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Thermal Lens Spectroscopy and Its Applications

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Thermal Lens Spectroscopy and Its Applications

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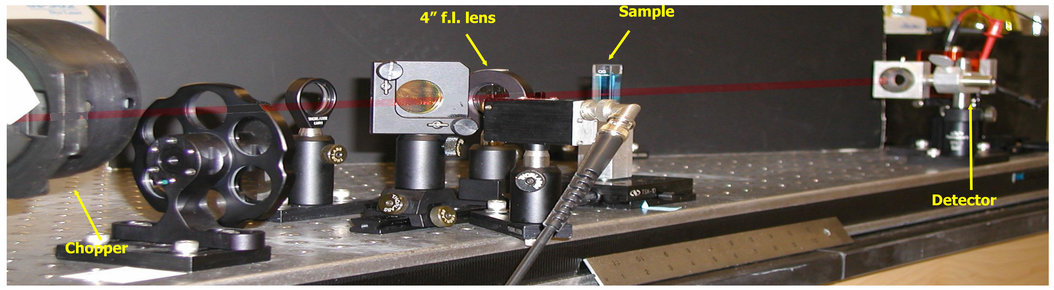
Abstract

Energy from a laser beam is absorbed when it passes through the sample. As a result, the sample forms "a molecular lens," due to the temperature dependence of the sample's refractive index, the signal of which can be detected as a time-dependent decrease in power at the center of the beam. There are two types of thermal lens arrangements, the coaxial and the transverse. In the coaxial setup, where the blue beam and the red beam were parallel, we tested the accuracy of thermal lens spectroscopy in three dyes: Malachite Green, Nile Blue and Cresyl Violet. We discovered that lower concentrations are necessary for precise measurement. In contrast, in the transverse setup, the apparatus maintained good precision even at higher concentrations. We explored the quenching effect of Rhodamine 610 with azulene. The thermal signal increased with the presence of more quencher. Besides conducting experiments on the photophysical aspect of thermal lens, we also researched photochemical effects. Using a pulsed laser, we observed no change in the intensity of the thermal signal but did observe changes in the time profile. We observed a decrease of the thermal signal of Methylene Blue solution as a function of ionic strength with the addition of KCl. At present we are still researching the quenching effect of Methylene Blue and Triethylamine.



Experiment Set up

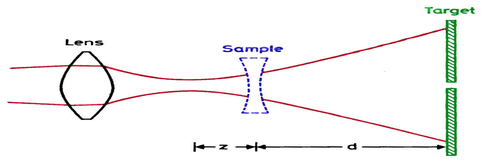


Fig.1 single-beam thermal lens spectrometer

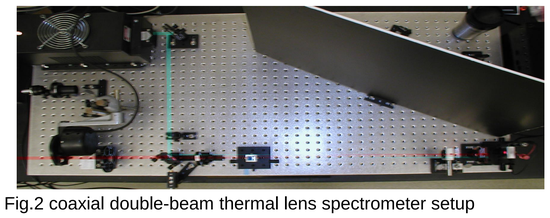


Fig.2 coaxial double-beam thermal lens spectrometer setup

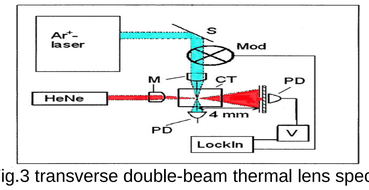


Fig.3 transverse double-beam thermal lens spectrometer setup

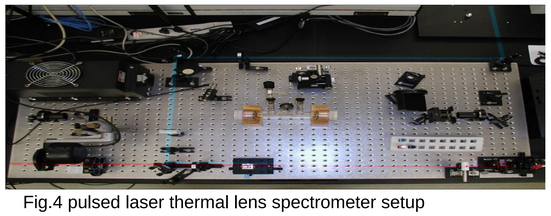


Fig.4 pulsed laser thermal lens spectrometer setup

$$\Phi_x = \left(\frac{\overline{\lambda_f}}{\lambda_{laser}}\right)\left(1 - \frac{A_{std}}{A_x}\frac{\alpha_x}{\alpha_{std}}\right)$$

Quantum Yield Result

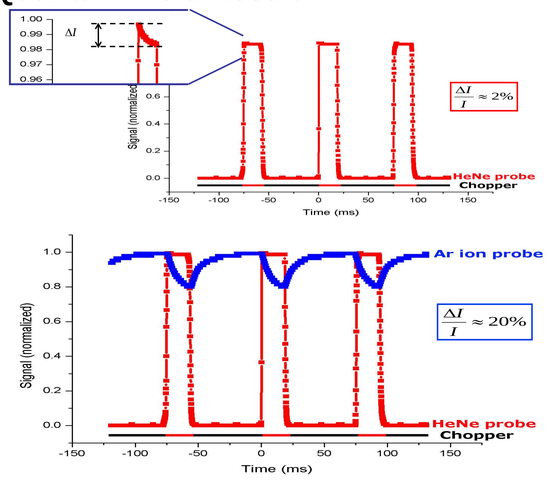


Fig.5 Sample graphs of the signal from single-beam experiment and double-beam experiment.

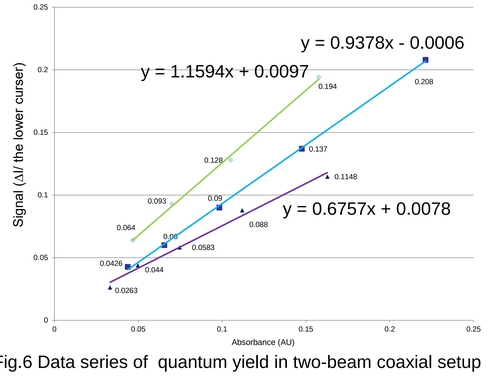


Fig.6 Data series of quantum yield in two-beam coaxial setup

Quantum Yield result:

	Experimental Value	Literature Value
Malachite Green	-	0
Cresyl Violet	0.38	0.54
Nile Blue	0.20	0.27

Photochemistry

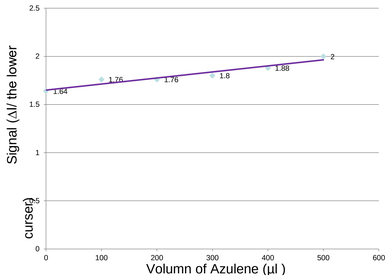


Fig .7 Data of salt effect

Rhodamine 610 + Azulene

Rhodamine B can be quenched by Azulene and results in more heat releasing in the system. Our experiments showed an increasing delta of the signal.

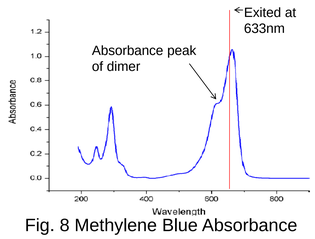


Fig. 8 Methylene Blue Absorbance

Methylene Blue + KCl

The increase concentration of KCl caused MB to dimerize and thus decreased the concentration of MB in the sample. The thermal lense effect decreased and the signal detected on the oscilloscope decreased as expected.

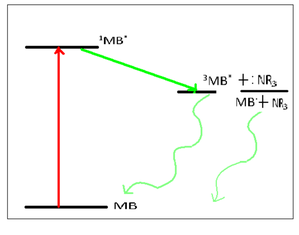


Fig. 9 Energy state diagram of Methylene Blue

Methylene Blue + Triethylamine

Ground-state Methylene Blue does not react noticeably with triethylamine, but the excited triplet state of Methylene Blue efficiently oxidizes the triethylamine. In the process, the Methlene Blue reduces to a radical which is colorless.

The time scale difference of the energy release is measured in the oscilloscope.

Acknowledgement

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Reference

Richard N.Zare *et al*. Laser Experiment for Beginners,1995, University Science Books, Sausalito, CA