出國報告（出國類別：學研訪問）

大阪大學實驗實作並討論相關論文

服務機關：國立交通大學
姓名職稱：杉山輝樹　副教授
派赴國家：日本大阪大學
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摘要

Optical manipulation science has recently attracted a majority of researchers in many kinds of research fields of optics, chemistry, physics, biology, and so on. Now we are exploring our experiments related to optical trap and manipulation based on a big project including international collaboration between many professors in Japan and me. One of the most important aims in this project is to control enantiomer on chiral crystallization from achiral organic compounds utilizing optical trapping. For the experiments, the most difficult issue is how to identify which of enantiomers is induced by optical trapping on a microscope because of small difference of circular dichroism for both enantiomers. In this business trip, I make a discussion with many professors of Japan joining this project in order to solve this difficulty in Osaka University, and conduct a fundamental experiment based on the discussion.

光學操作科學近來在許多研究領域中，像是光學、化學、物理、生物…等等，受到多數研究者的矚目。現階段，我們正在發展與光學捕陷及操作相關的研究計畫，這個計畫基於與一個廣大的國際合作計畫，包含多未來自日本的教授與我。本計畫中的一個重要目標便是使用光學捕陷以控制鏡像異構物自非對掌性有機溶液中產生對掌性結晶。這個實驗最困難的部分，便是如何分辨雷射捕陷在顯微鏡下所誘發之鏡像異構物的種類，其原因是鏡像異構物之間只有非常微小的圓二色性差異。在此次的行程中，為了克服這個實驗的困難之處，我在大阪大學與多位參與這個計畫的日本教授討論，並且基於討論的結果建構了基本的實驗架構。

目次

本文

一、目的

1.Discussion for identification of enantiomers for organic crystals（探討如何分辨有機分子之鏡像異構）

In order to discuss “enantiomer excess” on chiral crystallization, many trials should be necessary. Our laser trapping experiments are generally conducted using a microscope and the resultant crystals are precipitated on a cover glass. It takes about 30 min for one experiment, so that a considerably long time is needed to achieve sample numbers which can convince the efficient enantiomer excess to researchers. Therefore, the simple method enabling identification of crystal chirality should be necessary in our collaboration research. Currently, one of the most secure methods for the identification is to observe X-ray anomalous scattering for target crystals. However, it takes very long time for one experiment, and furthermore the professional technique and uphill work are necessary. So, an alternative method instead of X-ray technique should be considered. Prof. Okamoto, who is a professor of Institute for Molecular Science in Japan, successfully constructed a new optical setup to measure circular dichroism (CD) available for identification of enantiomer of chiral crystals. The first aim of this business trip is to understand the details of this method through discussion with prof. Okamoto to feedback it to our experiments in NCTU.

為了探討對掌結晶化的“鏡像異構物過剩率”，必須要多方嘗試。我們的雷射捕陷實驗一般都是在顯微鏡中進行，而產生的結晶則是沉積在蓋玻片之上。一組實驗過程通常需要 30 分鐘，因此要達到可信任並且有效的鏡像異構物過剩率需要相當多的實驗組數及時間。所以，開發一種可以簡單判定晶體對掌性的方法對此合作計畫來說是必要的。目前最常被用來判定的方法之一即為觀察晶體之 X 射線異常散射光。但是這個方法光是單獨實驗便需要較長時間，而且需要配合專業技術及繁複的實驗過程。因此，我們應該構思其他方法以取代 X 射線技術。

日本分子科學研究所的 Okamoto 教授成功的建構了新的光學設備，用以測量圓二色性並由此判別對掌性分子晶體的鏡像異構物。這次行程的首要目的便是與 Okamoto 教授討論並瞭解此光學技術之細節，並且從而能對我在交通大學的實驗有所幫助。

2.Identification of crystal chirality on laser trapping crystallization of $NaClO_3$
（判定雷射捕陷誘發 $NaClO_3$ 結晶之對掌性）

The second aim of this business trip is to conduct a simple experiment to identify crystal chirality of $NaClO_3$. Different from chirality of organic crystals, the chirality of $NaClO_3$ crystal can be determined by changing the angle of a polarizer under cross-Nicoled condition. This technique will be transferred to our Lab, which can accelerate our experiments on enantiocontrol of chiral crystallization using optical trap.

本次行程的第二目的是建構簡單的實驗用以判別 $NaClO_3$ 結晶之對掌性。與一般有機分子的對掌性不同，$NaClO_3$ 晶體的對掌性可以在正交偏振光影像之觀測下，經由改變偏振片之角度來判定。這個技巧將會轉移至我們實驗室，並將加速雷射捕陷控制鏡像異構物技術之發展。

二、過程

I first discussed with prof. Okamoto about a new identification method of crystal chirality on a microscope. Although he didn’t mention the details of his target samples, he displayed me one CCD scanning image and the corresponding cotton effect at 633 nm. The sample surely has an absorption coefficient at wide visible wavelength ranging from 400 to 800 nm. He also said that this method is available only for such a compound having absorption at the visible region because an objective lens has no transmission at UV range. This means that this method is not applicable for a majority of organic compounds because almost all of the organic compounds have no absorption and CD at visible range. However, to control enantiomer on chiral crystallization itself is a very promising research field, so I believe that this method will become a great powerful tool to identify the chirality of crystals showing an absorption at visible range. After the discussion, I conducted a fundamental experiment to confirm crystal chirality for $NaClO_3$ crystals on a microscope. A $NaClO_3$ aqueous solution saturated at 22°C was prepared, and the saturated solution (6.25 mL) and 2.5 mL Ag nanoparticle dispersion (10 nm, 0.02 mg/mL) containing 2 mM sodium citrate buffer (achiral) were placed in a hand-made cell. The sample solution is in the unsaturated state. The cell was constructed by enclosing a silicone sheet (1 mm thick) between a pair of cover glasses (120 μm thick). The surface of the cover glasses was preliminarily subjected to hydrophilic treatment using a UV irradiator. Due to the hydrophilic surface, the liquid mixture becomes a thin film on the surface. A laser trapping system using a circularly-polarized laser (CPL) was constructed utilizing an inverted optical microscope. Fig. 1 shows a schematic illustration of the optical setup for laser trapping system. The linear polarization of a CW green laser (λ = 532 nm) emitted from a Spectra Physics Millennia eV laser was converted to circular polarization using a quarter-wave plate. The handedness of the CPL can be switched by adjusting the angle between the plane of the linearly polarized light and the optical axis of the quarter-wave plate. The CPL was then introduced to a 60×objective lens through the reflection by a Notch-Dichroic half mirror (λ = 532 nm). The objective lens concentrates the CPL laser at the focal point. We paid special attention to the fact that the handedness of the CPL is inverted by the reflection. Although the obtained result cannot be opened yet because of a secret on our collaboration research, the chirality of the obtained crystals was surely identified very simply. As the first step of study on chirality control for crystals induced by optical trapping, this method is very useful.

首先，我與 Okamoto 教授討論新的以顯微鏡為基礎之晶體判別技術。雖然他並沒有告知樣品的種類，不過他用 CCD 掃描影像展示了對應波長 633 nm 的卡

滕效應（Cotton effect）。這個樣品確定在可見光波段 400-800 nm 具有廣大的吸收範圍。他同時也提到，這個技術只適用於在可見光波段有吸收的樣品，原因來自於顯微物鏡不具有紫外光波段之穿透性。這表示此技術不適用於大多數的有機分子，因為幾乎所有的有機分子在可見光波段都不具有吸收及圓二色性。即使如此，控制鏡像異構物及對掌分子結晶仍然是有前景的研究領域，所以我相信這個技術將是用來判別晶體在可見光波段之對掌性的強大技術。經過討論，我建構了一個基礎的實驗來觀測顯微鏡下 $NaClO_3$ 晶體的對掌性。首先製備 $NaClO_3$ 在 22°C 之飽和水溶液，然後取飽和水溶液（6.25 mL）與 2.5 mL 銀奈米粒子水溶液（10 nm, 0.02 mg/mL）包含 2 mM 檸檬酸鈉緩衝溶液，置於手製之樣品槽，此時樣品溶液為未飽和狀態。樣品槽是用兩片蓋玻片（厚度 120 μm）夾住一片矽膠片（厚度 1 mm）所製成。蓋玻片的表面則事先使用紫外光照射以產生親水性。因為這個親水的表面，樣品混合液體可以在玻片表面形成薄膜。使用圓偏振雷射（circularly-polarized laser, CPL）的捕陷系統則建構於倒立式顯微鏡。圖 1 表示雷射捕陷系統之光學設置圖。線性偏振連續波綠光雷射（Spectra Physics Millennia eV laser, λ = 532 nm）經過四分之波長板以轉換成圓偏振。CPL 的旋向性可以經由改變線性偏振雷射光軸與四分之波長板間的夾角來調整。CPL 則經由 Notch-Dichroic half mirror（λ = 532 nm）反射導入一個放大倍率 60 倍的顯微物鏡。顯微物鏡聚集 CPL 於焦點。在此我們特別注意 CPL 的旋向性會因為反射而相反。由於合作研究保密機制，目前的實驗結果還無法公開，不過產生之晶體對掌性可以經由簡單的方法來判定。作為初步雷射捕陷誘發對掌性結晶之控制，此方法是相當有用的。

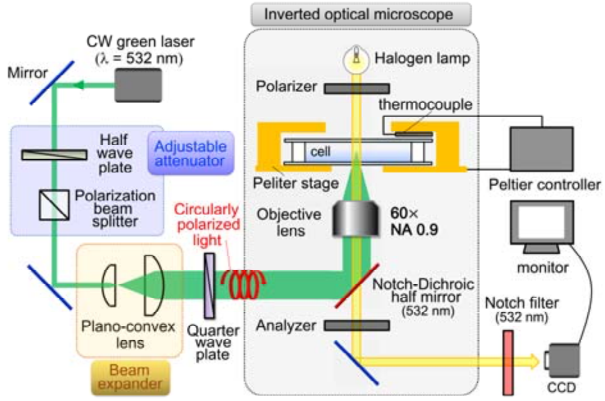

Fig. 1

三、心得與建議

（一）心得

This collaboration research includes three major topics. One of them is to control chirality on crystallization utilizing laser trapping, which will be conducted by me in NCTU. The laser trapping crystallization method was for the first time demonstrated by us in 2007 and then we have succeeded so far in crystallization for various amino acids, inorganic compounds, and proteins. As the next step and the most interesting topics of our study on the laser trapping crystallization, we intend to control crystal chirality on laser trapping crystallization. However, there are many serious problems on it, for example identification method for enantiomers, strong electron magnetic fields of laser, and laser beam shaping. The collaboration research can compensate the lack of our method and should be developed in future in order to achieve our research aim.

這個合作計畫包含三個主要題目。其一是利用雷射捕陷技術控制結晶之對掌性，而此題目將由我於交通大學建構。雷射捕陷誘發結晶化技術是由我們首先於 2007 年成功展示，而且目前我們已經成功結晶胺基酸、無機分子以及蛋白質。作為下一步與本實驗室研究中最有趣的一部分，我們試圖藉由雷射捕陷來控制晶體之對掌性。不過，目前有很多重要的課題，舉例來說，鏡像異構物的判別、雷射的強電磁場以及雷射光束的形狀。這個合作研究計畫可以補足我們研究方法中

不足的部分，並且以此精進我們的實驗技術，並在未來達到我的實驗目標。

（二）建議

Based on this project, I will accept and exchange many students and young researchers from many top-level universities in Japan. Through the exchange program, it is possible for Japanese students to understand high-level experimental instruments and atmosphere in NCTU, and I will have a plan of lab tours in NCTU for Japanese students in order to accelerate scientific exchange between Taiwan and Japan.

基於這個計畫，我將接受與交換數名來自日本的學生以及頂尖大學的年輕學者。藉由這個交換計畫，可以使日本學生了解交通大學高等級的實驗儀器及研究風氣。我也計畫讓日本學生參加交通大學之實驗室參訪，以加速臺灣與日本間的科學交流。