Vacuum Ultraviolet photoabsorption of molecules with astrochemical and astrobiological relevance: Benzonitrile and Hydroxylamine

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Introduction

Laboratory Astrochemistry | Molecular Spectroscopy | Photoabsorption | Vacuum-Ultraviolet | Irradiation

The photochemical studies can be broadly classified into: Photoabsorption, Photo-dissociation, and Photo-ionization processes, which can be studied with techniques like Infrared spectroscopy, Time-Of-Flight Mass Spectrometry, vacuum ultraviolet (VUV) spectroscopy, etc. VUV spectroscopy has been shown to be a useful tool to characterize the morphology of the molecular ices in astrochemical conditions [1-2]. Here we study the photoabsorption spectrum for two systems with astrochemical and astrobiological relevance: Benzonitrile and Hydroxylamine.

Fourier Transform-Infrared Spectroscopy has also been used in this work to study the deposited ices. This method allows us to characterize the ice morphology changes (between crystaline and amorphous forms) as the absorption peak structures change and in some cases, shifts in the peaks are observed.

Experimetal Methodology

Vacuum Ultraviolet Photoabsorption experiments were carried out using the high flux beamline BL03A1 of the Synchrotron Facility at NSRRC, Taiwan. The sample was deposited on a LiF window, and the absorption spectrum was recorded in the range 100-360 nm with a resolution of 1 nm. The gradual warming of the ices in both the sets of experiments was done at 1K/min.

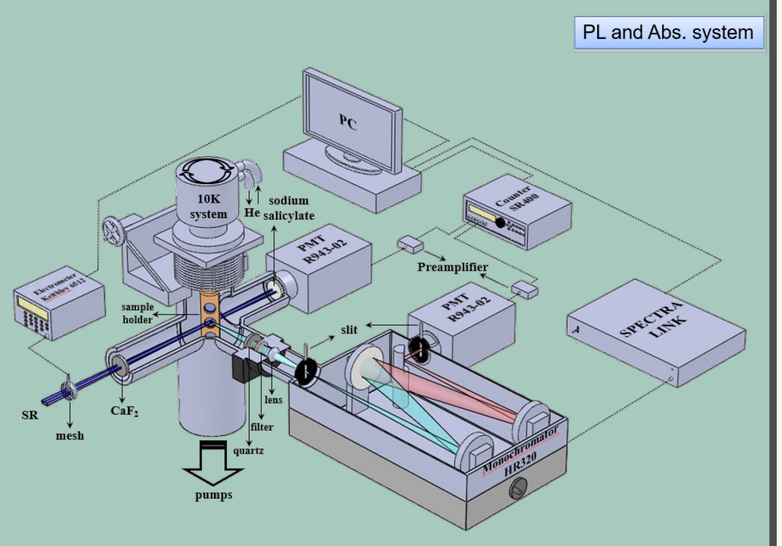

Figure 1. Station design at the BL03A1 beamline (Taken from the NSRRC webpage http://efd.nsrrc.org.tw/EFD.php?num=238)

Benzonitrile was deposited, for about 1.5 mins, while the pressure inside the chamber was maintained approximately at 1×10^{-7} mbar. The NH_3 and O_2 mixture of gases (6:1) was deposited for 6.5 mins, while the pressure inside the chamber was maintained at 5×10^{-8} mbar.

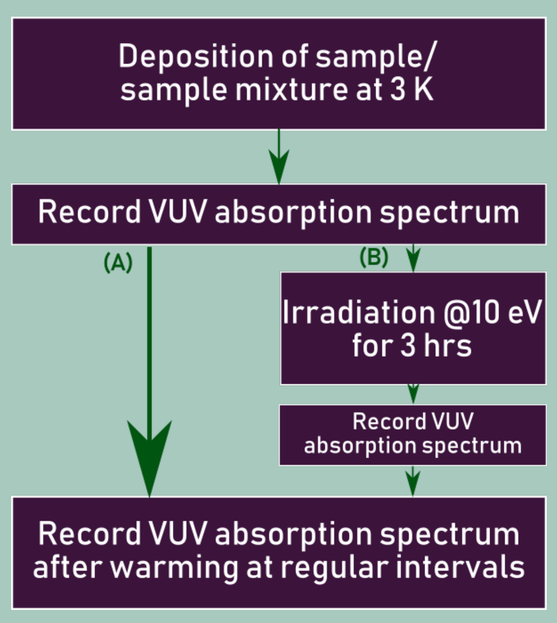

Figure 2. Flow chart showing the experimental procedure for the two sets of photoabsorption studies: (A) Benzonitrile and (B) NH_3-O_2 ices- Hydroxylamine

The infrared spectrum for benzonitrile ice was recorded using the experimental setup at the Physical Research Laboratory, India. The sample was deposited at 10 K, and warmed gradually. The Mid-IR spectra were recorded in the range 4000-500 cm^{-1} with a resolution of 2 cm^{-1}.

Acknowledgements

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Results: Benzonitrile

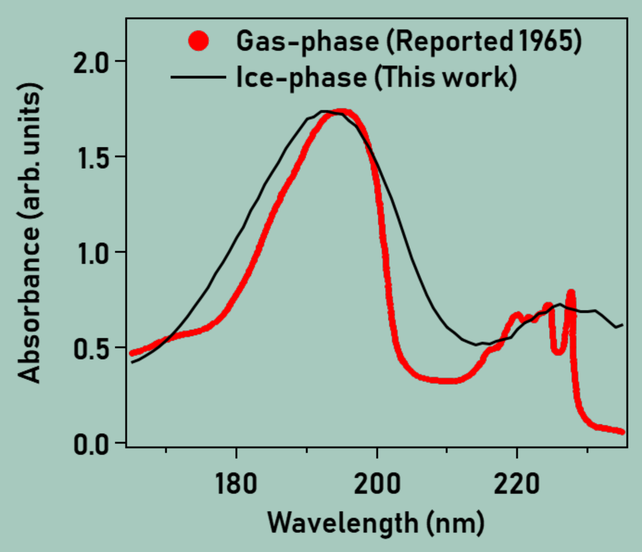

Figure 3: VUV photoabsorption spectrum recorded in this study for the solid phase compared with a previous study for gas phase of pure benzonitrile [3]

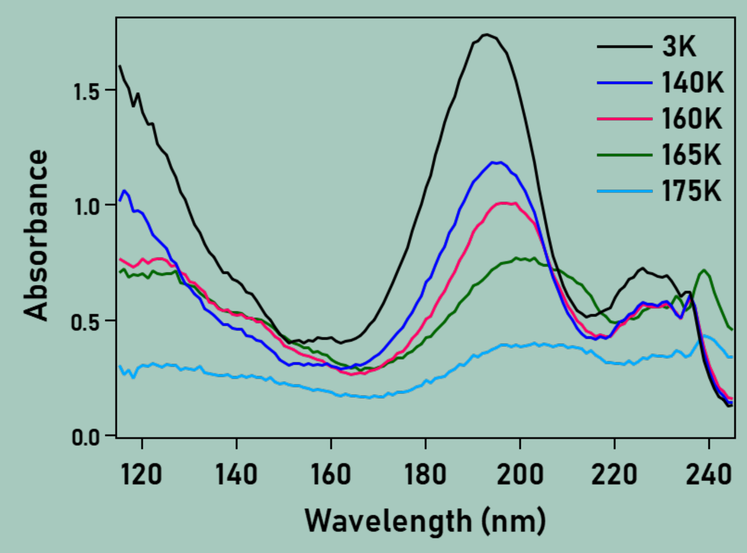

Figure 4: VUV photoabsorption spectra of pure benzonitrile warmed to different temperatures

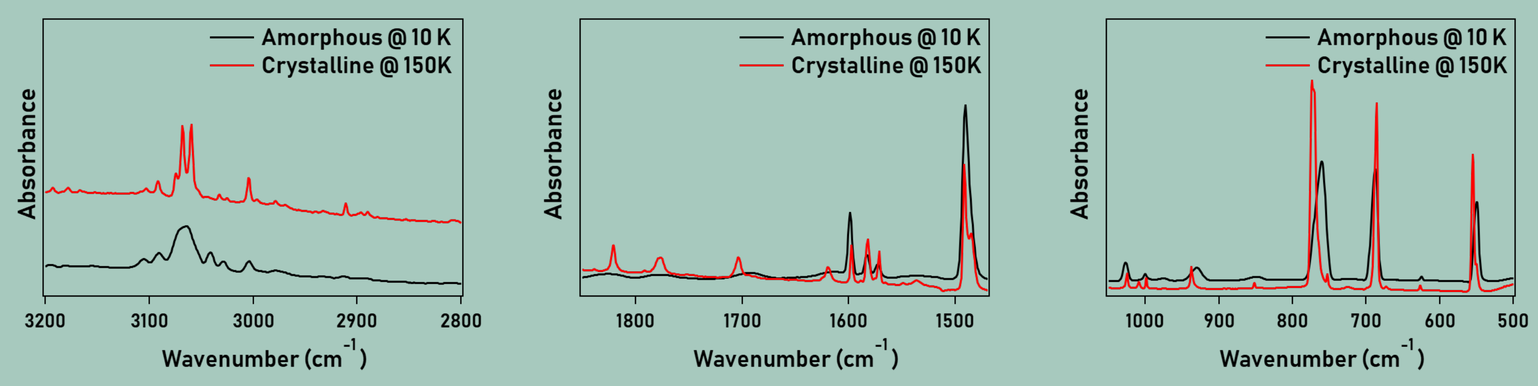

Figure 5. FT-Infrared spectrum recorded for pure benzonitrile at 10 K and 150 K showing amorphous and crystalline forms, respectively

Results: Hydroxylamine

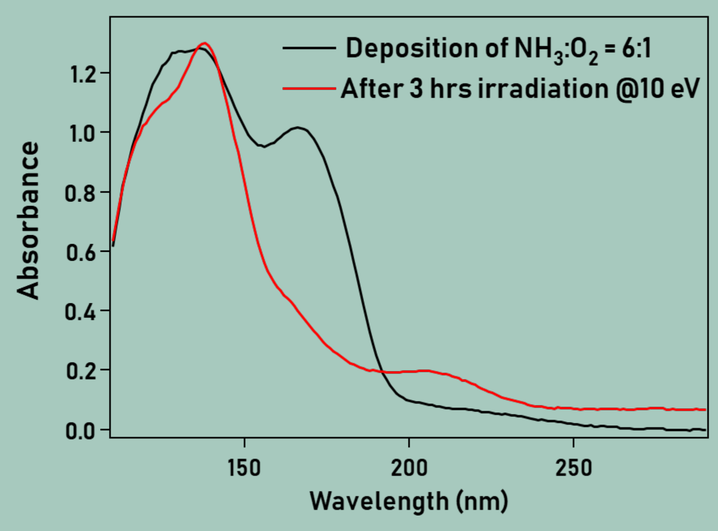

Figure 6: Absorption spectrum recorded before and after irradiation

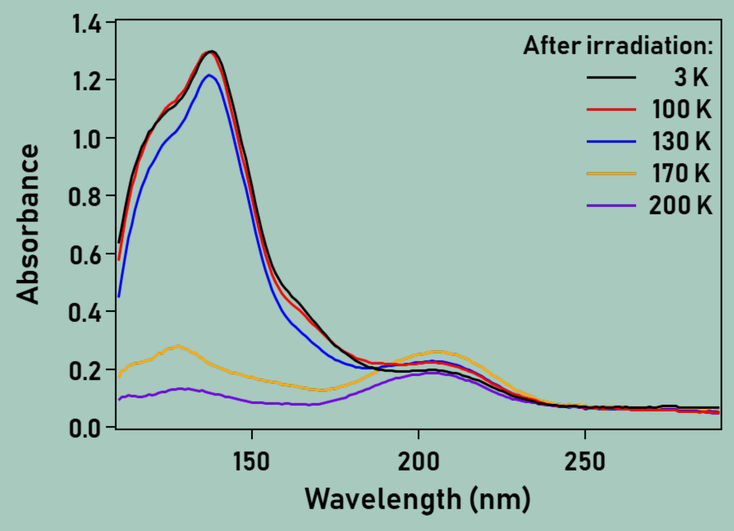

Figure 7: Absorption spectrum recorded after warming to higher temperatures

Conclusion

- VUV photoabsorption spectrum was obtained for benzonitrile.
- Hydroxylamine was produced by irradiating ammonia:oxygen ices and a VUV photoabsorption spectrum was recorded.

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