

In this study, we tried to develop a new type display driven by biomotor. First, we focused on body color change of some species of fish. This phenomenon is caused by cells containing many pigment granules, melanophore. These pigment granules are transported along radial microtubules elongated from center of the melanophore by motor proteins. The body color of fish depends on the distribution of them in the cell, for instance, when they aggregate into the center of the cell, the optical density of the cell reduces and thus the cell becomes lighter. Here, we tried to assemble artificial-melanophore in synthetic environments by using minimum components of the cell, motor proteins, microtubules and pigment granules. The final aim of this study is to fabricate a display that one pixel is equivalent to one artificial-melanophore. We designed protein-attaching dot patterns on coverslip and surrounded each dot by hexagonal walls. By growing microtubules from the each dot, we succeeded in the fabrication of numerous radial microtubules in each compartment. When beads coated by kinesin were introduced, they were attached on radial microtubules and were transported along the microtubules by addition of ATP. Now, we are trying to pack artificial-melanophores and display desired picture or character on this device by activation of specific area of artificial-melanophores. We believe that this study contributes to the development of micro-devices driven by bionano-systems.

3P-264 アポフェリチンを使ったカルシウムナノ粒子の合成における二酸化炭素分圧の影響

Effect of carbon dioxide partial pressure in Calcium nanoparticle synthesis using apoferritin

Hiroko Fukano (1), Mamoru Aizawa (1), Hideyuki Yoshimura (1) ((1) *Meiji University*)

Calcium nanoparticles (Ca-NPs) have been attracted great deal of attention as a new material for medical applications such as bone scaffold for treatment. We have proposed several methods for synthesizing Ca-NPs using iron storage protein, apoferritin. At the last BJS meeting (Fukuoka, 2008), we reported Ca-NPs synthesis under gaseous carbon dioxide (CO₂) pressure. Here we examined mineralization process of Ca-NP under CO₂ pressure. The fine granule of 10 mg CaCO₃ was mixed with a 3 ml solution of 0.5 mg/ml recombinant apoferritin. It was not dissolved because the solubility is less than 1 mM at room temperature. The solution was pressurized by gaseous CO₂ at 2 MPa. After several minutes it became transparent and most of CaCO₃ was dissolved. The pH of the solution under pressure was monitored using the pH indicating reagent bromothymol blue. Initial pH was about 9 and then decreased to about 4 after pressurization. Pressure was reduced to the normal atmosphere after one hour. Repeating this process two times, the solution was finally pressurized for one day. By electron microscopy, we confirmed formation of nearly spherical and uniform Ca-NPs with a diameter 5.8 ± 1.2 nm. When we use Ar gas instead of CO₂, Ca-NPs were not obtained. Use of buffer solutions such as HEPES or CHES also prevented mineralization in the apoferritin cavity. According to these results we concluded the key process of this synthesis is control of HCO₃⁻ concentration.

3P-265 アポフェリチンを用いた酸化アルミニウムの作製

Aluminum oxide synthesis using apoferritin

Kazuo Tomita (1), Tomoaki Harada (1), Toru Konishi (1), Hideyuki Yoshimura (1) ((1) *Meiji University*)

Nanoparticles of aluminum oxide (Al₂O₃) can be utilized as a catalyst for the growth of carbon nano tube (CNT), and/or applied for the mask of lithography technology, etc. We have reported Al nanoparticles synthesis in the apoferritin cavity at BJS meeting in Sapporo (2005). But its reproducibility was not good, so that we have optimized the condition again. The optimized condition is as follows; the mixture solution containing 30mM AlNH₄(SO₄)₂, 0.1mg/ml recombinant apoferritin and 100mM acetate buffer (pH4.5) was kept at room temperature for 24h. Then 100mM HEPES (pH7.0) was added to the solution and left standing for 24h at room temperature. The control of pH seems to be important for the synthesis. With transmission electron microscopy (TEM), nearly spherical particles with a diameter of about 7nm were observed in the resultant solution. By means of high resolution TEM, synthesized nanoparticles showed lattice structure with spacing of about 0.2nm. It coincides with the spacing of aluminum oxide (113) plane. The composition of the nanoparticles were examined by energy dispersive X-ray spectroscopy (EDS) and the peaks of Al (K α ; 1.49keV) and O (K α ; 0.53keV) were detected. This suggests the particle would be Al₂O₃, however further study is required to determine the precise composition of the nanoparticles.

3P-266 微小管による温度可逆的な水ゲルの創製

Thermo-reversible hydrogel formed by microtubules

Ryuzo Kawamura (1), Ken-Ichi Sano (1), Itsuki Kunita (1), Taiki Tominaga (1), Naoko Oda (1), Kuniharu Ijiri (2), Yoshihito Osada (1) ((1) *Molecular and System Life Science Unit, RIKEN Advanced Science Institute*; (2) *Molecular Device Laboratory, Research Institute for Electric Science, Hokkaido University*; *Molecular and System Life Science Unit, RIKEN Advanced Science Institute*)

Hydrogels which have covalently bonded polymer chains are being extensively exploited in the material science field to develop novel functional materials. However, they suffer from establishing such a multifunctional hydrogels as mechanical stress-responsive, temperature responsive, and self-repairable properties. Here, we produced a network gel of microtubules (MTs) with synthetic cross-linkers. MT is a one of the cytoskeletal components, which can be obtained by polymerizing tubulins as a monomer. Due to the polymerization and depolymerization property of MT, the sol-gel transition of the MT gel could be controlled by temperature change. We discuss the viscoelastic behaviors of the MT gel. Further, the reversibility of network formation is investigated, which is exerted by the re-polymerization of MTs. This approach to make a novel hydrogel with cytoskeletal protein may lead to a development of new biomaterials.

3P-267 重合可能なタンパク質の可逆的な"バイオハイドロゲル"の創製

Reversible 3D-crosslinked 'bio-hydrogel' by polymerizable proteins

Itsuki Kunita (1), Taiki Tominaga (1), Ryuzo Kawamura (1), Hiromichi Nakagawa (1), Naoko Oda (1), Rikako Tsukamoto (2), Kuniharu Ijiri (2), Ken-Ichi Sano (1), Yoshihito Osada (1) ((1) *Molecular and System Life Science Unit, RIKEN advanced Science Institute*; (2) *Molecular Device Laboratory, Research Institute for Electric Science, Hokkaido University*; *Molecular and System Life Science Unit, RIKEN advanced Science Institute*.)

We are aiming to create a 'bio-hydrogel' having biological functions, such as recirculating, self-repairing, and low-emission. In this study, we have developed a novel actin-polymer hydrogel that allows control of sol-gel transition by actin polymerization and depolymerization. Actin is a most abundant protein in eukaryotes, which has the primary responsibility in biological motile properties, such as cytokinesis, filopodia, and lamellipodia.

G-actin was reacted with multifunctional crosslinker to form multiple G-actin crossbridges. Then the gelation behavior of actin was investigated. The rapid gelation of crosslinked G-actin was observed by increasing ionic strength. An oscillating rheometry was used to evaluate the mechanical properties, and found that the gel has storage modulus (G') about 600 Pa. The G' of crosslinked actin hydrogel was significantly greater than the loss modulus (G''). In stark contrast, the mechanical properties of F-actin showed significantly lower G' by two orders of magnitudes. We also confirmed the gel-sol transition by depolymerization crosslinked actin hydrogel. The reversible re-gelation of crosslinked G-actin was occurred by adding salt. This cycle of gelation and solation was able to be repeated at least three cycles and can be repeated until desired number of cycles. This indicates that our developed hydrogel behaves as recirculating materials.

3P-268 遺伝的アルゴリズムによるキネシン・微小管を用いたマイクロ輸送機構のためのトラック形状最適化

Module Structural Design for Material Transport System Propelled by Kinesin with Genetic Algorithm

Takuya Sunagawa (1), Akihito Tanahashi (1), Motohisa Hirano (1), Matthew Downs (2), Henry Hess (2), Takahiro Nitta (1) ((1) *Gifu university*; (2) *University of Florida*)

To utilize microtubule movements over kinesin coated surfaces for material transport on Lab-on-a-chip devices, various modules, such as rectifiers and concentrators, have been developed. However, designs of module structures are depending on experimental trial and error. To aid designs of module structures, we previously developed a computer simulation which reproduced trajectories of microtubules in modules. In this study, based on the computer simulation, we developed an optimization method generating efficient module structures for intended tasks. We employed a genetic algorithm to optimize module structures. Genetic algorithms are optimization algorithms inspired by biological evolution and able to find optimum solutions in various types of problems. We demonstrated optimizations of rectifier structures which rectify gliding microtubules into the right direction with low probability of microtubule detachments from the kinesin coated surface. The optimization method generated a rectifier structure with the rectification probability of over a 90% and the detachment rate of less than 10%. We expect the optimization method is applicable for other modules.

3P-269 マイクロビームX小角散乱を用いた縮毛矯正による人毛の内部構造変化の解析

Analysis of internal structural change of person hair by the arrangement of straight-permed curly hair with microbeam's small angle X-ray scattering

Satoshi Yamaki (1), Minoru Kakizawa (1), Tomoyuki Kawasoe (1), Hideki Shimizu (1), Iitrou Hattai (2), Noboru Ohta (2) ((1) *SHISEIDO CO.,LTD.*; (2) *Japan Synchrotron Radiation Research Institute (JASRI)*)

The human hair shaft consists of cuticles, cortex and medulla. Cortex occupies most of hair shaft and is made from microfibrils and matrix proteins. In the earlier study, using BL40XU of Spring-8 (Japan Synchrotron Radiation Research Institute) for small angle X-ray scattering (SAXS) on the cross-sections of curly and straight hairs, it was suggested that most of the periodic structures of microfibrils in curly hairs were regularly aligned, and the arrangement of straight-permed curly hair was close to the periodic structures of microfibrils in the natural