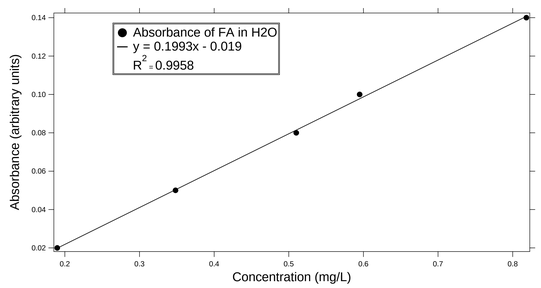


Figure 1. Absorbance of fulvic acid in water at 405 nm.

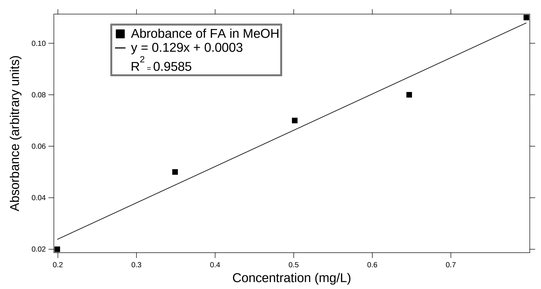


Figure 2. Absorbance of fulvic acid in methanol at 405 nm.

SOA Absorbance

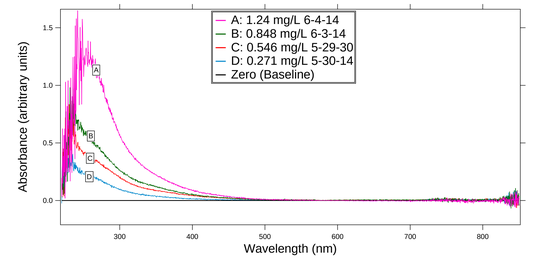


Figure 3. Absorbance spectra various concentrations of SOA in water.

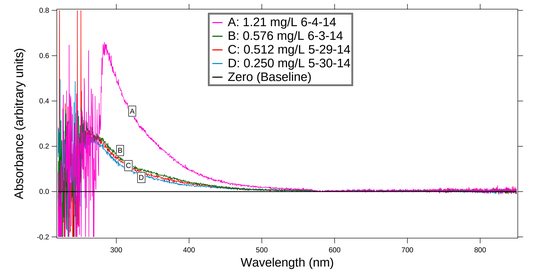


Figure 4. Absorbance spectra of various concentrations of SOA in methanol.

$$MAC_{UV/Vis} = \frac{A}{[FA]_e \; x \; L}$$

Equation 1. Mass absorption coefficient (MAC) values (in m^2/g)

	MAC in H_2O	MAC in MeOH
A	0.0747	0.0640
B	0.0470	0.1100
C	0.0580	0.0655
D	0.0650	0.0764

Table 2. MAC values at 405 nm for the SOA particles shown in figures 4 and 5.

Freshly generated SOA was collected and the absorbance was measured (A and C). The SOA was oxidized, collected and the absorbance measured again (B and D). This experiment was performed to determine if oxidation affected absorbance.

SOA Absorbance

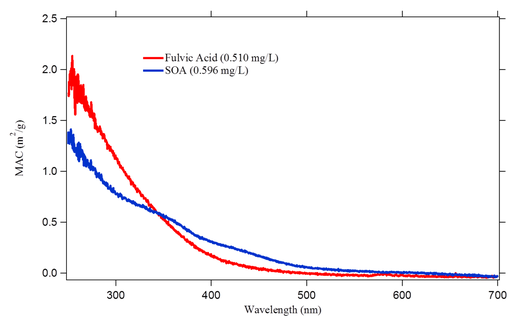


Figure 5. Absorption of SOA compared to fulvic acid.

Conclusion

The UV/Vis technique was optimized for use in two different solvent systems: water and methanol. After the procedure was verified, SOA particles were analyzed and found to absorb strongly between 280 and 400 nm. Furthermore, more oxidized SOA absorb slightly more radiation than less-oxidized SOA. It has been theorized that SOA absorb less strongly than fulvic acid. In one study it was found that SOA absorb radiation between 350 and 600 nm more strongly than fulvic acid. The research presented here is the impetus for future studies connecting SOA chemical composition and their light absorbing properties. The main goal of this work is to include SOA MAC values in climate models developed at PNNL.

References

[1]Ghabbour, Elham A. & Davies, Geoffrey (2009). Spectrophotometric analysis of fulvic acid solutions - A second look. *Annals of Environmental Science: 3*(10).

Acknowledgements

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