Academic Program [Oral B] | 19. Colloid and Interface Chemistry：Oral B

Wed. Mar 26, 2025 1:30 PM - 3:20 PM JST | Wed. Mar 26, 2025 4:30 AM - 6:20 AM UTC
[C]C507(C507, Bldg. 2, Area 2 [5F])

[[C]C507-1pm] 19. Colloid and Interface Chemistry

Chair: Yoichi Kobayashi, Shinya Maenosono

Japanese
1:30 PM - 1:50 PM JST | 4:30 AM - 4:50 AM UTC
[[C]C507-1pm-01]
Dispersion polymerization of polystyrene nanoparticles/nanodiscs and enhancement of antigen detection sensitivity for turbidimetric immunoassay

○Hayato Yokose[1,2], Yosuke Okamura[1,2] (1. Grad. Sch. of Sci. and Tech., Tokai Univ., 2. Micro/Nano Tech. Center, Tokai Univ.)

Japanese
1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC
[[C]C507-1pm-02]
Hydration and Biodistribution of Dendrimer Nanoparticles Modified with Zwitterionic Molecules

○Chie Kojima[1], Rikuto Hirata[2], Nanako Dei[2], Hao He[1,2], Akikazu Matsumoto[2] (1. Institute of Science Tokyo, 2. Osaka Metropolitan University)

Japanese
2:10 PM - 2:30 PM JST | 5:10 AM - 5:30 AM UTC
[[C]C507-1pm-03]
Nanocapsule Formation Via Self-Assembly of Oligo(Ethylene Glycol)-Modified Nanoparticles and Enrichment of Substances Within Them

○Takehiro Yachi[1,2], Honoka Watanabe[3], Kuniharu Ijiro[1], Hideyuki Mitomo[1] (1. RIES, Hokkaido Univ., 2. JSPS PD, 3. Graduate School of Science, Hokkaido University)

2:30 PM - 2:40 PM JST | 5:30 AM - 5:40 AM UTC
Break

Japanese
2:40 PM - 3:00 PM JST | 5:40 AM - 6:00 AM UTC
[[C]C507-1pm-04]
Relationship between Ligand Branching and Nanoparticle Dispersibility in Less-polar Solvents

○Masahiko Sagawa[1], Shohei Yamashita[1], Susumu Inasawa[1], Yohei Okada[1] (1. Tokyo University of Agriculture and Technology)

English
3:00 PM - 3:20 PM JST | 6:00 AM - 6:20 AM UTC
[[C]C507-1pm-05]
All Iron-Group and Platinum-Group Elements Metal High-Entropy Alloy Nanoparticles

○Mahin Julien[1] (1. Kyoto University)

ポリスチレンナノ粒子/ナノディスクの分散重合と凝集比濁法の抗原検出感度向上

（東海大院総理工[1]・東海大マイクロ・ナノ研[2]）○横瀬 颯人[1,2]・岡村 陽介[1,2]

Dispersion Polymerization of Polystyrene Nanoparticles/Nanodiscs and Enhancement of Antigen Detection Sensitivity for Turbidimetric Immunoassay ([1]*Graduate School of Science and Technology, Tokai University*, [2]*Micro/Nano Technology Center, Tokai University*) ○ Hayato Yokose,[1,2] Yosuke Okamura[1,2]

Turbidimetric immunoassay is a method for detecting antigens by specific aggregation induced between antibody-coated particles and antigens. Although this method is simple and rapid, it has the disadvantage of low detection sensitivity compared to conventional enzyme immunoassay methods[1]. Here, we focused on the shape of the particles. Disc-shaped particles have been reported to have properties such as improved adhesion to interfaces and enhanced aggregation reactions due to the surface-contact interaction between discs[2]. In this study, we propose polystyrene (PS) nanospheres and nanodiscs via dispersion polymerization and evaluate them as innovative carriers with high sensitivity in a turbidimetric immunoassay.

PS nanospheres were synthesized by dispersion polymerization of styrene in the presence of a large amount of poly(vinylpyrrolidone) as a stabilizer in methanol/water mixture. PS nanodiscs were then prepared by seeded dispersion polymerization of 2-ethylhexyl methacrylate with the PS nanospheres as seed particles, referring to a previous report[3]. Scanning electron microscopy images revealed that the diameters of the nanospheres and nanodiscs were 190 ± 15 nm and 314 ± 36 nm, respectively, which were extremely smaller than previous studies. Next, bovine serum albumin (BSA) was physically adsorbed on the surface of the nanodiscs, and antibodies were conjugated via amino groups of BSA. When the antibody-conjugated nanodiscs and antigen solution were mixed in the microplate to induce the aggregation, the nanodiscs could detect a lower and wider range of antigen by turbidity change than the nanospheres.

Keywords: Nanoparticles; Disc-shaped particles; Dispersion polymerization; Turbidimetric immunoassay

凝集比濁法とは、抗体を担持した微粒子と抗原の抗原抗体反応による凝集にて抗原を診断する方法であり、簡便・迅速に抗原を検出できるものの、検出感度は低い[1]。我々は、凝集比濁法の担体微粒子の形状に着目した。ディスク状の微粒子は界面への接触面積が増大することで、接着力の上昇や凝集反応の促進が報告されている[2]。本研究では、ポリスチレン (PS) ナノ粒子・ナノディスクの分散重合・シード分散重合による創製法を提案し、形状を活かした高感度な凝集比濁用担体への応用を図る。

メタノールと水の混合溶媒中にて、分散安定剤のポリビニルピロリドンが多量に存在する条件で低濃度のスチレンを分散重合し、PS ナノ粒子を得た。この PS ナノ粒子をシードとして、既報[3]を参考にヘキサデカン存在下でメタクリル酸 2-エチルヘキシル (EHMA) のシード分散重合を行い、PS ナノディスクを調製した。得られた PS ナノ粒子・ナノディスクは、電顕観察よりそれぞれ直径 190 ± 15 nm、314 ± 36 nm と、これまでに報告のない極小サイズであった。次に、ナノディスク表面にウシ血清アルブミン(BSA)を物理吸着させ、そのアミノ基を標的とした化学架橋にて抗体を修飾した。マイクロプレート内にて抗体結合ナノディスクと抗原溶液を混合し、抗原抗体反応による特異的な凝集を惹起したところ、ナノディスクは真球状ナノ粒子よりも低濃度かつ広範囲の抗原を濁度変化にて検出可能であった。

1) Molina-Bolivar J. A. *et al, J. Macromol. Sci. C Polym. Rev.* **2005,** 45, 59-98, 2) Zhang H. *et al. ACS Appl. Polym. Mater.* **2020**, *2*, 3355. 3) Fujibayashi T. *et al, Langmuir* **2007,** *23*, 7958.

双性イオン分子を修飾したデンドリマーナノ粒子の水和状態と体内動態

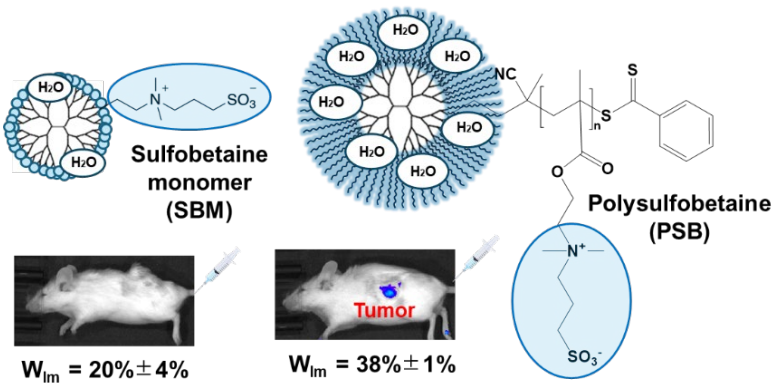
（東京科学大物質理工 [1]・大阪公立大院工 [2]）○児島 千恵 [1]・平田 陸翔 [2]・出井 菜々子 [2]・何 浩 [1,2]・松本 章一 [2]

Hydration and Biodistribution of Dendrimer Nanoparticles Modified with Zwitterionic Molecules ([1]*School of Materials and Chemical Technology, Institute of Science Tokyo*, [2]*Graduate School of Engineering, Osaka Metropolitan University*) ○Chie Kojima [1], Rikuto Hirata[2], Nanako Dei[2], Hao He[1,2], Akikazu Matsumoto[2]

Zwitterionic polymers exhibit antifouling properties, and dendrimers with regularly branched structure have been used in drug delivery system (DDS). In this study, we synthesized zwitterionic monomer- and polymer-conjugated dendrimers as a biocompatible nanoparticle and investigated the relation between hydration property and biodistribution. A sulfobetaine monomer (SBM) and polysulfobetaine (PSB) were conjugated at the termini of polyamidoamine (PAMAM) dendrimer. The PSB-conjugated dendrimers (PSB-dens) accumulated in the tumor after intravenous administration even after the second injection, but the SBM-conjugated dendrimer (SBM-den) did not. Intermediate water, that is water molecules loosely bound to the material, was examined by differential scanning calorimetry (DSC). The amount of intermediate water was related to the biodistribution in the zwitterionic dendrimers [1)], which is a possible design criterion for drug carriers.

Keywords : Dendrimer; Hydration; Zwitterionic Polymer; Tumor Accumulation

双性イオンポリマーは血液適合性を示し、規則的な分岐構造をもつ合成高分子であるデンドリマーは薬物運搬体として利用されている。本研究では、末端に双性イオン構造をもつスルホベタインモノマー（SBM）およびポリマー（PSB）を結合させたデンドリマーを合成した。PSB 結合デンドリマーは EPR 効果によって腫瘍に集積したが、SBM 結合デンドリマーは腫瘍に集積せず、肝臓に集積した。各デンドリマー水和サンプルの DSC 測定にて 0℃未満で融解する中間水量（W_{IM}）を定量したところ、PSB 結合デンドリマーでは中間水が豊富であるのに対して、PSB 結合デンドリマーでは中間水量が少なかった。以上より、ナノ粒子の中間水量すなわち水和状態と体内動態が相関する可能性が示唆された。[1)] これは、薬物運搬体を設計するための新たな設計指針となりうる。



1) C. Kojima, *Langmuir* in press.

オリゴエチレングリコール修飾ナノ粒子の自己組織化によるナノ粒子カプセル形成とその内部への物質の濃縮内包

（北大電子研[1]・学振 PD[2]・北大院生命[3]）○谷地赳拓[1,2]・渡邊ほのか[3]・居城邦治[1]・三友秀之[1]

Nanocapsule Formation via Self-Assembly of Oligo(Ethylene Glycol)-Modified Nanoparticles and Enrichment of Substances within Them ([1]*RIES, Hokkaido University,* [2]*JSPS PD Fellow,* [3]*Graduate School of Life Science, Hokkaido University*) ○ Takehiro Yachi,[1,2] Honoka Watanabe,[3] Kuniharu Ijiro,[1] Hideyuki Mitomo[1]

Nanoparticle capsules (NCs) have great potential in drug delivery systems and nanoreactors. However, achieving both precise NC formation and efficient material encapsulation remains challenging. In this study, we developed a novel and versatile method for forming inorganic NCs. This approach enables the formation of size-controlled NCs from various inorganic nanoparticles modified with oligo(ethylene glycol) via self-assembly at liquid-liquid interfaces. Furthermore, our method also allows efficient encapsulation of the target materials in the NC while enriching them. The mechanisms of NC formation and material encapsulation will be presented and discussed.

Keywords: Nanoparticles, Self-assembly, Nanocapsules, Pickering emulsion

ナノ粒子から形成されるカプセル構造はその内部空間と粒子由来の特性を生かすことでナノリアクターやドラッグデリバリーのキャリアへの応用が期待される．しかし，安定なナノ粒子カプセルの形成と効率的な物質内包を両立させることは未だ困難な課題である．我々は，THF のような水と混ざり合う有機溶媒と水との混合系において，塩によって誘起される相分離を利用し，オリゴエチレングリコール（OEG）で修飾されたナノ粒子をその液液界面へ集積させることで安定したナノ粒子カプセル形成が可能であることを新たに見出した（**Fig. 1**）．本手法では，OEG で修飾された Au ナノ粒子や Fe_3O_4 ナノ粒子など様々な粒子から 100 nm 程度の安定なナノ粒子カプセルを容易に形成可能であり，溶媒条件などを変更することで精密なサイズ制御なども可能であることが分かった．さらに，カプセルの形成過程において，水が有機溶媒へ抽出され塩が濃縮される過程を利用することで，カプセル内に粒子や分子を濃縮しつつ内包可能であることが明らかとなった．これらの結果から，本手法によって様々なナノ粒子からなるカプセル形成とその内部への効率的な物質内包が可能であることが示された．講演ではナノ粒子カプセル形成及び物質内包の詳細について報告する．

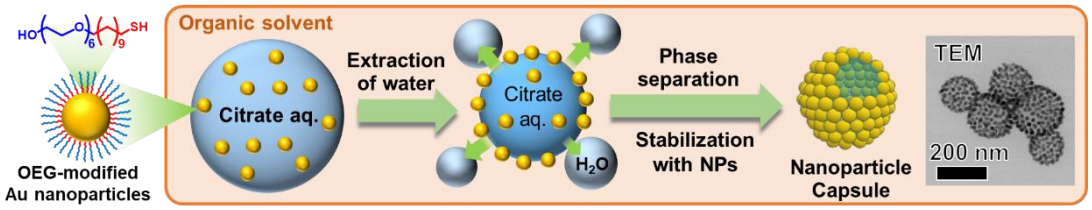


Fig. 1. Formation mechanism of nanoparticle capsules using the interface of salt-induced phase separation.

日本化学会 第105春季年会 (2025)

異なる分岐構造の有機配位子の修飾によるナノ粒子の低極性有機溶媒中での分散性への影響

(東京農工大学) ○佐川真彦・山下翔平・稲澤晋・岡田洋平

Relationship between Ligand Branching and Nanoparticle Dispersibility in Less-polar Solvents

(*Tokyo University of Agriculture and Technology*) ○Masahiko Sagawa, Shohei Yamashita, Susumu INASAWA, Yohei Okada

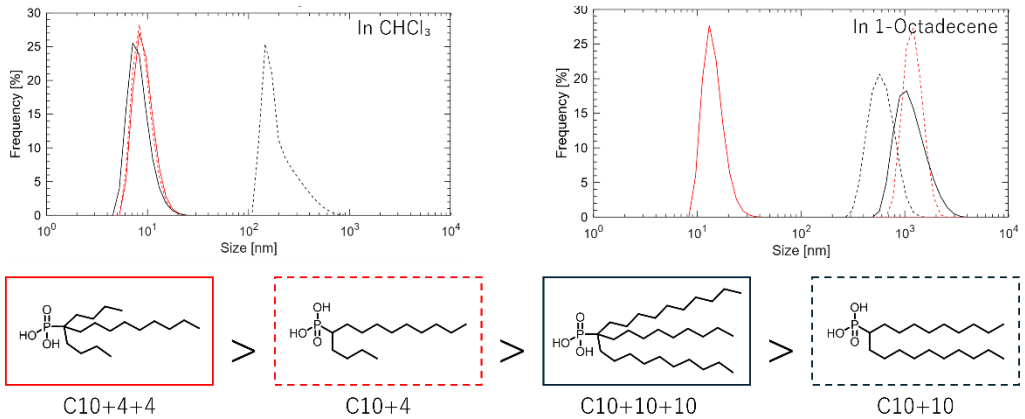
In nanoparticle applications, a major challenge is to disperse the nanoparticles in a solvent. To improve their dispersibility in less-polar solvents, a typical strategy is capping them with organic ligands. Recently, it has been reported that ligands with a branched structure can enhance the dispersibility better than ligands with linear structure. However, dispersion effects between different branching structures have not been thoroughly compared.

In this study, we evaluated the effect of different branching structures of ligands on the dispersibility of TiO_2 nanoparticles in less-polar solvents. The results showed that ligands with short side chain lengths and a three-branched structure (C10+4+4) provide good dispersibility in various less-polar solvents.

Keywords : Nanoparticle; Organic ligand; Dispersibility

ナノ粒子の応用では、ナノ粒子を溶媒中で分散させることが課題である。低極性溶媒中での分散性を向上させるために、ナノ粒子表面を有機配位子(リガンド)で修飾する戦略が一般的に用いられている。ナノ粒子の分散性はリガンドの構造により変化し、近年、分岐構造のリガンドは直鎖構造のリガンドよりも高い分散性を示すことが知られている。[1)]　しかし、異なる分岐構造間の分散効果は、十分に比較されていない。

本研究では、TiO_2ナノ粒子の低極性溶媒中での分散性において、主鎖と側鎖の長さの差や分岐構造の数の違いによる影響を評価した。その結果、以下の図のように、側鎖の長さが短く、3 分岐構造を持つリガンド(C10+4+4)が様々な低極性溶媒中で良好な分散性を示した。



1) Yang, Y. *et al. Nano Lett*, **2016**, *16*, 2133–2138

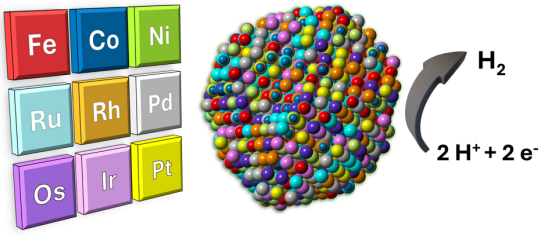
All Iron-Group and Platinum-Group Elements Metal High-Entropy Alloy Nanoparticles

([1] *Graduate School of Science, Kyoto University*, [2] *The HAKUBI Center for Advanced Research, Kyoto University*,[3] *The Ultramicroscopy Research Center, Kyushu University*,[4] *Center for Synchrotron Radiation Research, Japan Synchrotron Radiation Research Institute (JASRI) SPring-8*,[5] *Graduate School of Science, Osaka Metropolitan University*.)

○**Julien Mahin**[1], Kohei Kusada[1,2], Tomokazu Yamamoto[3], Takaaki Toriyama[3], Yasukazu Murakami[3], Osami Sakata[4], Shogo Kawaguchi[4], Hirotaka Ashitani[4], Yoshiki Kubota[5] and Hiroshi Kitagawa[1]

Keywords: High-Entropy Alloy; Iron-Group Metals; Platinum-Group Metal; Hydrogen Evolution Reaction; Electrocatalyst

High-entropy alloys, composed of 5 or more principal elements, are highly promising materials as catalysts for important energy transformation reactions[1]. So far, the research focus has been on noble metals such as the platinum-group metals because of their exceptional catalytic properties and because they are relatively easy to mix owing to their similar properties[2,3]. However, it is of great interest to study the alloying of more diverse elements such as 3d metals into platinum-group metal high-entropy alloys and study the effect of the addition of elements with very different sizes and d-band center energy on the catalytic activity. We synthesized for the first time alloy nanoparticles containing all the iron-group metals (Fe, Co and Ni) and all the platinum-group metals (Ru, Rh, Pd, Os, Ir and Pt) using a simple low temperature wet chemical method. We show that remarkably, alloying the iron-group base metals with the platinum-group metals results in a 50% increase the catalytic activity for the hydrogen evolution reaction under acidic conditions compared to the equivalent alloy containing only platinum-group metals conditions. This activity is three times that of a commercial Pt/C catalyst, enabling reduction of the precious metal content of heterogeneous catalysts while simultaneously increasing their performance.



1) Y, Xin, *ACS Catal.* 2020, 10, 19, 112802) D. Wu, *J Am Chem Soc*, 2020, 142, 13833. 3) D. Wu, *J Am Chem Soc*, 2022, 144, 3365–3369.