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PHOTOABSORPTION AND PHOTODISSOCIATION OF MOLECULES IMPORTANT IN THE INTERSTELLAR MEDIUM

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I. Introduction

The photoabsorption, photodissociation, and fluorescence cross sections of interstellar molecules and radicals have been measured in the vacuum ultravilet region. These quantitative optical data are useful for the understanding of the formation and destruction processes of molecules under the intense interstellar UV radiation field. IR emissions from UV excitation of aromatic molecules have also been observed in this research program. The research results are useful for studying the sources of the "unidentified" interstellar infrared (UIR) emission bands.

II. Research Accomplished

The research results accomplished in the period from Feburary 1, 1982 to January 14, 1993 are summarized below:

A. Photabsorption and Fluorescence Cross Sections of Interstellar Molecules and Radicals

The photoabsorption and fluorescence cross sections of interstellar molecules, such as Cl_2, HCl, HBr, H_2O, CH_2O, NO_2, SO_2, CS_2, OCS, N_2O, H_2S, CH_4, NH_3, C_2H_2, H_2O_2, CH_3OH, CH_3SH, $HONO_2$, C_2H_5OH, HCOOH, $HCOOCH_3$, aromatic hydrocarbons, etc., were measured in the 90-250 nm region using synchrotron radiation as a light source. Optical emissions from excited photofragments produced by VU excitation of these molecules were dispersed, and the emitting species were identified by the fluorescence spectra. The photoabsorption cross sections of the interstellar radicals, such as OH, OD, CN, SO, etc., were measured in the 106-200 nm region. The results have been summarized in the papers that are shown in the publication list.

B. IR Emission from UV Excitation of Aromatic Molecules

IR emissions were observed from UV excitation of aromatic molecules in the gas phase, such as benzene(C_6H_6), toluene($C_6H_5CH_3$), xylenes($C_6H_4(CH_3)_2$), naphthalene($C_{10}H_8$), phenanthrene($C_{14}H_{10}$), anthracene($C_{14}H_{10}$), pyrene($C_{16}H_{10}$), methylanthracene ($C_{14}H_9CH_3$), etc. An 3.3 μm band is commonly observed from all the aromatic molecules studied, and additional bands in the 3.4-3.6 μm region are observed from the methyl-derivatives of aromatic molecules. The 3.3 μm band is attributed to the aromatic C-H vibrational mode, and the 3.4-3.6 μm band to the vibrational modes of the CH_3 groups. The results are summarized in the papers as shown in the publication list.

The observed spectra are compared with the IR emissions universally observed in many astronomical objects. The current spectra are very similar to the UIR emission band as shown in the Fig. 5 in the paper published in Astrophysical Journal **383**, 459 (1991). IR emissions from UV excitation of many interstellar molecules other than the PAHs are also observed. It is found that the spectra from non-PAH molecules are quite different from the UIR bands; thus, the non-PAHs are not responsible for the UIR bands.

III. Publications

1. *"Fluorescence Yields from Photodissociation of NO_2 at 1060-1620 Å"*, L. C. Lee and C. C. Chiang, J. Chem. Phys. **76**, 4462 (1982).
2. *"Fluorescence Yields from Photodissociation of SO_2 at 1060-1330 Å"*, with M. Suto and R. L. Day, L. C. Lee, J. Phys. B: Atom Molec. Phys. **15**, 4165 (1982).
3. *"Photodissociation Yields of CS_2 at 1060-1520 Å"*, R. L. Day, M. Suto and L. C. Lee, J. Phys. B: Atom. Molec. Phys. **15**, 4403 (1982).
4. *"Fluorescence Yields from Photodissociation of OCS at 1060-1240 Å"*, L. C. Lee and C. C. Chiang. Chem. Phys. Lett. **92**, 425 (1982).
5. *"Fluorescence Yields from Photofragments of CH_4"*, L. C. Lee and C. C. Chiang, J. Chem. Phys. **78**, 688 (1983).
6. *"Photoabsorption Spectrum of Radicals Produced by a Pulsed-Discharge of Trace H_2O in Ar"*, R. L. Day and L. C. Lee, Chem. Phys. **75**, 17 (1983).
7. *"Photodissociation Processes of NH_3 at 106-190 nm"*, with Masako Suto and L. C. Lee, J. Chem. Phys. **78**, 4515 (1983).
8. *"$OH(A^2\Sigma^+ \rightarrow X^2\Pi)$ Yield from Photodissociation of H_2O_2 at 106-193 nm"*, Masako Suto and L. C. Lee, Chem. Phys. Lett. **98**, 152 (1983).
9. *"Emission Spectra of CF Radicals. V. Photodissociation of CF_3H, CF_3Cl and CF_3Br by Vacuum Ultraviolet"*, Masako Suto and L. C. Lee, J. Chem. Phys. **79**, 1127 (1983).
10. *"Production and Quenching of Excited Photofragments of N_2O"*, L. C. Lee and M. Suto, J. Chem. Phys. **80**, 4718 (1984).
11. *"Quantitative Photoexcitation and Fluorescence Studies of C_2H_2 in Vacuum Ultraviolet"*, M. Suto and L. C. Lee, J. Chem. Phys. **80**, 4824 (1984).
12. *"Photoabsorption Cross Sections of OH at 115-183 nm"*, J. B. Nee and L. C. Lee,J. Chem. Phys. **81**, 31 (1984).
13. *"Photodissociation Rates of Molecules in Interstellar Radiation Field"*, L. C. Lee, Astrophys. J., **282**, 172 (1984).
14. *"Photoabsorption and Photodissociation of $HONO_2$ in the 105-226 nm Region"*, M. Suto and L. C. Lee, J. Chem. Phys. **81**, 1294 (1984).
15. *"Photoabsorption Cross Section of OD at 115-180 nm"*, J. B. Nee and L. C. Lee, J. Chem. Phys. **81**, 3811 (1984).
16. *"Photodissociation Rates of OH, OD and CN by the Interstellar Radiation Field"*, J. B. Nee and L. C. Lee, Astrophys. J. **291**, 202 (1985).

17. *"Photoabsorption Cross Section of HF"*, J. B. Nee, M. Suto and L. C. Lee, J. Phys. B: Atom. Molec. Phys. **18**, L293 (1985).

18. *"Br^* Fluorescence from VUV Photodissociation of HBr"*, J. B. Nee, M. Suto and L. C. Lee, J. Chem. Phys. **83**, 2001 (1985).

19. *"Photoexcitation Processes of CH_3OH; Rydberg States and Photofragment Fluorescence"*, J. B. Nee, M. Suto and L. C. Lee, Chem. Phys. **98**, 147 (1985).

20. *"Photoabsorption Cross Section of CH_3CN; Photodissociation Rates by Solar Flux and Interstellar Radiation Field"*, M. Suto and L. C. Lee, J. Geophys. Res. **90**, 13037 (1985).

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23. *"Vacuum Ultraviolet Photoabsorption Study of SO Radical"*, J. B. Nee and L. C. Lee, J. Chem. Phys. **84**, 5303 (1986).

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27. *"Quantitative Photoabsorption and Fluorescence Study of H_2O and D_2O at 50-190 nm"*, L. C. Lee and M. Suto, Chem. Phys. **110**, 161 (1986).

28. *"Fluorescence from Extreme Ultraviolet Photoexcitation of CF_4"*, L. C. Lee, X. Wang and M. Suto, J. Chem. Phys. **85**, 6294 (1986).

29. *"CF_2 and CFCl Fluorescence from VUV Excitation of C_2F_3Cl"*, J. B.Nee, X. Wang, M. Suto and L. C. Lee, Chem. Phys. **113**, 265 (1987).

30. *"Quantitative Photoabsorption and Fluorescence Spectroscopy of H_2S and D_2S at 50-240 nm"*, L. C. Lee, X. Wang and M. Suto, J. Chem Phys. **86**, 4353 (1987).

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34. *"$CH_3O(\tilde{A} - \tilde{X})$) Fluorescence from Photodissociation of Dimethyl Ether"*, L. C. Lee, M. Suto and C. Ye, J. Chem. Phys. **89**, 6555 (1988).
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37. *"Fluorescences from Photoexcitation of CF_3X (X = H, Cl and Br) at 50-106 nm"*, L. C. Lee, J. C. Han, C. Ye, and M. Suto, J. Chem. Phys. **92**, 133 (1990).
38. *"Fluorescence from Photoexcitation of Cl_2 at 50 -105 nm"*, G. Ma, C. Ye, M. Suto and L. C. Lee, J. Phys. B: At. Mol. Opt. Phys., **23**, 1831 (1990).
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42. *"Infrared Emission from UV Excitation of Benzene and Methyl-Derivertives"*, J. Shan. M. Suto and L. C. Lee, J. Photochem. Photobio., A : Chem. **63**, 139 (1991).
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