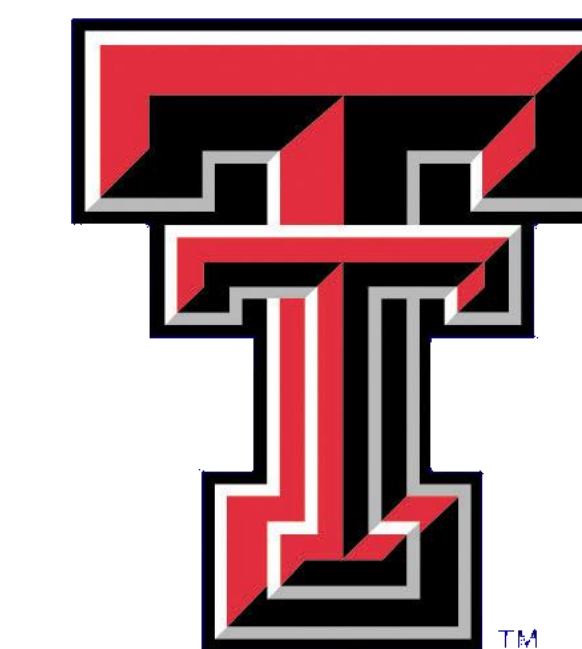




DEVELOPMENT OF A NEAR UV (355 nm) AEROSOL ALBEDOMETER



Lulu Ma, Jonathan E. Thompson

Department of Chemistry & Biochemistry, Texas Tech University

Introduction

In this work, an instrument is developed to study optical properties of aerosol particles at 355nm wavelength (near-ultraviolet range). When cavity ring down spectrometry (CRDS) is combined with integrating sphere nephelometry, extinction and scattering behavior of aerosol particles can be studied simultaneously. For these experiments, the third harmonic of a Nd:YAG laser was used as the light source. Different kinds of aerosols were studied in the laboratory. Ammonium sulfate particles, secondary organic aerosols (SOA) created by ozonolysis of alpha pinene, and photooxidation of toluene, soil dust, and particles from biomass burning have been examined. This work may provide a better understanding of aerosol optical behavior in the ultraviolet range and help improve models of tropospheric radiative transport. Future directions should be focused on collaborative instrument comparisons and field work.

Experimental Setup

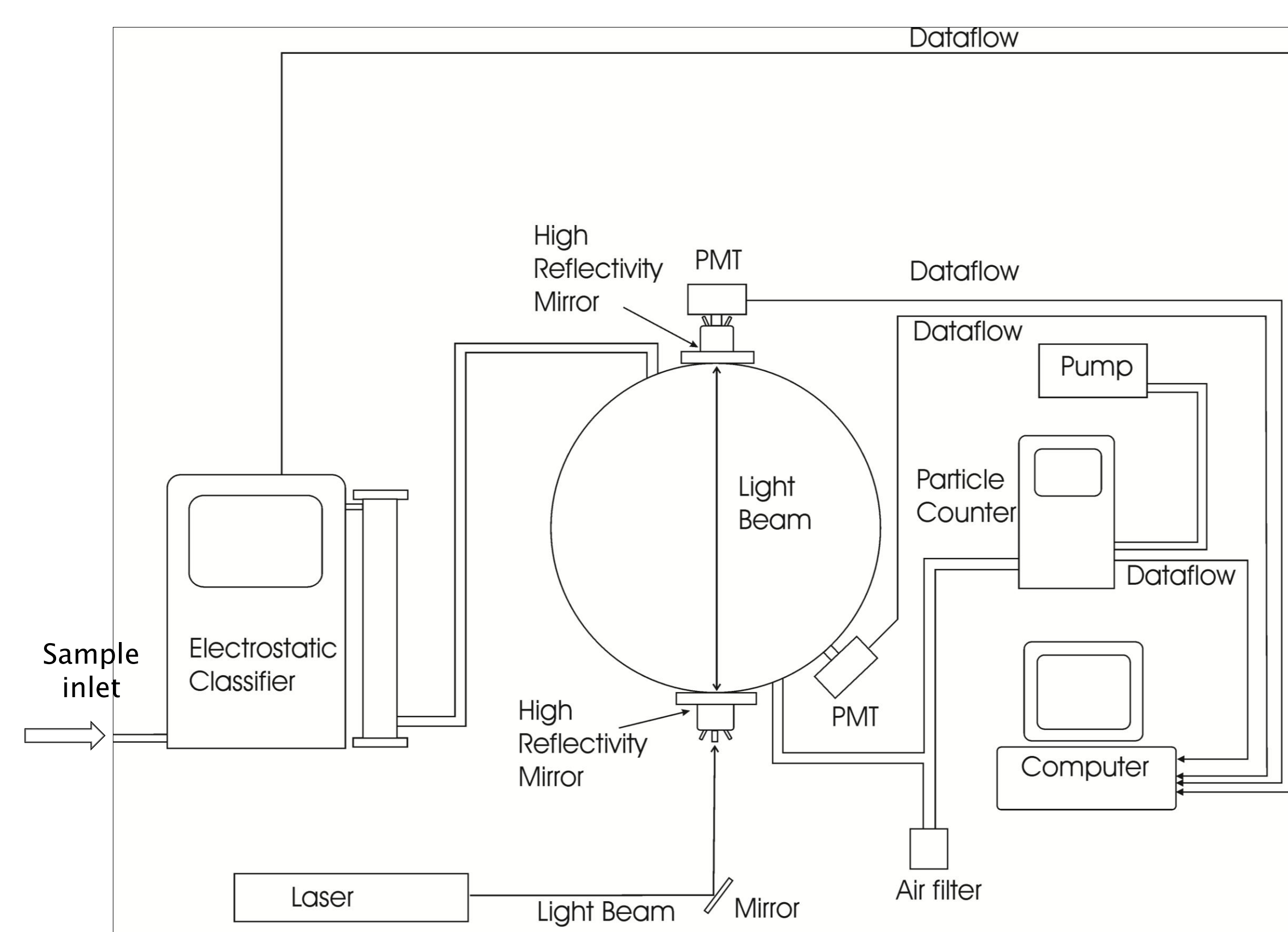


Figure 1. Schematic of instrument setup. The laser pulse reflects between two high reflectivity mirrors. Light signals were detected by two PMTs. Extinction PMT was placed on the top the sphere and scattering PMT was installed on the sphere surface. Signals were sent to computer for analysis. In some cases sample particles were size selected with an electrostatic classifier prior to the sphere. The outlet of the sphere was connected to a particle counter, which measured particle concentration of aerosol particles. Sample preparation methods were different according to the properties of aerosol samples. The limit detection of the integrating sphere setup were $8.2 \times 10^{-8} \text{ cm}^{-1}$ for scattering coefficient measurements and $1.1 \times 10^{-7} \text{ cm}^{-1}$ for extinction coefficient measurements.

CRDS and Scatter Signals

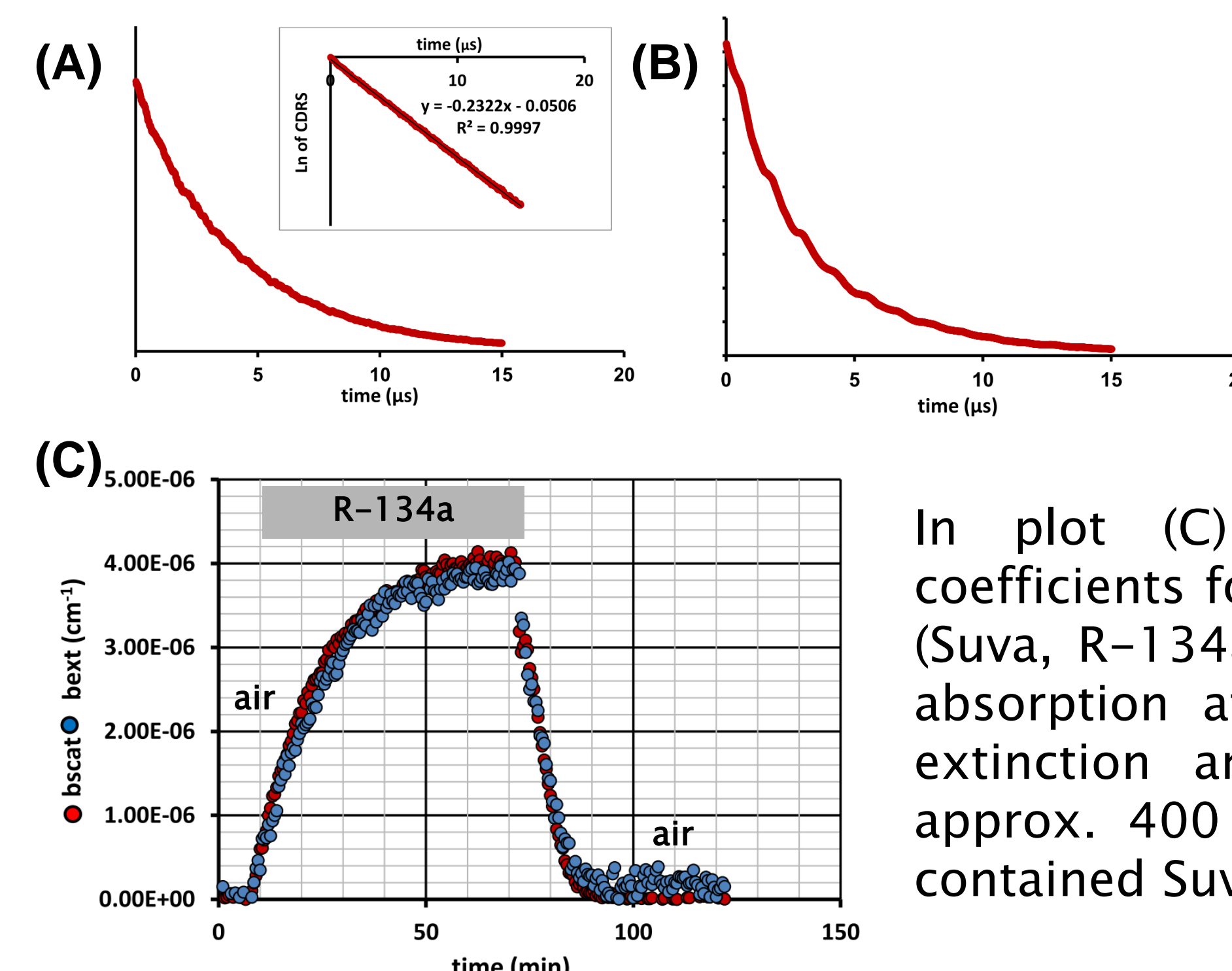


Figure 2. (A) and (B) are plots of CRDS and scatter signals vs. time. The inset of (A) shows the natural logarithm of CRDS signal. A linear relationship was found between the natural logarithm of CRDS signal and time indicating monoexponential decay.

In plot (C), the extinction and scattering coefficients for air and 1,1,1,2-Tetrafluoroethane (Suva, R-134a) are plotted in time. Suva had no absorption at 355nm wavelength, so both the extinction and scattering coefficients reached approx. 400 cm^{-1} when the integrating sphere contained Suva.

Ammonium sulfate particles and secondary organic aerosols (SOA).

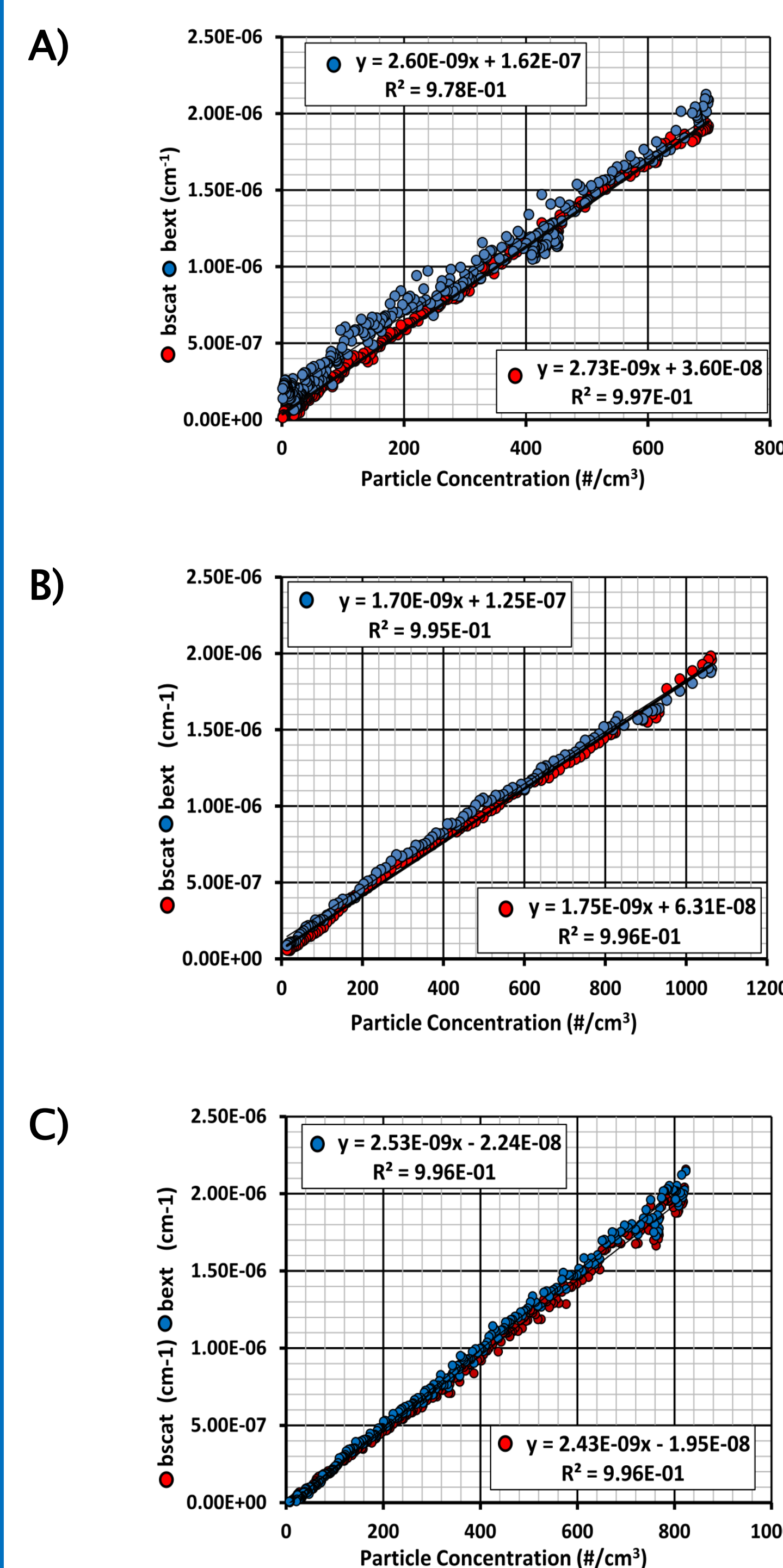


Figure 3. Plots of extinction and scattering coefficient at 355 nm vs. particle concentration for (A) ammonium sulfate particles, (B) alpha pinene SOA and (C) toluene photo-oxidation products (toluene SOA). All particles were $D_p = 300 \text{ nm}$. Ammonium sulfate particles were generated by an atomizer and dried through a diffusion dryer. Pinene SOA particles were produced in a 67.5 ft^3 Teflon chamber by mixing alpha pinene and ozone (10 ppmv) while irradiating with UV light. The method for generating toluene particles was similar except the reactant concentrations were ozone at 7-10 ppm, and NO_2 at 30-120 ppb. Toluene was added in the vapor phase and reaction mixture irradiated with UV light.

–Extinction cross sections ($\pm 95\%$ c.i.) were:

ammonium sulfate – $2.6(\pm 0.5) \times 10^{-9} \text{ cm}^2$
pinene SOA – $1.70(\pm 0.09) \times 10^{-9} \text{ cm}^2$
toluene SOA – $2.53(\pm 0.02) \times 10^{-9} \text{ cm}^2$

–Scattering cross sections ($\pm 95\%$ c.i.) were:

ammonium sulfate – $2.7(\pm 0.5) \times 10^{-9} \text{ cm}^2$
pinene SOA – $1.73(\pm 0.14) \times 10^{-9} \text{ cm}^2$
toluene SOA – $2.43(\pm 0.06) \times 10^{-9} \text{ cm}^2$

–Scattering coefficients were very close to the corresponding extinction coefficients, indicating that the particles produced had minimal absorption at 355 wavelength.

Soil dust and biomass burning aerosols.

Four kinds of light absorbing materials were tested: Pullman and Amarillo soil dusts common to the West Texas Panhandle, combustion products of fruit tree leaves and Afghanistan pine needles. For these experiments, particle size selection was not carried out. Single scatter albedo (SSA) for all these particles were well below one.

SSA ($\lambda=355 \text{ nm}$) of Aerosol Proxies:

Sample	SSA $\pm 95\%$ c.i.
Pull man Soil	0.843 ± 0.002
Amarillo Soil	0.745 ± 0.002
Pear Tree Leaves	0.843 ± 0.006
Afghanistan Pine Needle	0.826 ± 0.007

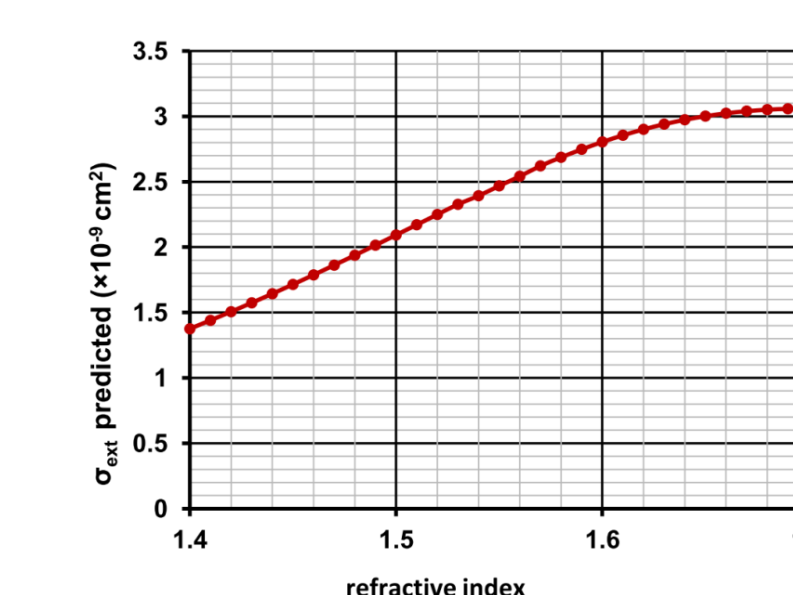


Summary of Data and Refractive Index

	$\sigma_{\text{ext}} \pm 95\% \text{ c.i.}$ ($\times 10^{-9} \text{ cm}^2$)	$\sigma_{\text{scat}} \pm 95\% \text{ c.i.}$ ($\times 10^{-9} \text{ cm}^2$)	Measured Refractive Index	Lit. Refractive Index
Ammonium sulfate	2.6 ± 0.5	2.7 ± 0.5	1.57	Approx. 1.55 (Toon et.al, 1976)
Pinene SOA	1.70 ± 0.09	1.73 ± 0.14	1.45	1.46 ± 0.02 (Nakayama et.al, 2010)
Toluene SOA	2.53 ± 0.02	2.43 ± 0.06	1.56	1.63 ± 0.04 (Nakayama et.al, 2010)

Nakayama, T, Matsumi, Y, Sato, K, Imamura, T, Yamazaki, A, and Uchiyama, A. *J. Geophys. Res.* 115, no. D24, (2010): D24204.

Toon, O.B., Pollack, J.B.; Khare, B.N. *J. Geophys Res.* 81(33) 5733-5748, 1976.



Conclusions

Extinction and scattering cross section values of ammonium sulfate, pinene SOA and toluene SOA were within the range of 1.6×10^{-9} and $3.2 \times 10^{-9} \text{ cm}^2$. None of these samples absorbed light extensively at 355 nm. Pinene SOA scattered less light than ammonium sulfate and toluene SOA per unit particle concentration. Both lab generated soil dust samples and biomass burning samples absorbed light in the near UV with SSA values in the range of 0.74 – 0.85.

Future directions should include instrument comparisons, and field measurements on ambient aerosols. Individuals interested in collaborating should contact Lulu or Prof. Thompson.

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