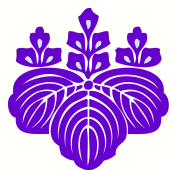




TSUKUBA  
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WEEK 



筑波大学  
*University of Tsukuba*

# ***Book of Abstract***

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*Engineering Science of Life and Environment Based on  
Colloidal Flocculation*

*TGSW 2020 Session 6-1*

*DATE: SEPTEMBER 29, 2020*



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***Session Name: "Engineering Science of Life and Environment Based on Colloidal Flocculation".***

Modern science is seeking for the analysis of pure elements as well as understanding of their complex interactions. Colloid science can be regarded as the latter. Obtained results have been utilized not only for the industrial production, but many aspects of environment, microbiology, food and human health care. University of Tsukuba has a uniquely long history in the study of colloidal flocculation from the period of its former Tokyo University of Educational University. In this session, we discuss the engineering science of colloidal domain in life and environmental science placing an emphasis on colloidal flocculation to elucidate the direction of future development.

**“コロイドの凝集から標榜する生命環境の科学工学”**

現代の科学は、物質の究極の姿を追求する一方で、個々の要素間の相互作用から作り出される多様で多彩な問題に取り組んでいる。コロイド科学は後者の典型であり、その成果は工業生産のみならず、環境面の諸課題、食糧、材料、生命、医療、生活における様々な問題に還元され役だてられる。筑波大学はその前進の東京教育大学から60年以上に渡りコロイドの凝集と分散の研究を繋いでおり、理学的な学理構築と農学、工学、環境への応用展開に特徴ある実績を有する。本セッションでは、現在我々が中心的に取り組んでいる「凝集」に注目して、基礎から応用にわたる一連の研究をレビュー討議することにより、原発事故やパンデミックなどを乗り越えて次世代に展開できるエンジニアリングサイエンスが食糧生産や生物資源環境分野に存在することを例示する。

Session Web Page : <http://www.eng.bres.tsukuba.ac.jp/colloid/research-unit/tgsw2020engbres/>

**Session Organizer:**

Yasuhisa Adachi, Professor, Faculty of Life & Environmental Sciences

Motoyoshi Kobayashi, Associate Professor, Faculty of Life & Environmental Sciences

**Session: September 29, 2020**

**Time: 09:20-17:10**

## Organizing committee

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Cordelia Selomulya (UNSW Sydney)

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Yang Xin

### **Secretary**

Susumu Sakurai



**Program: “Engineering Science of Life and Environment Based on Colloidal Flocculation”.**

29th Sep (2nd Day) 9:20-11:20	Free Theme No.6-1 (Online)	Engineering Science of Life and Environment Based on Colloidal Flocculation Organizer : Yasuhisa Adachi/Motoyoshi Kobayashi
	Food & Biomaterials, Chair: Sosaku Ichikawa/ Shingo Matsukawa	
	Cordelia Selomulya, University of New South Wales (Australia) Designing functional microparticles for encapsulation and targeted release via spray drying	
	GEONZON Lester, Tokyo University of Marine Science and Technology Studies on the gelation mechanism and network structure of carrageenan gels using particle tracking	
	Takashi KUROIWA, Tokyo City University Development and functionalization of edible dispersion systems using intermolecular interactions of biomolecules	
11:30– 13:30	Isao KOBAYASHI, Food Research Institute, NARO Microchannel emulsification: effects of food-grade composition and operating conditions	
	Ananda Kafle, Tokyo University of Science Impact of a polar plant steroid on the phase behavior of hydrogenated soy lecithin	
	Poster Session No.5-3 (Online)	Frontiers and Sustainability of Bioresources and Environmental Engineering Organizer : Muhamad Ezral Bin Ghazali/Lim Voon Huey
13:30- 15:10	On-Line Poster session (Lim/ Ezral/ Nisa)	
	Poster session is essentially 5parallel session carried out Teams. Lunch	
	Free Theme No.6-1 (Online)	Engineering Science of Life and Environment Based on Colloidal Flocculation (Continue)
	Soil and Environment, Chair: Kazuyoshi Ogawa/ Yuji Yamashita	
	Wengfen Tan, Hoazhong Agricultural University (Wuhan) The role of soil active colloids in trace element speciation and cycling in the environment	



	<p>Kamila Kydralieva, Moscow Aviation Institute, Volokolamskoe (Russia) Green Functional Materials Based on Humic Substances for Clean-Up Technologies.</p> <p>Takumi Saito, Nuclear Professional School, School of Engineering, The University of Tokyo Aggregation structures of humic substances studied by small-angle X-ray and neutron scattering</p> <p>Junyou Wang, East China University of Science and Technology (Shanghai China) Dendrimer Based Polyion Complex Micelles</p>	
	20min Break	
15:30-17:10	Free Theme No.6-1 (Online)	Engineering Science of Life and Environment Based on Colloidal Flocculation (Continue)
	Fundamental, Chair: Motoyoshi Kobayashi/ Yasuhisa Adachi	
	<p>Shinichi Takeda, Center for Colloid and Dispersion Technology Challenges and Prospects of Dispersion/Flocculation Theory from a Practical Point of View</p> <p>Partha Pratim Gopmandal, National Institute of Technology (India) Electrohydrodynamics of Composite Soft Particles: Fundamental and Applications</p> <p>Hiroyuki Ohshima, Tokyo University of Science How I entered the world of colloid science</p> <p>Herve Cottet, Institut des Biomolécules Max Mousseron, Université de Montpellier (France) Investigating the formation of polyelectrolyte complexes using capillary electrophoresis: effect of polyelectrolyte charge density and molar mass</p>	
Evening	On line Banquet	Review the activity of whole day and introduce planning Words of Thanks

Engineering Science of Life and Environment  
Based on Colloidal Flocculation

Oral Session



# Designing functional microparticles for encapsulation and targeted release via spray drying

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The talk will provide an overview on some of the research conducted using a microfluidic drying approach to generate uniform microparticles with tightly controlled characteristics and sizes in a scalable, almost waste-free process, for encapsulation and targeted release. The effects of formulation (pH, concentration, dopants, solvents) and process parameters (droplet size, drying time) on microstructural properties and controlled release functionalities are shown for silica-based and polymer-based microencapsulates.<sup>1,2</sup> The ability to control release kinetics of polymeric microparticles by manipulating their microstructures was demonstrated using polymeric Eudragit® dispersions as matrix materials. The microstructures of particles and corresponding release mechanisms could be tuned by different strategies, such as the incorporation of highly hydrophilic ingredients to accelerate release, using alginate or acid-hydrolysed tetraethyl orthosilicate (TEOS) as an additional barrier in the matrix, or using precursors containing components with different sizes (and thus diffusion rates) to generate defined core-shell structures.<sup>3</sup> Other examples including microencapsulation using whey proteins as wall materials that can be pre-treated to improve oil encapsulation<sup>4</sup>, or to adjust their release characteristics during digestion<sup>5</sup>.

The ability to produce highly uniform particles with this unique approach has contributed to the knowledge of how particles with different microstructures are formed, and how the physicochemical properties are related to their functionality. The underlying principles of particle formation mechanisms are useful to understand when designing new functional food products or improving the quality of existing products. The strategy can assist in the manufacturing of spray-dried powders with targeted properties using commercial spray dryers.

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# Studies on the gelation mechanism and network structure of carrageenan gels using particle tracking

○Lester Geonzon, Shingo Matsukawa†

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## Abstract

The most industrially utilized carrageenans are the  $\kappa$ -(KC),  $\iota$ -(IC) and  $\lambda$ -(LC) carrageenan which differs in the number of sulfate groups per carrabiose unit: one (G4S-DA) for KC, two (G4S-DA2S) for IC, and three (G2S-D2S,6S) for LC. Among the three types, KC and IC exhibited gelling properties influenced by temperature and presence of cations ( $K^+$ ,  $Ca^{2+}$ ). KC formed a hard and brittle gel while IC formed a soft and so-called “weak gel”. On the other hand, LC is non-gelling carrageenan. The functionality of carrageenan in various applications depends mainly on their rheological properties. In this study, the network structure of mixed gels (KC:IC and KC:LC), whether if formed a phase-separated or interpenetrated network, were investigated using particle tracking<sup>1,2,3</sup>. The mean square displacement (MSD) of the particle in KC gels showed independence with lag time while in IC gels showed diffusivity even at low temperature, revealing the network structure of a weak gel<sup>1</sup>. The individual MSD of particles in the mixture of KC:IC showed a broad distribution after 1-day storage, indicating the emergence of microstructural heterogeneity in the gel. This heterogeneity was attributed to the frozen structure on the way to phase-separated network structure<sup>2</sup>. The van Hove correlation plots and distribution of individual MSD and  $\alpha$  suggested the presence of two groups of particles with fast and slow mobilities suggesting that mixed KC:IC was frozen on the way to phase-separated network structures made of KC-rich and IC-rich domains with a size of >100 nm due to the network formation of KC and IC chains. Meanwhile, the phase-separated structure was also observed in a mixture of KC:LC gels<sup>3</sup>. The inability of LC to form a network and the extensive aggregation of KC suggests a phase transition from sea-island to island-sea network structure at different mixing ratios.

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# Development and functionalization of edible dispersion systems using intermolecular interactions of biomolecules

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(Faculty of Science and Engineering, Tokyo City University)

Typical foods mainly consist of proteins, polysaccharides, lipids, and water. Since these biomolecules have various partial structures including functional groups with hydrophilic or hydrophobic properties, they interact each other via multi-mode molecular interactions. The author's research group has studied the formulation techniques of edible dispersion systems by self-assembly processes based on intermolecular interactions between above biomolecules [1, 2]. Preparation procedure of these dispersion systems is simple: two or more materials of biomolecules dissolved or suspended in aqueous media are just only mixed to each other (Fig. 1) without high energy input, severe physicochemical stresses, nor use of harmful chemicals. Here, two examples of recent results and findings are introduced: first topic is “formulation of submicrometer-sized particles via self-complexation of chitosan and amphiphilic lipid molecules”, and the second is “formulation of microspheres with controlled diameter using biopolymers”. The properties of these dispersion systems, such as particle size, electrokinetic properties, physicochemical stability and encapsulation/controlled-release properties, are tunable based on the properties of used biomolecules and preparation conditions. These dispersion systems would be applicable for developing high-quality foods with good stability and beneficial functionality.

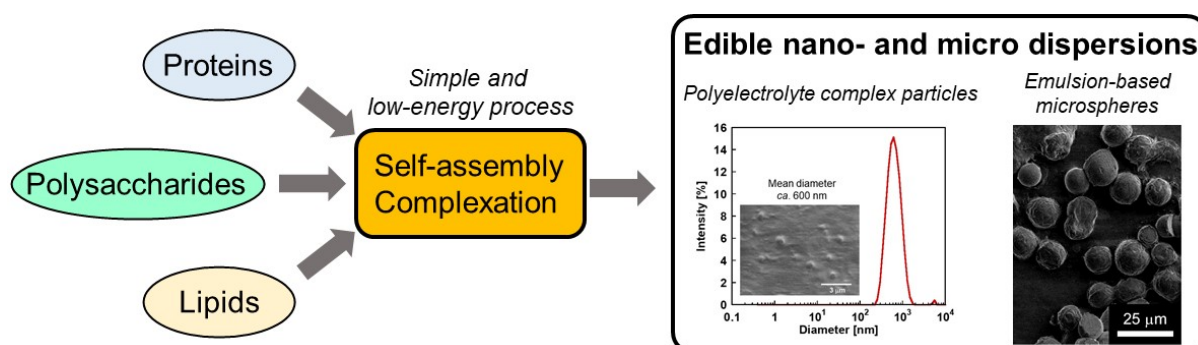


Figure 1. Formulation of edible nano/micro dispersions via self-assembly and complexation of biomolecules.

## References

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# Microchannel Emulsification: Effects of Food-Grade Composition and Operating Conditions

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Monodisperse emulsions and their secondary products have potential applications in food and some other industries. Microchannel (MC) emulsification is a robust technique to produce monodisperse emulsions with controlled droplet sizes of  $>1\ \mu\text{m}$ .<sup>1</sup> The uniquely mild droplet generation for MC emulsification exploits interfacial tension dominant at the micron level, suppressing degradation and denaturation of heat- and shear-sensitive emulsion components. Compactly arranged straight-through MC arrays also enable producing monodisperse emulsions with high droplet productivity. This brief overview covers MC emulsification researches aiming to produce monodisperse food-grade emulsions under different operating conditions. The use of MC emulsification can encapsulate the hydrophilic/hydrophobic bioactive compounds in various dispersions such as simple/multiple emulsions, solid/gel microparticles, and functional vesicles at high encapsulation efficiencies.<sup>2,3</sup> Surface-active extracts prepared from plant by-products were also successfully used for producing monodisperse oil-in-water emulsions by straight-through MC emulsification.<sup>4</sup> MC emulsification at different temperatures was correlated well with the contact angle of the dispersed phase to the MC walls that was measured using a unique MC array method.<sup>5</sup> Scale-up and parallelization of MC emulsification setup could satisfy minimum industrial-scale production of monodisperse food-grade emulsions.

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# Impact of a polar plant steroid on the phase behavior of hydrogenated soy lecithin

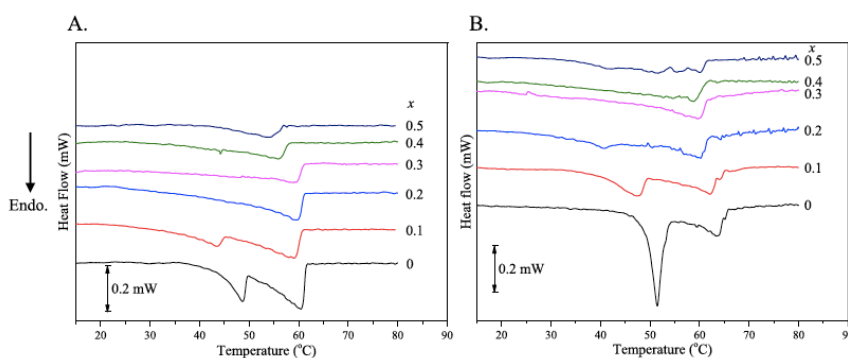
○Ananda Kafle, Masaaki Akamatsu, Avinash Bhadani\*, Kenichi Sakai, Chihiro Kaise\*\*, Teruhisa Kaneko\*\*, Hideki Sakai

(Department of Pure & Applied Chemistry, Faculty of Science & Technology, Tokyo University of Science, \*Research Center for Science & Technology, Tokyo University of Science, \*\*LVMC Inc. Tokyo)

We have studied the phase behavior of hydrogenated soy lecithin in the presence and absence of  $\beta$ -sitosteryl sulfate. Soy lecithin is a commercially important phospholipid, which, by utilizing its self-assembling properties, can be used to prepare drug delivery systems for cosmetics and pharmaceuticals. A sterol, conventionally cholesterol, is necessary to optimize the properties of the phospholipidic formulation.<sup>1</sup> As  $\beta$ -sitosteryl sulfate, a steroid environmentally friendlier than cholesterol, has been previously established to better optimize size and enhance dispersibility and hydration of phospholipids<sup>2</sup>, we were motivated to study this system.

For this study, the samples consisting of hydrogenated soy lecithin (HLC) and sodium  $\beta$ -sitosteryl sulfate (PSO<sub>4</sub>) in mole fractions ( $x$ ) varying from 0 to 0.5 were prepared by solvent evaporation followed by hydration method. The soy lecithin used contained phosphatidylcholine (PC), phosphatidylethanolamine (PE), phosphatidic acid (PA) and lysophosphatidylcholine (LPC). The phase behaviors of the fully hydrated mixtures were studied with the help of polarized optical microscopy (POM), differential scanning calorimetry (DSC), Small & Wide-angle X-ray Scattering (SWAXS) and electron microscopy.

The POM results indicated two coexisting gel phases ( $L_{\beta 1}$  and  $L_{\beta 2}$ ) in hydrated HLC. We carried out DSC measurements on the HLC-PSO<sub>4</sub> system (Fig. 1 A) as well as another system consisting of HLC of higher PC content (Fig 1 (B)), both of which showed two phase-transition peaks. As the intensities of the first and the second peaks increase and decrease, respectively, in proportion to the PC and (PE + PA) compositions, we assign these peaks respectively to these two fractions. The segregation of the two gel phases is due to the nonideal mixing of the lipids in the bilayer.



**Fig. 1.** DSC heating endotherms of the HLC samples (A), and corresponding endotherms of the higher PC HLC sample (B).

Evidence from SAXS and WAXS indicated that the addition of PSO<sub>4</sub> converts the PC fraction into a fluid, liquid ordered phase ( $L_o$ ) with only minimal impact on the (PE + PA) fraction. Above the second transition temperature, the bilayers of all compositions change into liquid crystalline ( $L_\alpha$ ) phase. The fluidizing effect of PSO<sub>4</sub> in HLC can be useful for cosmetic and pharmaceutical formulations.

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# The role of soil active colloids in trace element speciation and cycling in the environment

Wenfeng Tan<sup>†</sup>, Mingxia Wang, Juan Xiong  
(Huazhong Agricultural University)

With the increase of environmental pollution, the risks and damages to human health caused by the entry of external pollutants such as heavy metals into the soil attracted great concern. The vast majority of the heavy metals would be adsorbed by soil active components, and exposed on the soil chemical interface. Soil interfacial interactions have profound effects on the sequestration, degradation and biological metabolism of the pollutants. Therefore, focusing on the chemical behaviours of heavy metals in soil and developing soil remediation technologies to meet the social and public needs were of prime importance. To date, our understanding of the impacts of soil active colloids on the behaviours of heavy metals in soils, and of an advanced model through soil-plant continuum is still relatively limited <sup>1</sup>.

The bioavailability and toxicity of heavy metal in soil is mostly decided by its speciation, but not by its total amount. Therefore, it is necessary to make accurate assessments of heavy metal species and speciation distribution. Geochemical models are widely used to predict the speciation and transport of heavy metals that will be important in the control of the solubility, bioavailability and the fate of heavy metals. The various types of models have been developed to calculate chemical speciation or the distribution of chemicals over all relevant forms on different soil active colloids <sup>2</sup>. Fundamental understanding of these reactions and processes at the atomic, molecular, and microscopic levels is essential for remediation of heavy metal pollution in soils, sustaining and enhancing soil health, which includes human health, on a global scale <sup>3</sup>. Future research on this extremely important and exciting area of science should be stimulated to soil pollution and remediation as well as sustain the ecosystem integrity.

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# Green Functional Materials Based on Humic Substances for Clean-up Technologies

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Humic substances (HS) have the most striking feature in the context of environmental due to constellation of such unique properties as non-toxicity, biocompatibility, resistance to biodegradation, and polyfunctionality. As a result, we have been derived a set of diverse functional and hybrid materials based on humic substances such as dispersants, flocculants, chelators, etc.<sup>1</sup> also being non-toxic<sup>2</sup>. Formulated humics-functionalized magnetic nanoparticles (MNPs) was demonstrated to remove effectively radionuclides, heavy metals, pharmaceuticals<sup>3</sup> from contaminated water. Being magnetic, the HS-coated MNPs are readily separable using an external magnetic field, while the HS coating effectively stabilizes the particles against aggregation. Magnetic imprinted HS-based nanoparticles possessed with high recognition for set of metal ions including  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{UO}_2^{2+}$  in the presence of competing ions. The point is in the recognition and binding of ions of those metals, which were used as template ions in the synthesis of macrocomplex. Non-stoichiometric interpolyelectrolyte complexes (NIPECs) formed by interaction of oppositely charged HS and PEI/PDADMAC were proved to be effective materials to suppress water and wind erosion thereby preventing a spread of ecotoxins from contaminated sites and to bind a majority of toxic metals due to incorporation of metals inside hydrophobic NIPECs fragments<sup>4</sup>.

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# Aggregation structures of humic substances studied by small-angle X-ray and neutron scattering

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Humic substances (HSs) play essential roles for the fate of pollutants and nutrients in nature, affecting their speciation in water or on surfaces. Many researchers have made efforts to reveal the structures of HSs over decades. Historically, so-called the polymer model was prevailing among researchers as a structural model for HSs, in which HSs are considered to be randomly coiled macromolecules that elongate or shrink in response to pH or ionic strength. More recently, various experimental evidences suggest that HSs are composed of relatively small organic molecules, leading to so-called the supramolecular or pseudomicellar model.<sup>2</sup> Nevertheless, details of association or aggregation structures of HSs remain unclear. In this study, we are trying to solve this long-standing issue by combining small-angle scattering with different probes, namely X-ray and neutron. Small-angle scattering can provide mesoscopic structural information on a target and particularly useful for objects with hierarchical structures like aggregates. Small angle X-ray scattering, SAXS, probes a variation of the electron scattering length density (SLD) in a target object, which is proportional to electron density of constituting elements; meanwhile, small-angle neutron scattering, SANS, does that of the neutron SLD, which is isotope dependent and has a particularly large value for hydrogen. By comparing SAXS and SANS, one can assess to structural inhomogeneity of a target object. We have examined the nm to sub- $\mu\text{m}$  scale structures of two humic acids (HAs) by SAXS and SANS. Purified Aldrich humic acid (PAHA) was used as a model of HSs in surface environments and Horobe humic acid (HHA) extracted from deep sedimentary groundwater at the Horonobe underground research laboratory of the Japan Atomic Energy Agency (JAEA) in Hokkaido, Japan was used as the counterpart in deep underground environment. Both HAs are reported to have rather different physicochemical properties.<sup>3</sup> The SANS and SAXS profiles of both PAHA and HHA increase at low scattering vector,  $q$ , indicating the formation of aggregates even at relatively high pH, where the HAs have large negative charges and repel each other. For HHA the onsets of the rise of the scattering intensity are shifted to higher  $q$  with a decrease of pH, indicating the formation of more compact aggregates at low pH. On the other hand, the SAXS and SANS curves of PAHA do not correspond with each other, and the latter show no pH dependence. This means the presence of structural inhomogeneity in the aggregates of PAHA. The detailed structural models of both HAs will be introduced in the talk.

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# Dendrimer Based Polyion Complex Micelles

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Dendrimer-based PIC micelles are novel nanostructures from the assembly of dendrimers with polyion-neutral diblock copolymers.<sup>1</sup> Such soft structures can not only effectively load functional biological molecules (enzymes, RNA, polypeptides, etc.), but also maintain their biological (secondary) structure and activity, thus exhibiting unique properties and potential applications in the fields of cell simulation and biomimetic materials. Because of the branched and three-dimensional structure of dendrimers, understanding the electrostatic assembly is challenging yet essential for manipulating the formation and property of the dendrimer-based PIC micelles.<sup>2</sup> In this paper, we report the electrostatic assembly of PAMAM dendrimers with different charged building blocks. Specifically, effects of control factors including pH, ionic strength, charge mixing ratio, length ratio of polyion-neutral diblock copolymer and dendrimer generation on the charged assembly and formed PIC micelles have been studied systematically.<sup>3-5</sup> Our results and new findings shall be helpful for understanding the assembly of asymmetric polyelectrolytes, as well as for designing new PIC micelles and functional soft nanocarriers.

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# Challenges and Prospects of Dispersion/Flocculation Theory

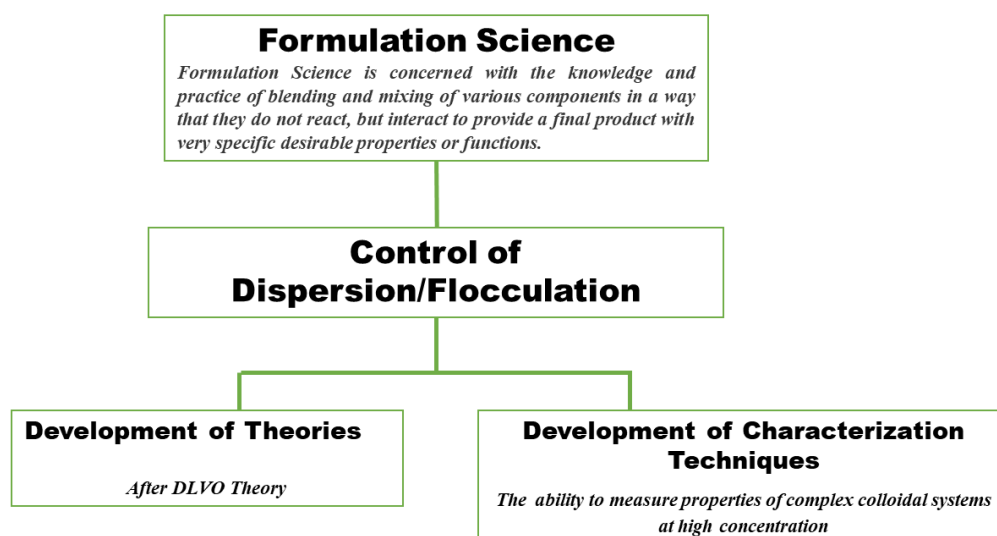
## from a Practical Point of View

○Shin-ichi Takeda (Center for Colloid and Dispersion Technology)

Practical dispersion systems include hard and soft particle systems, both of which have been widely used in the industry for a long time. Furthermore, recently, it has been widely used in fields such as energy and electronics which have not been dealt with in the conventional colloid science. Therefore, the range of application and the types of particles to be handled are diversified, and there are expectations for the development of theoretical aspects that can be utilized.

In general, mainly DLVO theory has been used to solve the problems in practical dispersion systems. Since a variety of applications associated with colloid science have increased recently, theories needed for practical dispersions are summarized in this paper. For example, 1) highly concentrated systems, 2) organic solvent or mixed solvents systems, 3) solvents consisting of non-Newtonian fluid, 4) dispersion with multiple phases etc. Discussion will be made at a talk on theoretical challenges and prospects.

From a practical perspective, we expect that the development of dispersion theory will contribute to the development of “Formulation Science”. While the basic knowledge of dispersion and emulsion systems have been known and used for many years, there are still substantial areas of developing science which will be critical to developing new, optimized, efficient products in the market. In this sense, personally, it is hoped that advances in dispersion theories and the ability to measure properties of complex colloidal systems at high concentration will develop within the framework of “Formulation Science”. The outline and the role of “the developing dispersion theories” are shown below.



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# Electrohydrodynamics of Composite Soft Particles: Fundamental and Applications

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The electrophoretic transport phenomenon refers the motion of a charged particle under the influence of an externally imposed electric field. Due to various applications ranging from basic to applied sciences, specifically for the measurement of electric properties of the charged particulate, the electrophoretic transport phenomena is studied by the worldwide researchers. The earliest works in this direction were made by Smoluchowski<sup>1</sup> and Huckel<sup>2</sup> for the electrophoresis of colloids under a thin and a thick Debye-layer limit, respectively. Later Henry<sup>3</sup> introduced a general theory for the electrophoresis when the Debye layer thickness is comparable to the particle radius. These classical theories are however, valid for an ion and fluid impenetrable rigid colloid.

There are various examples of biological and environmental entities<sup>4,5,6</sup>, synthesized nanoparticles<sup>7</sup>, etc. where the classical concept of the surface potential loses its meaning due to composite structure of these (nano)particulate systems. Such types of particles can be represented by a core-shell composite soft particle, which are comprised of inner polymeric/rigid core and is surrounded by a layer of polymeric materials. The penetration of electrolyte ions and fluid flow across the inner core and/or outer shell may depend on the electrostatic and hydrodynamic softness's of the respective regions. The electrohydrodynamics of such type of composite core-shell soft particle in extent of ionized liquid depends on various factors, including pH and concentration of the bulk medium, net amount of structural charges entrapped within the inner core and/or the outer shell, dielectric gradient mediated ion partitioning effect, Brinkman screening length of the core and/or shell, effects of ion-ion interaction, relaxation and dielectric polarization, etc. In this review article we aim to present the recent theoretical developments in the field of electrohydrodynamics of composite soft particles with an emphasis on their practical applications.

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## How I entered the world of colloid science

○Hiroyuki Ohshima†  
(Tokyo University of Science)

It is my great pleasure to talk about “How I entered the world of colloid science”.

I was originally a physics student at the University of Tokyo. But I had to change my research theme in the first year of my PhD course owing to unexpected circumstances.

### **1. Virus adsorption to bacteria as interaction between colloidal particles (Mishima 1970):**

I did experiments on the adsorption of viruses to bacteria at the National Institute of Genetics in Mishima city (where, incidentally, I was born), Japan, which was totally different from what I was doing so far. When I tried to analyze my experimental data, I came across a paper written by a famous physicist Max Delbrück. Surprisingly, he considered the virus adsorption to bacteria as physico-chemical interaction between two colloidal particles. Actually, viruses and bacteria are typical biocolloids. This was my turning point and I never came back to the world of pure physics and the world of experimental science. My PhD thesis was “Theory of electrostatic interaction between colloidal particles with constant surface charge density and its applications to interactions of biological cells”, which was published in *Colloid and Polymer Science*.

### **2. Standard theory of electrophoresis (Melbourne 1981):**

In 1981, I started my post-doc life at Prof. Tom Healy’s lab at the University of Melbourne, Australia. It was very fortunate that I had a chance to work with Dr. Lee White. He is already famous for the O’Brien-White’s electrophoresis theory. He moved to Melbourne from Canberra to join Healy’s team just at the same time as I did. I began to become familiar with theories of electrokinetics and we published several papers on this topic in *J. Chem. Soc. Faraday Trans. 2*.

### **3. Gouy-Chapman surface potential and Donnan potential (Buffalo, NY 1983):**

I moved to Prof. Shinpei Ohki’s lab at the State University of New York at Buffalo in 1983. One day Prof. Ohki asked me “How are the Gouy-Chapman surface potential and the Donnan potential of a polyelectrolyte-coated surface related to each other. We then started to consider this problem, publishing a paper on this topic.<sup>1</sup>

### **4. Soft particle electrophoresis (Tokyo 1985):**

Finally, Prof. Tamotsu Kondo offered me a position at his lab at the Tokyo University of Science in 1985. Prof. Kondo suggested me an idea that Smoluchowski’s mobility formula is applicable for a hard particle without surface structures, but a different formula should be necessary for biological cells, which can be modeled as soft particles, i.e., polyelectrolyte-coated particles. This is an important suggestion for me. This is how we started to develop the electrophoresis theory to cover soft particles by introducing the Donnan potential.<sup>2</sup>

And I continue now!

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# Investigating the formation of polyelectrolyte complexes using capillary electrophoresis: effect of polyelectrolyte charge density and molar mass

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In this work, a systematic study of the interactions between poly(L-Lysine) and variously charged statistical copolymers of acrylamide and 2-acrylamido-2-methyl-1-propanesulfonate (PAMAMPS) has been investigated by frontal analysis continuous capillary electrophoresis (FACCE)<sup>1</sup> and isothermal titration calorimetry (ITC)<sup>2</sup>. Interaction parameters (binding constant and stoichiometry) were determined by these two methods at different ionic strengths and for different PAMAMPS charge densities varying between 15% and 100%. The range of investigated ionic strengths was carefully adjusted according to the PAMAMPS charge density to get measurable binding constants (i.e. formation binding constant typically comprised between  $10^4$  and  $10^6 \text{ M}^{-1}$ ). The number of released counter-ions during the polyelectrolyte complex formation was determined from the log-log dependence of the binding constant according to the ionic strength, and was compared to the total number of condensed counter-ions estimated from the Manning theory of counter-ion condensation.

A descriptive and predictive model relating the physico-chemical properties of the two partners (chemical charge density, molar mass), the binding constant and the ionic strength is proposed in the framework of multiple independent interaction sites of equal energy. Thermodynamic parameters of the complexation between the oppositely charged polyelectrolytes confirm that the complex formation was entropically driven together with a favourable (but minor) enthalpic contribution<sup>1,2</sup>. The effect of molar of the polycation on the binding constant and on the number of released counter-ions has been studied in details by FACCE<sup>3</sup>.

The polyelectrolyte complex stoichiometry was strongly dependent on the PAMAMPS chemical charge density and on the initial polycation to polyanion molar ratio. In contrast, PEC stoichiometry was not affected by the mixing order of the two polyelectrolyte partners. A general rule capable of predicting the PEC stoichiometry (or global charge) will be presented<sup>4</sup>.

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# Engineering Science of Life and Environment Based on Colloidal Flocculation

## Profile of Speakers





**Cordelia Selomulya**

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School of Chemical Engineering  
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Australia

■ Short Biography

Prof Cordelia Selomulya joined UNSW in late 2019 as a Professor (Food & Health) in the School of Chemical Engineering and as a Research & Commercialisation Director of the Future Food Systems CRC (<https://www.futurefoodsystems.com.au>). Prior to joining UNSW, she was an ARC Future Fellow at Monash University, leading the Biotechnology and Food Engineering group with an internationally recognised reputation in particle engineering and drying technology research, particularly for food and dairy applications. She was the director of the Australia-China Joint Research Centre for Future Dairy Manufacturing, a joint strategic initiative funded by the Australian and Chinese governments, and industry partners in both countries, including Bega, Saputo Dairy Australia, Fonterra, Gardiner Foundation, COFCO, and Mengniu Dairy. At UNSW, she is continuing her work to develop new functional dairy ingredients via spray drying, in collaboration with Penn State and Soochow Universities, supported by the Australian Research Council (ARC) Discovery program. She is also collaborating with Jacobs Douwe Egberts to improve powder properties for beverage applications.



**Lester Canque Geonzon**

Postdoctoral Fellow  
Department of Food Science and Technology  
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#### ■ Short Biography

Lester Canque Geonzon is currently an advanced research post-doctoral fellow in the Department of Food Science and Technology, Tokyo University of Marine Science and Technology, under the supervision of Prof. Dr. Shingo Matsukawa. His current topic is entitled Studies on the mechanism of texture improvement by polysaccharide additions to Surimi gels using NMR and particle tracking method. His research objectives involve the characterization of the food material at different length scale perspective. His Ph.D. dissertation is focused on the elucidation of the gelation mechanism and network structure of mixed carrageenan gels using particle tracking. In the study, the gelation mechanism and structure of carrageenan gels and its mixtures were investigated at macroscopic and microscopic levels. His expertise in single-particle tracking has been translated into several publications wherein he published several papers and book chapters about the gelation mechanism and network structure of pure and mixed polysaccharide gels by particle tracking to international journals with high impact factors and presented his results in international conferences with invited presentations. International and local awards were also conferred from this stint, which includes the University President Student Excellence Award at Tokyo University of Marine Science and Technology, Best Poster Award in Innovations in Food Science and Human Nutrition 2019, Rome, Italy, and Best Oral Presentation Award in 2nd International Conference on Nanomaterials & Advanced Composites 2019, Taiwan. Dr. Geonzon was a recipient of the award for FY2020 KAKENHI (Grant-in-Aid for Early-Career Scientists Grant No. 20K1319) on his project entitled “Studies on the mechanism of texture improvement by polysaccharide additions to Surimi gels using particle tracking and NMR. Recently, he was selected as a JSPS Postdoctoral Fellowship for Overseas Researcher under the host researcher, Prof. Dr. Motoyoshi Kobayashi, at the Faculty of Life and Environmental Science, University of Tsukuba.



**Takashi Kuroiwa**

Professor  
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Tokyo City University  
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■ Short Biography

Takashi Kuroiwa received his Ph.D. in Biotechnology from University of Tsukuba (Japan) in 2005. After working at University of Tsukuba and National Food Research Institute, National Agriculture and Food Research Organization as a postdoctoral fellow, he is now professor of Faculty of Science and Engineering, Tokyo City University. His major is biochemical engineering, biomaterial chemistry, and food engineering, focusing on fabrication of functional materials via the self-assembly of biomolecules, application of advanced emulsification technology, and design of multiphase enzymatic reactions.



**Isao Kobayashi**

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■ Short Biography

Isao Kobayashi received his degrees of B.Sc. (1998) and M.Sc. (2000) in Engineering from Tokyo University of Science, and his Ph.D. degree (2003) in Agricultural Science from University of Tsukuba. He had worked as a JSPS postdoctoral research fellow at University of Tsukuba from 2003 to 2005. In fall 2005, he joined the National Food Research Institute, Japan as a research scientist. He had been a visiting research scientist at University of California, Davis from 2010 to 2011. Currently he is a principal research scientist at Food Research Institute, NARO, Japan. He is also a professor (Collaborative Graduate School Program) at University of Tsukuba. He is the author or co-author of more than 150 peer-reviewed scientific articles. His current research interests include delivery systems of nutrients and bioactive components, micro/nanofluidics, and gastrointestinal digestion of micro/nanostructured foods.



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### Education

- 2015/04 – 2018/03 Doctor's Degree (D. Eng.) in Industrial Physical Chemistry, Tokyo University of Science, Noda, Chiba, Japan
- 2003/12 – 2005/12 Master's Degree (M. Sc.) in Inorganic Chemistry, Tribhuvan University, Nepal
- 2000/11 – 2003/11 Bachelor's Degree (B. Sc.) in Chemistry, Tribhuvan University, Nepal
- 1998/09 – 2000/09 Intermediate of Science (I. Sc.), Tribhuvan University, Nepal

### Professional experience

- 2018/04 - Present Postdoctoral Fellow, Tokyo University of Science, Department of Pure and Applied Chemistry (Sakai-Sakai Lab)
- 2011/12 - 2015/04 Lecturer of Chemistry, Kathmandu University, Nepal
- 2010/05 - 2011/12 Chemistry Teacher at Kathmandu University High School Cambridge A-Level Program
- 2007/05 - 2010/05 Lecturer of Chemistry, Birat Science Campus, Biratnagar, Nepal
- 2009/04 – 2010/04 Part-time lecturer for M. Sc. level, Postgraduate Department of Chemistry, Mahendra Morang Campus, Tribhuvan University, Nepal

### Awards

- 2019 Journal of Oleo Science Best Author Award, Japan Oil Chemists' Society
- 2017 Student Award for Oral Presentation, ACOS-2017 Conference, Tokyo, Japan
- 2014 Monbukagakusho Scholarship from Japan Government's Ministry of Education, Culture, Science and Technology (MEXT)
- 2001 Prize from Tribhuvan University (Mahendra Morang Campus), for obtaining highest scores in annual examinations (2001)



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Wenfeng Tan is currently Professor of Environmental Soil Science at Huazhong Agricultural University (HZAU). He received his Ph.D degree from HZAU in 2000. During 2006-2007 he had worked as post-doctoral in Wageningen University. He is interested in the chemical and biological processes that govern the fate and transport of heavy metals and nutrients in soils. Mineral-humic substance interacts from geochemical perspective, application to nutrients and toxins in the environment and their mobility through the Critical Zone of Earth. Characterizing manganese and iron oxides surface geochemistry/biogeochemistry plays in major aspects of the earth sciences, including especially environmental issues. He was awarded National High Level Talents Special Support Plan in 2017, Outstanding Young Research Follow of Natural Science Foundation of China in 2014, and One Hundred Elitist Program of Chinese Academy of Sciences Program in 2009.



**Kamila Kydralieva**

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Kamila Kydralieva, D. Sc. (Chem). Professor of Moscow Aviation Institute (National Research University). She graduated from Kirgiz State University, Department of Physical and Colloid Chemistry. Prof. Kydralieva received her PhD in 1992 and her Doctorate in Chemistry in 2005 from the Institute of Chemistry and Chemical Technology (Kyrgyzstan). The scope of her scientific interest is: natural polymers (humic substances, pectin, chitozan), metal-containing polymers, nanomaterials. Areas of expertise include metallopolymer nanocomposites and nanomaterials. She is acting as an Past President of Russian Language Branch of the Society of Environmental Toxicology and Chemistry (SETAC), and Member of International Society of Humic Substances ([www.ihss.org](http://www.ihss.org)).





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Junyou Wang is an Associate Professor of Chemistry at the East China University of Science and Technology (ECUST). He completed his PhD in 2012 (working with Prof. Martien Cohen Stuart) and postdoctoral fellowship in 2016 (working with Prof. Aldrik H. Velders), both at the Wageningen University. He joined the faculty at School of Chemical Engineering, ECUST in 2016. His research focuses on designing functional polyelectrolyte complex micelles and nanoparticles, and exploiting their applications as soft carriers for encapsulation and delivery of proteins as diagnosis and therapy agents, and nanoreactors for enzyme catalysis. He has published more than 40 peer-reviewed papers in journals such as *Angew Chem. Int. Ed.*, *Chem. Mater.*, *Chem. Commun.* and *Macromolecules*.



**Shinichi Takeda**

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■ Short Biography

Since 1986, he has been engaged in the development of zeta potential measuring devices for electrophoresis, streaming potential, and ultrasonic methods at Okayama University. After that, he was engaged in research on characterization of highly concentrated dispersion systems, and started joint research with Columbia University in the United States in 1995. He also has been serving as an ISO international committee member from 2002. He started Takeda Colloid Techno-Consulting in 2007 as a measurement / consulting service company based on colloid science and electrokinetics. From the beginning of this year, he established the Center for Colloid and Dispersion Technology, which facilitates / promotes activities to support industrial and academic people who are working on research of practical dispersion systems.



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Dr. Partha P. Gopmandal is Assistant Professor in the Mathematics Department of the National Institute of Technology (NIT) Durgapur, West Bengal, India (December 2018- till date). Formerly he has worked as an Assistant Professor in the Mathematics Department of NIT Patna, Bihar, India (2014-18). Gopmandal did his Masters in Applied Mathematics from the University of Burdwan, West Bengal and subsequently qualified the National Eligibility Test with CSIR fellowship, to pursue the Ph. D. Thereafter, he joined in the Indian Institute of Technology (IIT) Kharagpur, India for his doctoral research (2009-13). Later, he worked in the Mechanical Engineering Department of the Washington State University, Pullman, USA, as a Post-Doctoral research associate (2013-14). Gopmandal has research interest in the area of colloid and interface science, including theoretical and computational modelling. His research mainly focuses on (a) Electrophoresis and sedimentation of various type of bioparticles, (b) Modulation of electroosmotic flow through microfluidic devices, (c) Streaming potential mediated energy conversion through engineered nanochannel. His has published 35+ papers in International Journals of high repute.



**Hiroyuki Ohshima**

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Hiroyuki Ohshima is Professor Emeritus of the Tokyo University of Science, Japan. He received the B.S. (1968), M.S. (1970), and Ph.D. (1974) degrees in physics from the University of Tokyo. He spent his post-doc life at University of Melbourne (1981-1983), State University of New York at Buffalo (1983-1984), and University of Utah (1984-1985). He is the author of “Theory of Colloid and Interfacial Electric Phenomena (Elsevier, 2006), “Biophysical Chemistry of Biointerfaces” (Wiley, 2010), and “Encyclopedia of Biocolloid and Biointerface Science” (Wiley, 2016), and over 350 book chapters and journal publications reflecting his research interests in colloid and interface science (especially, theoretical studies on electrokinetics and electrostatic interactions of colloidal particles). He has been editing Colloid and Polymer Science since 2002. In 2016, Ohshima was awarded the 29th Khwarizmi International Award by the Iranian Research Organization for Science and Technology for his contribution to the theory of colloid and interfacial electric phenomena. In 2017, he was selected as one of Asia's top 100 scientists for 2017 (The Asian Scientist Magazine, June 2017).



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- Sept. 2007- Present    Professor (Classe exceptionnelle from dec. 2016) at the University of Montpellier (Institut Universitaire Technologique de Montpellier, Chemistry Department)  
Research at the Institut des Biomolécules Max Mousseron, UMR CNRS 5247, University of Montpellier, CNRS  
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