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Optical Activity Emergence of Amino-acid Films under Circularly Polarized Lyman-α Light Irradiation

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The origin of homochirality in terrestrial biomolecules (L-amino acid and D-sugar dominant) remains one of the most mysterious problems in the research for the origins of life. One theory about the origin of homochirality is that racemic amino acids produced in outer space were exposed to polarized quantum radiation, such as circularly polarized photons or spin-polarized electrons, inducing asymmetric reactions, which then became asymmetric seeds and were transported to Earth [1, 2].

Among the polarized quantum radiation sources, circularly polarized light (CPL) has been proposed as a source of symmetrical breaking. Recent theoretical calculations have shown that background light scattering by aligned dust particles in interstellar space causes ultraviolet light to become circularly polarized [3], and it is possible that circularly polarized Lyman alpha emitted from star-forming regions in galaxies plays an important role in the origin of homochirality [4].

To verify the cosmogenesis scenario, several ground-based simulation experiments have been investigated using ultraviolet CPL from high-energy particle accelerators. In this study, we focused on the hydrogen Lyman α wavelength of 121.6 nm, where strong emission lines are observed in star-forming regions. We conducted experiments in which a racemic alanine film sample was irradiated with Lyman-α CPL to investigate the photoreaction of biomolecules. Thin solid film samples of a racemic mixture of alanine (DL-alanine) were prepared on CaF_2 substrates from crystalline powder of DL-alanine by vacuum deposition. The irradiated CPL wavelength corresponds to photon absorption bands with the chromophores from the electronic transitions of carboxyl and amino groups (π-σ*) of alanine molecules [5, 6]. The CD spectra of the specimen, before CPL irradiation, were measured using the synchrotron radiation CD beamline BL-12 at the Research Institute for Synchrotron Radiation Science (HiSOR), Hiroshima University, and with the J-1500 CD spectrometer (JASCO Corporation) at the Institute for Molecular Science. The samples were irradiated with L-CPL or R-CPL at hydrogen Lyman-α wavelength of 121.6 nm using undulator beamline BL1U of UVSOR-III. The samples were set in a vacuum sample chamber preventing attenuation by air absorption. The total photon beam intensity irradiated on the sample was monitored with photoelectron current of a silicon photodiode settled at the beam downstream side of the sample holder. The 121.6 nm wavelength radiation from the undulator is reflected by a gold coated mirror located in the mirror chamber directly beam upstream of the sample chamber and then enters the sample chamber. On the beam entrance side of the vacuum sample chamber, a gate valve with an MgF_2 vacuum sealing window (0.5 mm in thickness) was mounted. The use of gold-coated mirror reflections has made it possible to suppress high-energy higher-order light from the undulator source expecting to reduce the transmittance loss of the MgF_2 window due to high-energy radiation induced defects.

After CPL irradiation, the CD spectra was measured by rotating the sample in a plane perpendicular to

the CPL beam by 45° increments to eliminate the effect of the linear component [7]. The obtained CD spectra were averaged to minimize the effects of linear dichroism and birefringence. Circular dichroism (CD) spectrum measurements revealed that irradiation with right-handed (left-handed) CPL induced a positive (negative) anisotropy coefficient g in the wavelength range of 180–240 nm. However, the spectrum was different from that of enantiopure alanine, showing a broad wavelength range and no sign change.

Further studies on the photo-reactions of solid biomolecules under VUV CPL irradiation are required to elucidate the mechanism of optical activity emergence.

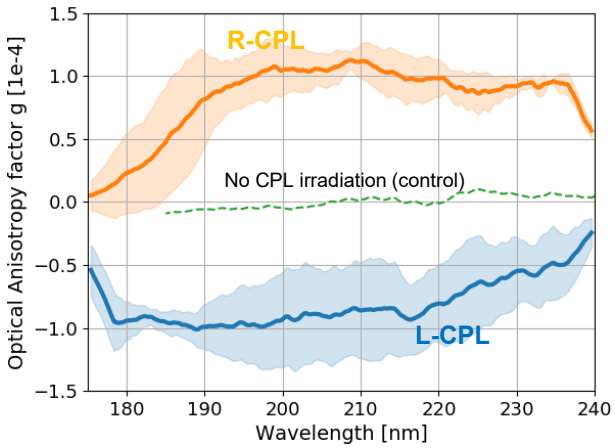

FIGURE 1. Optical anisotropy factor *g* of the DL-alanine samples after Lyman-α R- (orange) and L- (blue) CPL irradiation. Data from three samples were averaged for each case, with error bars representing the 95% confidence interval. The case without CPL irradiation is indicated by the dashed line.

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