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Structure of Evaporated Uracil Thin Films

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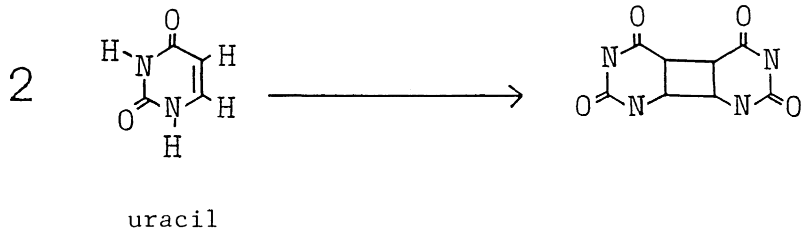
Thin films of uracil were prepared by vacuum evaporation. The stacking structure of the molecules in the films were investigated using a transmission electron microscope(TEM) and electron diffraction analysis. The films showed a substantially higher sensitivity for ultraviolet(UV) light irradiations.

A number of detailed and accurate determinations of uracil crystal structure were reported.[1,2] It is known that when a pyrimidine base is irradiated near the wavelength of its maximum absorption(λ_{max}), monomers are converted to dimers.[3] The products can be reversed to the starting materials by irradiating shorter wavelength light.[3,4] Therefore, uracil, the species of pyrimidine bases, and their derivatives have possibilities as new media of reversible optical memory. In this paper, we report the TEM observation and electron diffraction analysis of the evaporated thin films of uracil, and the sensitivity for the irradiation of UV light.



The evaporation was started when the vacuum pressure became lower than $5X10^{-6}$ Torr. Powdery uracil was obtained from Wako Pure Chemical Industries Ltd., as source material. About 2 g of the uracil powder was placed in a crucible and evaporated by heating at 100-160°C. The substrates were kept at room temperature. Transparent NaCl plates (Ohyo Koken Kogyo Co., Ltd.) were used as the substrates for IR measurements and quartz glass substrates were used for UV measurements. The films for TEM observations were evaporated on Collodion-coated grids. The substrates were held 41 cm above the crucible. The thickness of the films was monitored with SLOAN MODEL DTM-3 throughout the evaporation. A 2500 nm thick transparent uracil film was formed by evaporating for about 2 minutes. The surface of the film was smooth and its thickness was uniform. Judging from the IR spectra and the UV absorption, it was confirmed that the film consisted of uracil molecules.

TEM observations and electron diffraction measurements were carried out using an electron microscope(Hitachi HU-12A) with a 100 kV incident beam.

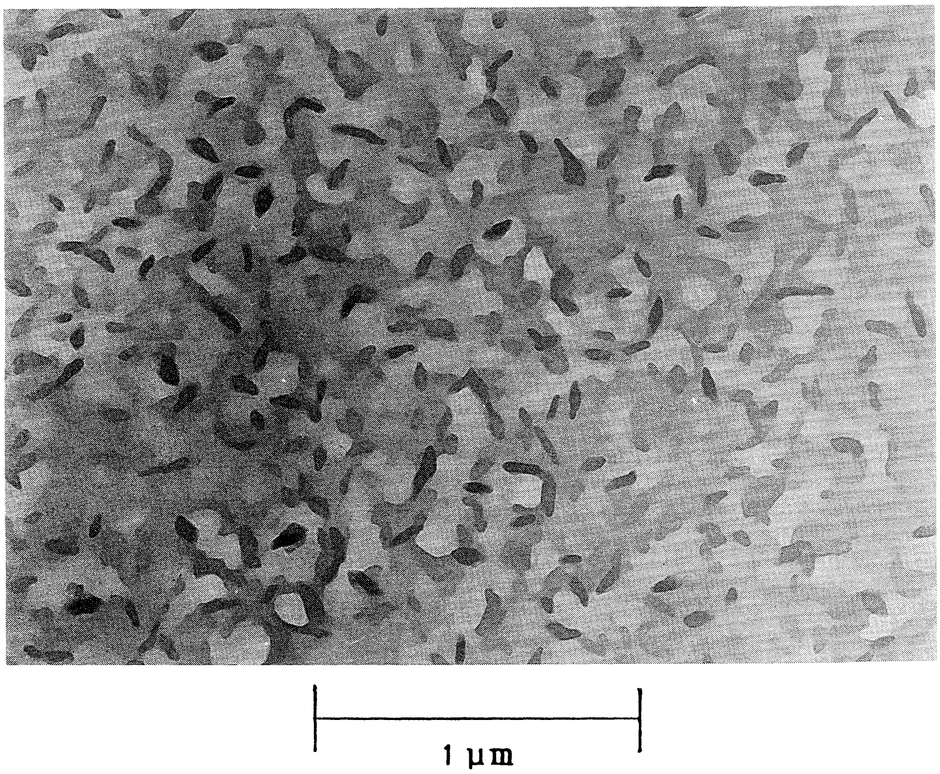


Fig.1. Transmission electron micrograph of evaporated uracil film.

Figure 1 shows the TEM image of the film. This pattern is observed throughout the film. The size of each segment is around 100 nm. It can be expected that the local variation of crystallinity in the film is the origin of the pattern.

Figure 2 shows the THEED pattern. The uracil films evaporated on the Collodion-coated grids gave several electron diffraction rings. Figure 2a shows four strong diffraction rings. The observed diffraction patterns showed a variety of crystallinity. All of the rings were very sensitive to electron beam irradiation, and the crystallinity of the films was degraded by the irradiation. Figure 2b shows the diffraction of Collodion film for reference.

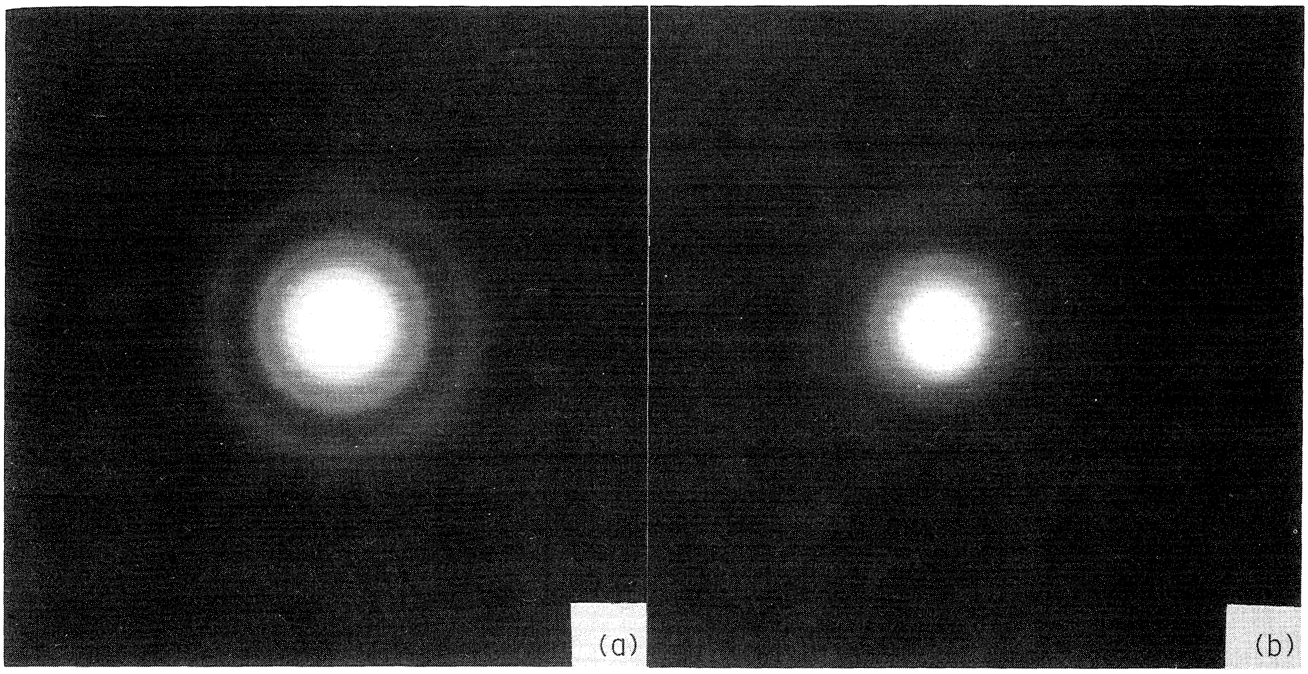


Fig.2. (a) THEED pattern of evaporated uracil film prepared on Collodion-coated grid. (b) Diffration of Collodion film for reference.

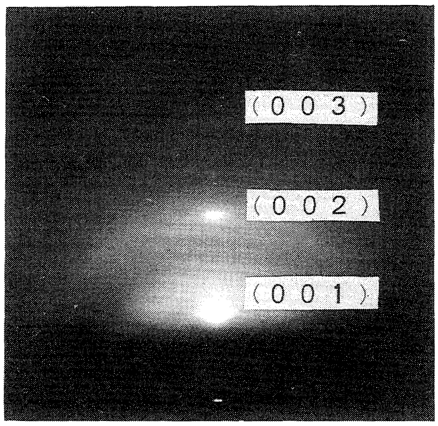


Fig.3. RHEED pattern of evaporated uracil film.

In order to obtain the information on the molecular stacking structure, the RHEED patterns of the films were examined. Uracil was evaporated on a glass substrate covered with a gold thin film. Gold was spattered on the film surface as an internal standard. The diffraction pattern is shown in Fig.3. Table 1 shows the plane distances. The RHEED pattern clearly indicates a stacking of uracil molecules which are oriented parallel to the film plane.

Table 1. Plane distances of evaporated uracil films obtained from the RHEED data

Spot No.	Plane distance / Å	hkl
1	3.17	001
2	1.56	002
3	1.04	003

The UV photochemistry of evaporated uracil thin films was investigated[5] and the stereochemistry of its photodimers was analyzed.[6] We examined the irradiation of UV light to the evaporated thin films. The film thickness was 1000 nm. Low pressure mercury lump(100 W) was used and the films were held 5 cm from the lump. The irradiation decreased the UV absorption of the film around λ_{max}.(Fig.4) Direct irradiation to powdery uracil for several hours caused little change. It is concluded that the difference in the sensitivity for the UV irradiation is related with the stacking structure of the molecules.

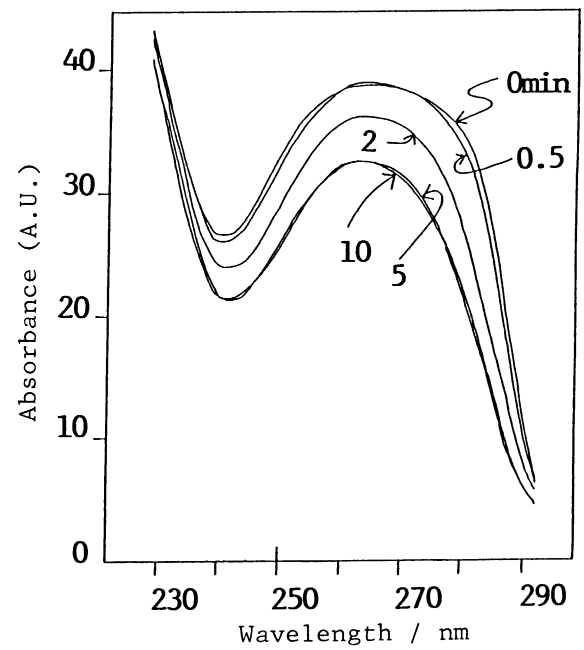


Fig.4. Decrease of the U.V. absorption as a function of irradiation time.

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