IMBA International MARINE BIOTECHNOLOGY Association Established 1989

IMBA symposium

Biomaterials from the Sea

Friday, September 23 2022

Virtual

8:00am- 10:00am EDT

Convener: Dr. Song Qin
President, IMBA

Register Here

Marine biodegradable biomaterials: potential and challenges | **Wei Zhang | Ph.D | Flinders University**

Polyphosphate nanoparticles: a marine biomimetic product with an unprecedented regeneration accelerating activity | **Werner Mueller | Ph.D | University Mainz**

Marine Biotechnology for Material Research | **Tadashi Matsunaga | Ph.D | JAMSTEC & Tokyo University of Agriculture and Technology**

Flash Talks by Graduate Students & Junior Scientists

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Agenda

Intro and Main Speakers

8:00-8:10 Song Qin

8:10-8:35 Wei Zhang

8:35-8:40 Q&A

8:40-9:05 Werner Mueller

9:05-9:10 Q&A

9:10-9:35 Tadashi Matsunaga

9:35-9:40 Q&A

Flash Talks by Graduate Students/Junior Scientists

9:40-9:50 Atsushi Arakaki

9:50-9:55 Yu Wang

9:55-10:00 Zhenzhen Deng

See profiles&abstracts below.

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Marine biodegradable biomaterials: potential and challenges

Wei Zhang

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Centre for Marine Bioproducts Development, Flinders University, Australia
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Globally petrochemical-based polymer industry uses about 80% of all the non-fuel chemical by weight, which has produced a cumulative 8.3 Gt of plastics and 6.3 Gt of plastic waste by 2015. Majority of these plastics are difficult to degrade and often take longer than 100 years to fully decompose. In addition, it is the world's top 5 biggest climate polluter. The demand in replacing these non-degradable, non-renewable fossil-fuel based plastics by biodegradable is gigantic and urgent. Renewable biomass-based and biodegradable biomaterials have been suggested as a solution, but their potential has not been realised with only 0.75% of the global polymers market.

In searching these biodegradable biomaterials, the ocean hosting at least 250,000 marine species, presents a vast reservoir of natural biopolymers with extraordinary properties. These marine biopolymers include proteins (e.g. collagen and gelatine), polysaccharides (e.g. chitin, chitosan, cellulose, alginate), and lipids (e.g. long-chain fatty acids), often as composite biomaterials with minerals. The nature has evolved with many enzymes that are capable of rapidly degrade these biopolymers such as hydrolases and lyases. However, this area of research and development is relatively underexplored, present a great opportunity for both science and industry.

This presentation will give an overview of marine biodegradable biomaterials, their potential and challenges. We will use our own research as case studies especially in the developing biodegradable biomaterials from seaweeds for applications in agriculture, food packaging, textile, and medical industries.

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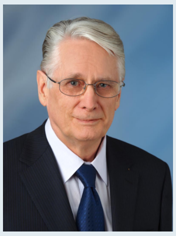
Polyphosphate nanoparticles: a marine biomimetic product with an unprecedented regeneration accelerating activity



Werner E. G. Müller

ERC Advanced Investigator Grant Research Group at the Institute for Physiological Chemistry, University Medical Center of the Johannes Gutenberg University Mainz, Germany. E-mail addresses: wmueller@uni-mainz.de

Inorganic polyphosphate (polyP) is the oldest chemical energy-providing molecules in biological systems. This polymer, existing in large concentrations in marine organisms, contains a much longer sequence of high-energy phosphate units than the universal energy donor adenosine triphosphate (ATP). It has attracted increasing attention for potential biomedical applications because of its diverse metabolic and regulatory functions and its ability to form biologically active nano/microparticles.

In its particulate form, polyP is not biologically active but these particles easily transform into a coacervate form in which polyP becomes biologically active. polyP can be easily combined with other materials used in tissue engineering, e.g. for the production of bioprintable bioinks (even for cell printing) or for stable polymers such as polymethacrylate of polycaprolactone. In this way, the material could be applied not only as a filler, but also for the fabrication of larger mechanically more stable implants. In addition, together with other negative polyanions, polyP is able to self- organize in the presence of divalent cations to polymer bundles stabilized by Ca^{2+} bridges. Likewise, polyP nano/microparticles can be synthesized in situ from polyP and can be incorporated into hydrogels.

Through the selection of suitable hydrogel-forming polymers and controlled hardening via calcium ions, hybrid biomaterials of defined porosity and mechanical properties can be fabricated, which are not only morphogenetically active, i.e. capable of promoting cell growth, differentiation and migration via, but also provide the cells with the energy needed for their function, including those processes which proceed in the extracellular space.

Marine biotechnology for material research

Tadashi Matsunaga

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Marine science and technology have recently developed. However, marine microorganisms and microalgae have not largely unexplored even if they have big potentials for material, energy and food.

Nano-sized magnetic particles offer vast potential in ushering new nano-techniques as they can be easily manipulated by magnetic force. Magnetic bacteria synthesize nano-sized bio magnetite, otherwise known as bacterial magnetic particles that are individually enveloped by a lipid bilayer membrane. Bacterial magnetic particles are ultrafine magnetite crystals (50-100 nm diameters) with uniform morphology produced by *Magnetospirillum magneticum* AMB-1. The molecular mechanism of bacterial magnetic particle synthesis is a multi-step process which includes vesicle formation, iron transport and magnetite crystallization, and the elucidation of its mechanism by genomic, proteomic, and bioinformatic approaches has been conducted.

Ability to convert CO_2 into useful materials by marine microalgae increased interest in their use for carbon dioxide emissions reductions. Now, we face the third challenge in biofuel development; countermeasure against escalating oil prices and toward the prevention of global warming. Recent biofuel development has been more focused on technologies directly related to the business or industrial sector, biodiesel, bioethanol or bio ETBE (ethyl tertiary-butyl ether). Marine diatom, *Fistulifera solaris*, produced 65% oil. The oil is mainly triacyl glycerol and main fatty acids are C16:0, C16:1 & C20:5.

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Adsorption of biomineralization protein to inorganic materials and its relationship with crystal formation

Atsushi Arakaki

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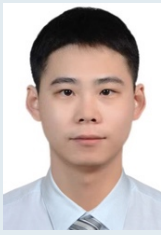
Nature has evolved sophisticated strategies via biomineralization processes to synthesize functional inorganic materials. Most biomineralization processes occur under ambient physiological conditions, often templated or guided by proteins. We have previously identified a group of unique protein named as Mms from the surface of iron oxide biomineral of magnetotactic bacteria. The protein plays an important role in regulating magnetite crystal morphology. Here, we show a direct adsorption ability of Mms on magnetite nanoparticles in vitro. An adsorption isotherm indicates that Mms has high adsorption affinity to magnetite nanoparticles. In addition, Mms also demonstrated adsorption on other inorganic nanoparticles such as titanium oxide, zinc oxide, and hydroxyapatite. In this presentation, we would like to discuss about role of the identified function in magnetite crystal formation in the bacteria.

Magnetosomes: the coastal originated magnetic nanoparticles for biomimetic applications



Yu Wang, Song Qin*

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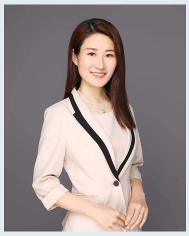
Magnetotactic bacteria (MTBs) were first isolated from the mud sediment of the coastal zone and are the simplest and oldest species capable of moving according to the external magnetic field. Fe_3O_4 particles in MTB, namely magnetosomes (MSs), are the key cellular structure during magnetotaxis. They have attracted attention for magnetic biomedical applications because the design of effective drug distribution and controllable drug release are important research directions in cancer therapy.

MSs extracted from *Magnetospirillum magneticum* (AMB-1) are single domain magnetism and have more coercive force than superparamagnetism or multidomain magnetism, which means they can generate much more heat in the alternative magnetic field for tumor thermotherapy. In our research, we synthesized a fatty alcohol derivative (FAD) that could coat AMB-1 originated MSs. Through the optimization of the preparation process, aseptic FAD coated MSs (FAD-MSs) were prepared. It’s worthy to point out that FAD-MSs had little toxicity for cells at administered concentration, whereas they showed remarkable toxicity in vitro when they are accumulated to certain concentrations. Experimental results also showed that most of FAD-MSs could be passively transported to the livers of mice. We will continue the evaluation of FAD-MSs that might have the potential application as a thermotherapy medium against hepatoma cells in the liver with the help of an external magnetic field.

Combination of fucoidan-based magnetic nanoparticles promote macrophages polarization and enhance miRNA tumor- targeted therapy

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The abnormal tumor microenvironment of pancreatic cancer (PC) is a key factor promoting tumor development, among which tumor-associated macrophages (TAMs) account for more than 50% of tumor immune cells. It plays a key role in tumor growth, invasion, migration and drug resistance. Therefore, immunotherapy targeting TAMs is a very promising therapeutic strategy, which may bring new breakthroughs in the treatment of PC. Fucoidan is a kind of polysaccharide which contains fucose and sulfate group. In this study, Fucoidan (LF2) was used as the carrier to co-react with miRNA coated with nano-iron oxide, aiming to construct a drug delivery system with dual effects of tumor targeting, improving tumor microenvironment and killing tumor cells.

Fuc-miRNA NPs nanoparticles were constructed by co-reaction of LF2 as immune enhancer with miRNA coated with nano-sized iron oxide. The average particle size of the nanoparticles was 117 nm, and the nanoparticles were uniformly dispersed in aqueous solution and presented stable solution system. It was found that Fuc-miRNA NPs significantly promoted the M1 phenotypic transformation of macrophage. Further studies found that Fuc- miRNA NPs released miRNAs in vivo and in vitro, and played a targeted role in inhibiting tumor growth. In vivo experiments showed that Fuc-miRNA NPs significantly inhibited tumor growth and effectively reduced TMAs infiltration in mice.

In conclusion, the Fuc-miRNA NPs could not only target tumors and improve tumor microenvironment, but also inhibit tumor growth by targeting oncogenes, which provides a new therapeutic strategy for the systematic treatment of PC.