LASER LIGHT SCATTERING FROM SILVER SOLS AND MICELLES

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ABSTRACT

The purpose of this work was to observe laser light scattering from silver sols and micelles, to prepare for possible laboratory experimental work in an undergraduate chemistry course.

Keywords

laser light scattering, silver sol, micelles

INTRODUCTION

An objective of this work was to observe laser light scattering from colloidal and micelle systems, using simple and relatively inexpensive equipment, in a manner that could be incorporated in an undergraduate chemistry course or independent study. The observations should be meaningful both qualitatively and semi-quantitatively.

METHODS

A silver sol (colloidal silver in water) was prepared by treating aqueous silver nitrate with tannin (Schlessinger, 1962). The sol was orange-brown in appearance. Qualitative observations were also made on laser light scattering from solutions of sodium lauryl sulfate in water. Materials used were reagent grade chemicals.

With silver sol in a small glass container, light scattering was observed using two low power lasers. A red laser pointer, manufactured by Quarton Inc., was a laser diode device rated with 4 mW output in the 630-680 nm wavelength range, a Class IIIA laser product. A green helium-neon laser Uniphase model 1674, was rated 0.75 mW minimum at 543.5 nm, Class IIIA. Both lasers were unpolarized.

A handheld laser power meter, LaserCheck by Coherent, had a range of 0.5 μW to 1 W. Most measurements of relative intensity were made using a simple cadmium sulfide photoresistor from Radio Shack, with an ohmmeter (multimeter).

RESULTS AND DISCUSSION

For particles which are small in comparison with the wavelength of light, and for unpolarized light, theory indicates that the intensity of scattered light is

proportional to $(1 + \cos^2\theta)$ and inversely proportional to λ^4. The usual inverse square law applies. Scattered intensity depends also on concentration, molecular weight, and (dn/dc), where n is refractive index and c is a measure of concentration. (Matthews 1985, Atkins 1998).

The relative scattered intensity was measured as a function of angle for the silver sol, for the red laser and the green laser.

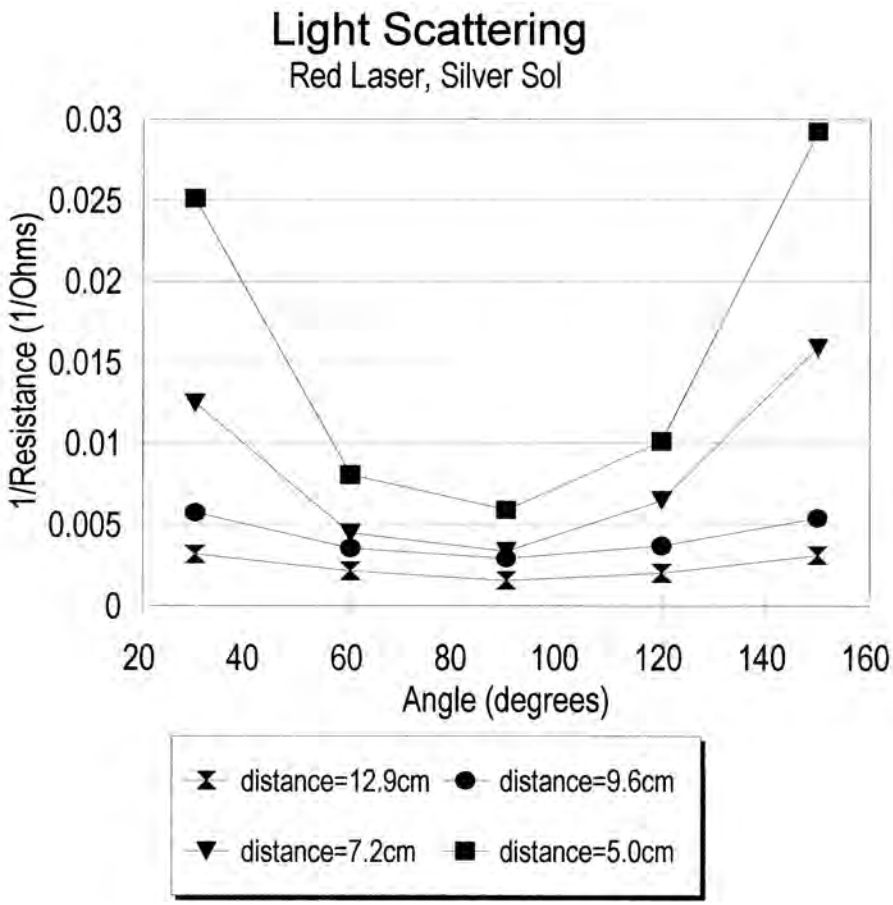

Fig. 1. Red laser light scattering from silver sol

These results were in good qualitative or semi-quantitative agreement with expectations from theory. In particular, the minimum at 90 degrees corresponds to the expected minimum in $(1+\cos^2\theta)$ for unpolarized incident light.

Qualitative observations were made on laser light scattering from solutions of sodium lauryl sulfate in water. The critical micelle concentration (CMC) of this twelve carbon chain is expected to be somewhere near that of sodium dodecanoate, which also has twelve carbons. The latter CMC is 0.024 M at 25°C

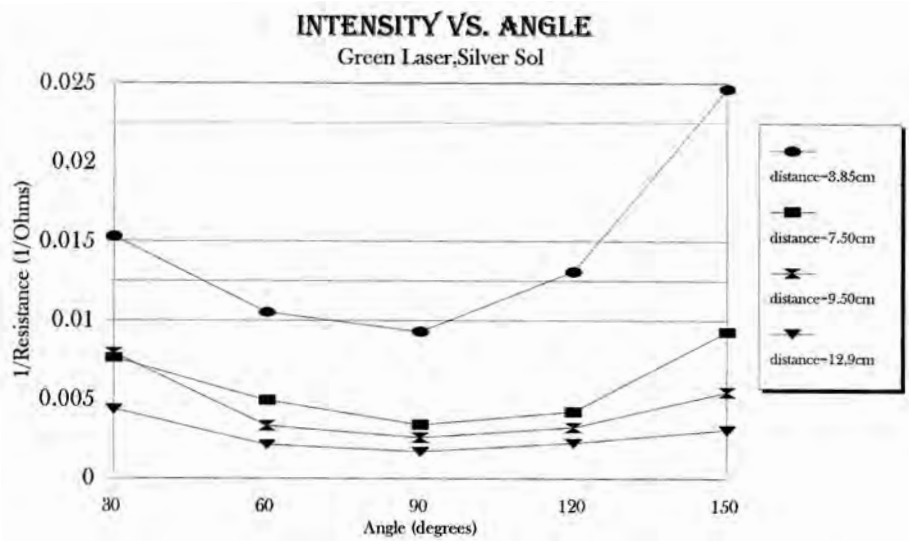

Fig. 2. Green laser light scattering from silver sol

(Ross 1988). At concentrations in the millimolar range, a distinct beam of light could be seen across the solution. Variation of intensity with angle was similar to the silver sol.

CONCLUSION

Laser light scattering from the silver sol followed the $(1 + \cos^2\theta)$ pattern expected from theory for unpolarized incident radiation, for particles small compared with the wavelength of light. This was true both for the red laser pointer (around 630-680 nm) and the green He-Ne laser at 543.5 nm. Sodium lauryl sulfate behaved similarly at sufficiently dilute solutions (millimolar range).

LITERATURE CITED

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ACKNOWLEDGMENTS

Most of this research was carried out as part of the Summer Science Institute, during Summer 1998, at Augustana College.