

Trapped Ion Laser Induced Fluorescence (TLIF)

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Introduction

The fluorescence properties of molecules and nanoparticles can be strongly dependent on the environment the fluorophore is embedded. The advantage of fluorescence experiments in gas phase over condensed phase measurements is the complete control of the environmental effects which might otherwise screen the intrinsic properties of the system under investigation. We have recently completed the setup of a new experiment to study the fluorescence properties of trapped ionic molecules, clusters, and nanoparticles in gas phase.

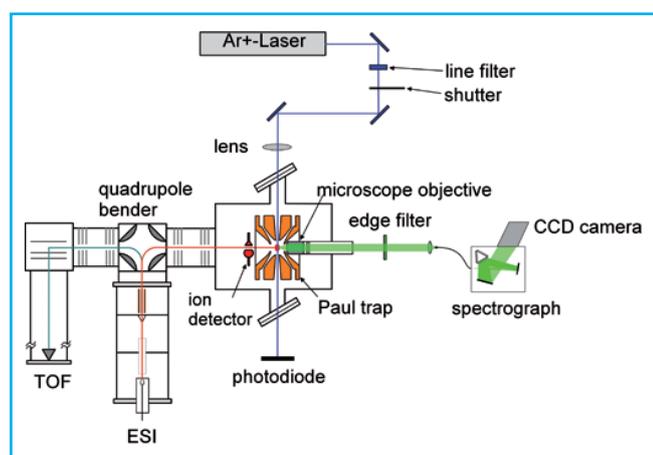


Figure 1 - Schematic of the TLIF setup.

Experimental Setup

The experimental setup comprises an electrospray ionization source (ESI), a time of flight mass spectrometer and a Paul trap where the ions are trapped, stored and mass-selected. For fluorescence measurements, the ion cloud is crossed by a focused Ar⁺-laser beam. The fluorescence light is collected by a microscope objective, spectrally resolved by a TRIAX 190 spectrograph (Jobin-Yvon) and detected in an Andor Newton EMCCD (DU970N-BV) camera provided by LOT-Oriel. The low number of trapped ions (10²-10⁵) requires effective photon detection. Because of the high quantum efficiency together with the single photon sensitivity, the Andor Newton EMCCD camera was the first choice.

Results

To characterize our experimental setup and detection capability, fluorescence studies of dye molecules have been conducted. Fig. 2 shows a fluorescence spectrum of the Rhodamine 6G cation in gas phase (black). The total acquisition time was only 15 minutes (sum of 100 spectra with 10 sec exposure time each).

Application Note

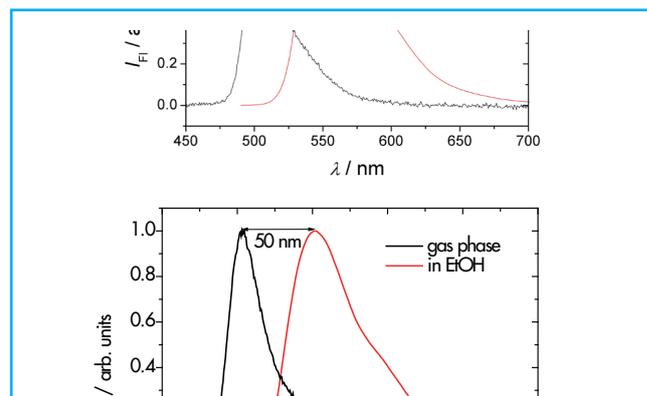


Figure 2 - Fluorescence Spectrum of the Rhodamine 6G cation in the gas phase (black) and in ethanoic solution (red).

In comparison to the fluorescence spectrum in ethanoic solution, a considerable blue shift of 50 nm in the gas phase spectrum is observed.

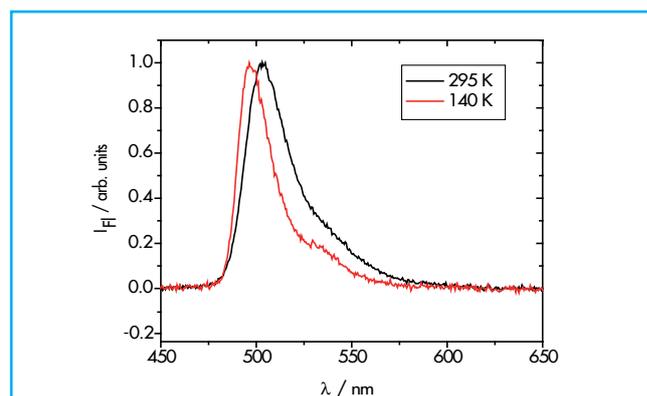


Figure 3 - Spectra of the Rhodamine 6G cation in the gas phase depending on the trap temperature.

Even shorter exposure times can be reached if the ion density in the trap is increased. Fig. 3 shows temperature dependent spectra where the 140 K data was measured with a total acquisition time of minutes. The shift of the fluorescence maximum and the broadening originate from temperature effects due to different populations of vibrational sublevels in the electronically excited state which cannot relax to the vibrational ground state because of the absence of collisions during the fluorescence lifetime.

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