Welcome to the 6th annual CEPA conference!

The biggest event on the Chemical Engineering Postgraduate Association (CEPA) calendar each year, the CEPA conference brings together the diverse research areas encompassed by the Chemical Engineering department in a single event. In doing so, it hopes to foster the exchange of ideas between these different research areas, and a greater understanding of both the depth and breadth contained within the department.

For many here today, it is a chance to understand the research areas of their fellow colleagues, and in many cases to also present their research in turn. For others, it is their first experience presenting their work in a conference format, and an opportunity to refine their presenting skills before presenting their work on a bigger stage.

On behalf of the CEPA committee we would like to thank you for attending the conference, and especially extend our gratitude for those who have chosen to present their research during this event.

Sincerely,
CEPA committee
## ORAL PRESENTATION

### SESSION A – Lecture Theatre S1

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<tr>
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<td>Plenary session by A/Prof Mathew Hill</td>
<td>Lecture Theatre S1</td>
<td>1</td>
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<tr>
<td>09:30</td>
<td><strong>Functional Nanomaterials</strong></td>
<td>Chair: Amlan Chakraborty Targeted gold nanorods for smart theranostic applications in In Vitro and Pre-clinical studies Ramya Chandrasekaran**</td>
<td>3</td>
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<tr>
<td>09:55</td>
<td><strong>Bifunctional Particles For Bio-sensing And Mechanical Sensing Application</strong></td>
<td>Chair: Lim Wei Yap**</td>
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<tr>
<td>10:20</td>
<td><strong>Two-dimensional Plasmonic Nanoparticle Superlattices</strong></td>
<td>Chair: Qianqian Shi*</td>
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</tr>
<tr>
<td>10:45</td>
<td><strong>Highly Durable Wearable Biomedical Sensors based on Ionic Liquids</strong></td>
<td>Chair: Yan Wang*</td>
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<tr>
<td>11:10</td>
<td>Morning Tea</td>
<td>Foyer area outside S1 – S4</td>
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<tr>
<td>11:40</td>
<td><strong>Multifunctional Nanoparticles for Delivery of siRNA</strong></td>
<td>Chair: Dao Lam</td>
<td>8</td>
</tr>
<tr>
<td>12:05</td>
<td><strong>Novel 2D Hybrid MOF/Graphene Oxide Seeding for Synthesis Ultrathin Molecular Sieving Membranes</strong></td>
<td>Upulie Divisekera**</td>
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<tr>
<td>12:30</td>
<td><strong>Recyclable Nanofibre Composites as Excellent Barriers in Packaging Sector</strong></td>
<td>Yaoxin Hu</td>
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<tr>
<td>12:55</td>
<td><strong>Controllable Growth of Zeolitic Imidazolate Framework Composite Membranes for Gas Separation</strong></td>
<td>Uthpala Garusinghe</td>
<td>13</td>
</tr>
<tr>
<td>13:20</td>
<td>Lunch and poster presentation</td>
<td>Foyer area outside S1 – S4</td>
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</tr>
<tr>
<td>14:20</td>
<td><strong>Surface, Colloidal Science and Molecular Rheology</strong></td>
<td>Chair: Siddhartha Shrestha</td>
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<tr>
<td>14:45</td>
<td><strong>Building Dual-Scale Roughness Using Inorganic Fillers for Super-Hydrophobic Paper</strong></td>
<td>Xue Zhang</td>
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</tr>
<tr>
<td>15:10</td>
<td><strong>Advancement of Paper-Based Microfluidics for Diagnostics – The Original Motivation and Current Status</strong></td>
<td>Weirui Tan</td>
<td>18</td>
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<tr>
<td>15:35</td>
<td><strong>Cellulose Aerogel with Double-Layer Structure for Oil/Water Separation</strong></td>
<td>Zhiyong He**</td>
<td>19</td>
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<tr>
<td>16:00</td>
<td>Refreshment and announcement of winners</td>
<td>4th Floor Lounge, New Horizons Building</td>
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*Mid-candidature

**Pre-submission
## SESSION B – Lecture Theatre S2

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<td></td>
<td>Lecture Theatre S1</td>
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<td>11:10</td>
<td>Morning Tea</td>
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<td></td>
<td>Foyer area outside S1 – S4</td>
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<tr>
<td>11:40</td>
<td>Simulation and Computational Techniques</td>
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<td></td>
<td><strong>Chair: Thilina Gunawardhana</strong></td>
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<tr>
<td></td>
<td>Finite Element Investigation of Dense Granular Flow in Shear Cells</td>
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<tr>
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<td>Qi Luo</td>
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<tr>
<td>12:05</td>
<td>Investigation on Plug Formation of Coarse Particles with a Draft Tube Feeder by CFD-DEM Coupling Method</td>
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<td>He Zhang</td>
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<tr>
<td>12:30</td>
<td>DEM Study on the Flow of Ellipsoids in a Rotating Drum</td>
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<td>Siyuan He</td>
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<tr>
<td>12:55</td>
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<tr>
<td>13:20</td>
<td>Lunch and poster presentation</td>
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<tr>
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<td>Foyer area outside S1 – S4</td>
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<tr>
<td>14:20</td>
<td>Simulation and Computational Techniques</td>
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<tr>
<td></td>
<td><strong>Chair: Kahlil Desai</strong></td>
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<tr>
<td></td>
<td>Zheng Qi*</td>
</tr>
<tr>
<td>14:45</td>
<td>CFD Modelling of Pneumatic Conveying of Powder Through Various Pipelines</td>
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<tr>
<td></td>
<td>Zhen Miao*</td>
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<tr>
<td>15:10</td>
<td>CFD Investigation of the Injection of Victorian Brown Coal into an Ironmaking Blast Furnace</td>
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<td>Junhai Liao*</td>
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<tr>
<td>15:35</td>
<td>Modelling and Analysis of The Multiphase Flows in Hydrocyclones</td>
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<tr>
<td></td>
<td>Li Ji**</td>
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<tr>
<td>16:00</td>
<td>Refreshment and announcement of winners</td>
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<td>4th Floor Lounge, New Horizons Building</td>
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*Mid-candidature  
**Pre-submission
**SESSION C– Lecture Theatre S3**

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<th>Session</th>
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<tr>
<td>09:00</td>
<td>Plenary session by A/Prof Mathew Hill</td>
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<tr>
<td>09:30</td>
<td><em>Food and Pharmaceutical Engineering/ Biotechnology / Biorefining / Functional Biomaterials</em></td>
<td><em>Huadong Peng</em></td>
<td>Negin Amini* Microwave Assisted Xylan and Lignin Removal from Eucalyptus</td>
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<tr>
<td>09:55</td>
<td>Immunogenicity and Biodistribution Of Nanoparticles In Vivo</td>
<td><em>Peter Tsirikis</em></td>
<td>Peter Tsirikis**</td>
</tr>
<tr>
<td>10:20</td>
<td>Creating Tuneable Agglomerates via 3D Printing</td>
<td><em>Ruihuan Ge</em></td>
<td></td>
</tr>
<tr>
<td>10:45</td>
<td><strong>Morning Tea</strong></td>
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<tr>
<td>11:10</td>
<td>morning Tea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:40</td>
<td><em>Food and Pharmaceutical Engineering/ Biotechnology / Biorefining / Functional Biomaterials</em></td>
<td><em>Joel Samsu</em></td>
<td>Liam Powles Vaccine Carrier Design: Iron Oxide Nanoparticle Synthesis and</td>
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<tr>
<td></td>
<td><strong>Immunomodulatory Role of Functionalized Nanoparticles on Antigen Presenting Cells</strong></td>
<td></td>
<td>Interactions with Antigen Presenting Cells</td>
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<tr>
<td>12:05</td>
<td><strong>Production of High Value Oleochemicals Using Cyclopropane Fatty Acid Synthase Biocatalysts</strong></td>
<td><em>Melissa Mace</em></td>
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<tr>
<td>12:30</td>
<td>Improving the Mixing Process of Dry Powder Inhaler Formulations with the Iron Oxide Colour Method</td>
<td><em>Amlan Chakraborty</em></td>
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</tr>
<tr>
<td>13:20</td>
<td><strong>Lunch and poster presentation</strong></td>
<td></td>
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<tr>
<td>14:20</td>
<td><strong>Energy and Fuels, Biorefining and Sustainable Processing</strong></td>
<td><em>Craig Osborne</em></td>
<td>Baiqian Dai Reactivity of Victorian Brown Coal CO₂ Gasification</td>
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<tr>
<td>14:45</td>
<td>Non-catalytic and catalytic pyrolysis of automotive shredder residue (ASR): In-situ Synchrotron Infrared microscopy</td>
<td><em>Isha Kohli</em></td>
<td>(FT-IR) and Thermogravimetric analysis coupled with infrared spectroscopy</td>
</tr>
<tr>
<td>15:10</td>
<td>Novel Ferulic Acid Esterase from Fibrobacter Succinogenes for Biomass Pretreatment</td>
<td><em>Cameron Hunt</em></td>
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<tr>
<td>15:35</td>
<td>Nickel-Molybdenum-Phosphide Nanowires for Efficient Electro-Catalytic Hydrogen Generation in Both Acidic and Alkaline Media</td>
<td><em>Yang (Daisy) Wang</em></td>
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<tr>
<td>16:00</td>
<td><strong>Refreshment and announcement of winners</strong></td>
<td></td>
<td><em>Mid-candidature</em></td>
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*Mid-candidature
**Pre-submission
POSTER PRESENTATION

EVALUATION OF LIPID STORAGE IN GENETICALLY ENGINEERED YEAST BY FLOW CYTOMETRY
Huadong Peng

REAGENTLESS FLUORESCENCE BIOSENSOR FOR CONTINUOUS ANALYTE MONITORING
Jiaul Islam

Growth of Graphitic carbon nitride nanosheet on TiO$_2$ mesoporous spheres with highly improved photocatalytic activity under visible light irradiation
Xiaofang Chen

CAN CARRAGEENAN IMPROVE THE FAT ENCAPSULATION EFFICIENCY IN MILK POWDER PRODUCTION?
Martin Foerster

Ultrathin two dimensional MOF nanosheets: Towards a high-performance molecular sieving membrane
Meipeng Jian

ENGINEERING NANOCELLULOSE GELS
Llyza Mendoza

INVESTIGATION OF MODIFIED ORGANOSILICA CORE-SHELL NANOPARTICLES FOR STABLE PH SENSING IN BIOLOGICAL ENVIRONMENTS
Kye Robinson

NOVEL ADSORBENT-CELLULOSE FIBRE COMPOSITES FOR LIQUID FILTRATION
Aysu Onur
Pathways to Leadership in Scientific Innovation
Matthew R. Hill

Department of Chemical Engineering, Monash University

Improved efficiency and sustainability in the way we use our limited resources are crucial factors across many industry sectors.

Metal Organic Frameworks (MOFs), made up by joining metal atoms with organic linkers forming an array similar to a building scaffold, are the world’s most porous materials – they are almost entirely made of holes. One teaspoon of MOF may have as much surface area as an entire football field hidden inside it.

Like a sponge, the pore surfaces can store and release substances on demand, such as fertilisers or fuels, or, like a sieve, the uniform pore sizes can be used to separate one thing from another, such as natural gas from impurities or carbon dioxide from an exhaust stream.

Career development in this area is often seen as quite unconventional. This presentation will offer some perspectives on things that might help in this difficult pathway.

MOFs are finding use in situations where higher performance from less material is crucial.
Biography

Associate Professor Matthew Hill is an Australian Research Council Future Fellow and the Winner of a 2014 Australian Prime Minister’s Prize for Science. Matthew leads an interdisciplinary team of researchers that are actively involved with industry partners to bring exciting discoveries in the laboratory to market.

Recent publications

Targeted gold nanorods for smart theranostic applications in *In Vitro* and Pre-clinical studies

Ramya Chandrasekaran¹, Kylie M. Wagstaff², Bock Lim³, Karlheinz Peter³, David Jans², and Wenlong Cheng¹

¹Cheng Nanobionics Group, Department of Chemical Engineering, Monash University, Clayton.
²Jans Lab, Department of Biochemistry and Molecular Biology, Monash University, Clayton.
³Baker IDI Heart and Diabetes Institute, Melbourne.

Extended Abstract

Introduction

Considering the fact that tumor cells arise from normal cells and hence have similar genotype, highly specific molecular recognition towards tumor cells is necessary to ensure a treatment that does not affect the surrounding healthy cells in the tissue cell population. The available cytotoxic chemotherapeutic agents remain elusive in this fact and recent developments in terms of plasmonic nanoparticles capable of photothermal killing have some promise when targeted to tumor cells. Targeting moieties like antibodies, folic acid, peptides have been used for active targeting but none of these are truly tumor specific as their epitopes are usually expressed in normal cells, but to a lesser extent. In this work, we have made novel, tumor biomarker specific DNA aptamer-tethered gold nanorods (GNRs) and for the first time we have used isogenic tumor and normal cells for direct comparison to ensure high tumor specificity of our aptamer.

Over a period of time, the tumor cells develop resistance to chemotherapy used in clinics, which has to be prevailed over by using a combinatorial therapy. Such a combinatorial therapy can use photothermal property of plasmonic nanoparticles and chemo delivery through them. Especially, the unique plasmonic properties of gold nanorods enable them to be used as a theranostic agent for image guided therapy. Here we describe novel DNA aptamer-tethered gold nanorods (GNRs) modified with a thermosensitive pNIPAM polymer layer that act as efficient drug delivery vehicle to tumour cells, but not to their isogenic normal cell counterparts. We have demonstrated the loading of a model drug, Calcein into the GNR-pNIPAM nanocapsule and its release upon increase in temperature causing the shrinkage of the polymer. During in vitro studies, we were able to trigger the release of calcein through the photothermal effect from GNRs, only inside the tumor cells, as the nanocapsule is directed by the aptamer to the tumor cells whereas very minimal drug release was observed in normal cells. When Dox was released using similar mechanism to achieve combinatorial therapy, it induced a pronounced cell death (>90%) in tumor cell population but not in normal cell, validating the specificity of our aptamer for breast tumor cells. Through in vivo studies, we have established our aptamer targeted GNR-pNIPAM nanocapsule as a contrast agent for CT imaging. These nanocapsules after accumulating in the tumor site could be activated with a NIR laser for photothermal therapy which in turn could cause the drug release from the thermosensitive polymer shell. This demonstrates the
significant potential of our Apt-GNR/pNIPAM nanocapsule as a specific and selective theranostic agent to treat breast cancer through image guided therapy in clinical settings.

**Materials and Experimental**

**Synthesis and Functionalization of GNRs with Aptamers**

The seed solution was prepared by mixing 5 mL of CTAB with 100 μL of HAuCl₄ solution. 600 μL of NaBH₄ was added to the mixture while 5 mL of the CTAB was added to 5 mL of HAuCl₄ in a separate tube. To this 200 μL of AgNO₃ solution and 80 μL of Ascorbic acid solutions were added. Finally, 12 μL of the seed solution was added to this solution. To the prepared GNRs, 1 mL of mPEG-SH solution was added followed by addition of the 100 μL of thiolated KW16-13 Apt which was deprotected using tris (2-carboxyethyl) phosphine (TCEP) solution.

Synthesis and Functionalization of GNR/pNIPAM nanocapsule

GNRs were prepared as described above. The excess CTAB was removed using centrifugation at 700 rpm for 10 mins and mesoporous silica was coated using Ethanol/Ammonia and 200 μL of TEOS. The Silica layer was modified with silane coupling agent and then pNIPAM shell was formed using 28 mg NIPAM, 2.8 mg BIS and 10 mg KPS. The pNIPAM chains were modified with a chain transfer agent called 11-MUA to functionalize them with the KW 16-13 aptamer.

**Results and Discussions:**

The KW16-13 when attached to GNRs, directed the complex to tumor cells exhibiting strong internalisation by them with minimal uptake by the normal cells. Upon near infrared (NIR) light irradiation for plasmonic photothermal therapy, tumour cell death of > 96%, could be effected, compared to < 1% in the normal cells or cells incubated with GNRs alone, our KW16-13 aptamer-targeted GNRs thus showing >71-fold tumor cell death than GNRs-targeted with a previously described aptamer. The cell viability assessment through flow cytometry further confirmed the photothermal efficiency of KW16-13-GNRs which showed <71% cell death in the tumor cells. This demonstrates the significant potential for Aptamer functionalised-GNRs to be used effective and above all selective anti-cancer photothermal therapeutics.

The Dox loaded GNR-pNIPAM nanocapsule induced <90% cell death in tumor cells while only minimal death in normal cells. Through in vivo studies, we have established our aptamer targeted GNR-pNIPAM nanocapsule as a contrast agent for CT imaging.

**Biography**

Ramya Chandrasekaran completed Master’s in Nanomedical Sciences from India.
BIFUNCTIONAL PARTICLES FOR BIO-SENSING AND MECHANICAL SENSING APPLICATION
Lim Wei Yap\textsuperscript{1,2,3}, Yonggang Zhu\textsuperscript{2,3}, Wenlong Cheng\textsuperscript{1,3*}

\textsuperscript{1} Department of Chemical Engineering, Monash University, Clayton, VIC 3800, Australia
\textsuperscript{2} CSIRO Manufacturing, Private Bag 10, Clayton South, VIC 3169, Australia
\textsuperscript{3} The Melbourne Centre for Nanofabrication, 151 Wellington Rd., Clayton, VIC 3168, Australia

Abstract

Synthetic progress in wet chemistry synthesis of plasmonic nanoparticles provides a rational route to engineer their sizes and shapes, formulating so-called plasmonic periodic table. Control over self-assembly of these plasmonic atoms allows for fabrication of unique SERS substrates which are soft and elastic enabling direct identification of chemicals sitting on topologically complex surfaces or satellite SERS particles. Satellite SERS particle can be designed and fabricated into multifunctional particles by utilizing multicomponent hybrid nanostructures, in particular involving a combination of magnetic and plasmonic properties. In this PhD work, I’ve focused on designing a bifunctional metal-metal oxide Fe\textsubscript{3}O\textsubscript{4}@AuNPs@Ag particle. The bifunctional particles were then synthesized, applied and enhanced for biosensing in microfluidic platform developed in CSIRO microfluidic lab to improve the assay time and binding specificity. With extensive tuning on plasmonic particle size, fluid flow and mixing time, these particles were demonstrated to achieve low limit of detection of rabbit Immunoglobulin G antibody with improved binding specificity compared to conventional non-microfluidic immunoassay.

In another application, I’ve used this bifunctional particle for mechanical sensing. To do this, I’ve grown gold nanowires (AuNWs) on Fe\textsubscript{3}O\textsubscript{4} particle. After the growth, this particle became a three dimensional conductive percolation network which can be useful in pressure sensing applications. I have also explored the ability of using this particle in fabrication of sensors for other mechanical sensing application such as strain, wind and magnetic field sensing.

Biography

Lim Wei Yap received his Bachelor degree in Chem. Eng. from Monash University and is currently a third year PhD student in the Department of Chemical Engineering at Monash University under the supervision of Prof Wenlong Cheng and Prof Yonggang Zhu. His research interests include design and fabrication of nanoparticles with multiple functionality for applications in bio-sensors, mechanical sensors and wearable electronics.
TWO-DIMENSIONAL PLASMONIC NANOPARTICLE SUPERLATTICES
Qianqian Shi 1,2, Kae Jye Si 1,2, Debabrata Sikdar 3, Lim Wei Yap 1,2, Malin Premaratne 3, and Wenlong Cheng 1,2,*

1Department of Chemical Engineering, Faculty of Engineering, Monash University, Clayton 3800, Victoria, Australia.
2The Melbourne Centre for Nanofabrication, 151 Wellington Road, Clayton 3168, Victoria, Australia.
3Advanced Computing and Simulation Laboratory (AxL), Department of Electrical and Computer Systems Engineering, Faculty of Engineering, Monash University, Clayton 3800, Victoria, Australia.

Abstract

Nanoparticle superlattices represent a new class of advanced metamaterials which have exhibited unusual optical, electrical, plasmonic, magnetic and mechanical properties. In particular, two-dimensional (2D) ordered plasmonic nanoparticle arrays can take full advantage of the shape-dependence, spatial arrangement, and directional properties of the nanoparticle. The properties of these superlattice sheet can be adjusted by controlling the nanoparticle size and adjusting the interparticle spacing, changing the shape of the constituent nanoparticles and further tuning their orientations. In principle, any plasmonic particles in the “artificial nanoparticle periodic table” could be used as constituent elements towards the fabrication of superlattice solids. However, only a few plasmonic nanoparticles have been successfully utilised in nanosheets fabrication due to the extreme difficulties in controlled self-assembly, limiting the further application of 2D superlattice. Here, by using of a new plasmonic element – gold nanobipyramid (Au NBP) as building blocks, we fabricated a new type of plasmonic nanoparticle superlattice, which showed four distinct orientational packing orders, corresponding to horizontal alignment, circular arrangement, slanted alignment and vertical alignment of constituent particle building elements. The orientational packing ordering directly influenced plasmonic coupling strength and modes, hence, determined the surface-enhanced Raman scattering (SERS) enhancements of plasmonic superlattices. In particular, vertical alignment structures showed the highest Raman enhancement factor, which was about 77-fold greater than the horizontal alignment arrays and about 19-fold greater than circular arrangement. The results reveal the nature and significance of orientational ordering in controlling plasmonic coupling and SERS enhancements of ordered plasmonic nanoparticle arrays.

Biography

Qianqian Shi, finished bachelor and master degree in South China University of Technology, China; now is a PhD student in Wenlong Cheng’s group, works on the project of assembly of nanoparticles into 2D superlattice.
Highly Durable Wearable Biomedical Sensors based on Ionic Liquids

Yan Wang1,2, Stephen. J. Wang5,6, George. P. Simon2,4, Wenlong Cheng1,2,3,5,6

1Department of Chemical Engineering, Monash University, Clayton, Victoria 3800, Australia;
2New Horizon Research Centre, Monash University, Clayton, Victoria 3800, Australia;
3The Melbourne Centre for Nanofabrication, Clayton, Victoria 3800, Australia;
4Department of Materials Science and Engineering, Monash University, Clayton, Victoria 3800, Australia;
5International Tangible Interaction Design Lab, Monash University, Clayton, Victoria 3800;
6Department of Art Design & Architecture, Monash University, Caulfield, Victoria 3145.

Abstract

An ideal wearable electronic product requires the integration of outstanding optoelectronic properties with high mechanical compliance into a single materials system, which can function while being pressed, bent, twisted and stretched. The incorporation of inorganic materials into elastomeric polymers represents a promising strategy but often experiences material delamination and/or local fracturing in inorganic components due to their mechanical mismatch. Here, we describe an entirely ionic liquid (IL)-based approach to fabricate rubber band-like, stretchable strain sensor, which can circumvent these limitations. Non-volatile and flow properties allow us to simply to ‘fill and seal’ microchannel fabricated by 3D printing to obtain lightweight, waterproof, thermal-sensitive wearable sensors. Despite the simplicity in fabrication, the sensors show outstanding performance, including tuneable sensitivity, detection of a wide range of strains (0.1% - 500%), high durability (little change in signal-to-noise ratios after 6 month storage under ambient conditions), excellent long-term stability of 50,000 life cycles under both low (5%) and high (100%) strain. We further show that our IL-based sensor can accurately identify wrist pulses, and can be woven with commercial rubber bands into colourful bracelets for hand gesture detection, and seamlessly interface with wireless circuitry for detecting cervical movements.

Biography

Joined in Wenlong Cheng’s group as postgraduate student in September 2014. Research project focuses on stretchable electronics based on ionic liquids and 3D printing.
MULTIFUNCTIONAL NANOPARTICLES FOR DELIVERY OF siRNA
Upulie Divisekera1,2, Ramya Chandrasekheran1,3, Yi Chen4, Kerry Hourigan5, Christina Cortez-Jugo2 and Wenlong Cheng1

1Cheng Nanobionics Group, Department of Chemical Engineering, Monash University, Clayton
2Caruso Group, Department of Chemical Engineering, University of Melbourne
3Department of Biochemistry, Monash University
4South Eastern University, China
5Director, Division of Biological Engineering, Monash University

Extended Abstract

Introduction
The efficient and targeted delivery of therapeutic agents into cells is an important pharmacological challenge [1]. We seek to address this problem via the engineering of multivalent nanoparticle delivery systems to deliver gene therapy in the form of short interfering RNAs (siRNA) [2]. Here, we report the construction of siRNA conjugates generated siRNA to cells overexpressing these genes through passive and active delivery. First, the pore-forming protein Listeriolysin O [3] is successfully conjugated to amine-modified siRNA. Second, we engineered multivalent gold nanoparticles to attach biomolecules. siRNA was attached to modified gold nanoparticles through a reversible cross linker. Particles were engineered to specifically target cancer cells through the addition of aptamer attached to the multivalent surface. Third, poly-N-isopropyl acrylamide (PNIPAM) particles were loaded with siRNA and gold nanoparticles to deliver siRNA to cells using photothermal therapy.

Materials and Experimental
siRNAs targeting luciferase were custom generated by Sigma with amine modification on the 5’ end. siRNAs were conjugated to LLO proteins at a ratio of 1:20 using SPDP polylinker (Pierce) [4]. Efficacy of conjugates was tested by treatment of HEK 293 luc cells (ATCC), knockdown of luciferase expression was determined by luminescence assay. Toxicity was determined by Alamar Blue assay.

Citrate-stabilised gold nanoparticles were generated using previously described methods and stabilised with PEG-S (Nanocs)[6]. Particles were treated with 1,8 octanedithiol (ODT, Sigma) to provide anchoring for modified siRNAs. siRNA was treated as before with SPDP (Pierce) before being added to ODT-modified gold particles. Particles were then treated with thiol-modified aptamer. Particles were characterised by absorbance spectra, gel shift assay. To test that the
particles could deliver siRNA to cells, MCF10Ah and MCF10A cells (Jans Lab) were treated with aptamer-siRNA particles and examined by CytoViva for uptake.

PNIPAM particles were made using previously described methods. Particles were incubated with gold nanoparticles, followed by loading with siRNA. Particles were analysed by TEM and added to cells to determine release of siRNA and knockdown.

**Results and Discussions**

HEK 293 luciferase-expressing cells were treated with LLO-luc siRNA conjugates, free LLO and siRNA, siRNA on its own; with or without Lipofectamine. Results indicate that in the presence of Lipofectamine, conjugate is taken up by cells and siRNA does induce knockdown in the cell, suggesting that a targeting molecule is required for LLO-siRNA uptake. Alamar and lytic assays indicate that cells proliferate in the presence of conjugate, and are non-toxic ; unlike free, unconjugated LLO.

Gold nanoparticles loaded with siRNA and aptamer were analysed by gel shift assay, indicating that the ODT coating was necessary for the attachment of siRNA and aptamer. Particles were added to tumour line MCF10Ah and the isogenic line MCF10A. Incubations at 1hr, 4hr and 16 hours indicated enhanced uptake of particles containing the aptamer targeted molecule.

**Conclusions**

siRNA can be conjugated to a protein or gold particle surface with a reversible bond. Conjugation of siRNA to the lytic protein LLO removes the toxicity of the protein but the conjugate still requires a targeting molecule. Gold nanoparticles modified with ODT can be used to attach various targeting and therapeutic moieties. The particles had enhanced uptake with an aptamer, indicating that delivery can be specific. Further analysis of ability of siRNA to knockdown expression will be carried out.

**Acknowledgements**

Thanks to my supervisors Prof Wenlong Cheng and Dr Christina Cortez Jugo, and Prof Kerry Hourigan. I also thank current and former members of Cheng Nanobionics Group, particularly Romiza Mazid, Yi Cheng and Ramya Chandrasekheran. I also thank the Jans lab for provision of the aptamer and MCF10 cell lines.

**References**


**Biography**

Upulie Divisekera is a PhD student in the Cheng Nanobionics. Her thesis looks at the generation of novel drug delivery nanoparticles through the use of the pore forming protein Listeriolysin O and gold particles for the delivery of siRNA.
**NOVEL 2D HYBRID MOF/GRAPHENE OXIDE SEEDING FOR SYNTHESIS ULTRATHIN MOLECULAR SIEVING MEMBRANES**

Yaoxin Hu, Jing Wei, Yan Liang, Huacheng Zhang, Xiwang Zhang, Wei Shen, and Huanting Wang*

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**Abstract**

Metal organic framework (MOF) membranes have shown great potential for energy-efficient gas separation. Despite various fabrication methods being developed, the fabrication of ultrathin MOF membranes remains a challenge owing to the difficulty in controlling heterogeneous nucleation and growth on porous substrates. We have recently reported an innovative strategy to fabricate ultrathin and defect-free MOF membranes on various porous substrates using two-dimensional (2D) hybrid MOF/Graphene Oxide (GO) seeding layer. Zeolitic imidazolate framework-8 (ZIF-8), an important MOF used for fabrication of gas separation membranes, was chosen to demonstrate the 2D nano-hybrid seeding strategy. A defect-free ZIF-8/GO membrane with a thickness of 100 nm was prepared on a porous substrate using 2D ZIF-8/GO hybrid nanosheets as seeds, followed by a uniform deposition and confined growth process. The 2D ZIF-8/GO hybrid nanosheets were composed of ZIF-8/GO/ZIF-8 sandwich-like structure, with both sides of GO nanosheets fully covered with small ZIF-8 nanocrystals (<50 nm in size). In addition, such hybrid nanosheets with a suitable amount of ZIF-8 nanocrystals were essential for producing a uniform seeding layer that facilitated fast crystal intergrowth during membrane formation. Furthermore, the seeding layer acted as a barrier between two different synthesis solutions, and self-limited crystal growth and effectively eliminated defects during the contra-diffusion process. The thickness of ZIF-8/GO membranes was one of the thinnest ever reported and its separation performance was amongst the best ZIF-8 membranes reported thus far, with a high CO₂/N₂ selectivity of 7. This 2D nano-hybrid seeding strategy can be readily extended to fabricate other defect-free and ultrathin MOF or zeolite molecular sieving membranes for a wide range of separation applications.

**Biography**

Yaoxin Hu is a PhD candidate of Chemical Engineering, where her research focuses on two-dimensional nanocomposites, membrane science and gas separation.
RECYCLABLE NANOFIBRE COMPOSITES AS EXCELLENT BARRIERS IN PACKAGING SECTOR

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Abstract

Cellulose nanofibres are an exciting low-cost renewable new nanomaterials. Cellulose nanofibre sheets have exciting future prospects as barriers. The most important barrier properties of cellulose nanofibre sheets are water vapour permeability (WVP) and oxygen permeability (OP). Due to smaller diameter and small pore size, cellulose nanofibre sheets have low OP, however the WVP is high due to hydrophilic nature of cellulose. Many commercially available packaging materials are associated with wax, aluminium and plastic materials, which has low WVP, but such materials are not recyclable and biodegradable. Therefore, keeping low OP while reducing WVP is a key challenge to the utilisation of cellulose nanofibres as recyclable barrier material today. One way of addressing this issue is to do surface modifications to increase the hydrophobicity of cellulose nanofibres by coating nanofibres with suitable low WVP materials. Another way to address this issue is to increase the tortuosity of the nanofibre sheet thereby water vapours find it difficult to travel across the membrane. This paper explores the latter by preparing nanocellulose hybrids.

Composites were prepared through filtration process by addition of nanocellulose and layered silicates (nanoclays). The nanoclay composition varied between 10-60wt%. The effect of fibre fibrillation on the WVP of the sheet and the effect of nanoclay addition on WVP of the composite sheet were determined. Effect of nanoclay addition on strength and porosity of the composite was determined as well. The WVP values obtained for composites showed an improved results when compared with the performance of other cellulose sheets reported in literature. Therefore, this work presents a new recyclable packaging material with excellent OP and WVP.

Biography

Uthpala is a final year PhD candidate working with nanocellulose-nanoparticle composites and its applications in Bioresource Processing Institute of Australia (BioPRIA).
ZEOLITIC IMIDAZOLATE FRAMEWORK COMPOSITE MEMBRANES FOR GAS SEPARATION

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Extended Abstract

Introduction

Zeolitic imidazolate frameworks (ZIFs), a subfamily of MOFs, are known for their permanent porosity and exceptional chemical and thermal stability. The ultimate goal of this research is to address challenges that hinder the facile synthesis of ZIF membranes in a reproducible and scalable manner. In this study, three new approaches are demonstrated to potentially address the challenges associated with the reproducible and scalable synthesis of ZIF membranes.

Results and Discussions

First, a novel scalable strategy of using vapor phase to chemically modify the polymer support for ZIF membrane fabrication is developed (Figure 1). The resulting ZIF-8 membranes exhibited exceptional H₂ permeance as high as 2.05 ×10⁻⁶ mol m⁻² s⁻¹ Pa⁻¹ with high H₂/N₂ and H₂/CO₂ selectivities (9.7 and 12.8, respectively).

![Figure 1: Cross sectional SEM images of the polymer support (right) and the supported ZIF-8 membrane (left) [1].](image)

Next, based on the chemical vapour modification, a simple, effective, and environmentally friendly method is described for the fabrication of high-quality ZIF-8 membranes with controllable positioning on a polymer substrate in aqueous solution [2].
Finally, a new concept for the use of one-dimensional material (e.g. CNT) as nano-scaffolds and pseudo-seeds for the fabrication of molecular sieving membranes supported on a porous substrate is introduced (Figure 3) [3]. At 25 °C and 1 bar, the ideal separation selectivities of H₂/CO₂, H₂/N₂, H₂/CH₄, C₃H₆, and C₃H₈ are 14, 18, 35, 52.4 and 950.1, respectively, with H₂ permeance as high as 2.87 × 10⁻⁵ mol m⁻² s⁻¹ Pa⁻¹.

**Conclusions**

Finally, it is anticipated that the novel strategies developed in this research may be further developed for the fabrication of other MOF and zeolite molecular sieve membranes.

**Acknowledgements**

E.S. thanks Monash University for Postgraduate Publication Award (PPA) and MGS and FEIPRS scholarships.

**References**


**Biography**

Ezzatollah Shamsaei is currently in the Department of Chemical Engineering, Monash University. His research is focused on the development of composite membranes for separation applications.
BUILDING DUAL-SCALE ROUGHNESS USING INORGANIC FILLERS FOR SUPER-HYDROPHOBIC PAPER

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Abstract

This study reports the preparation of super-hydrophobic paper via a facile two step dip coating method and investigation the effect of three kinds of inorganic pigments on fabrication of super-hydrophobic paper. Precipitated Calcium Carbonate (PCC), Ground Calcium Carbonate (GCC) and Montmorillonite (MTM) were used as inorganic pigments nanoparticles to study the effect of forming a rough layer on the surface of the filter paper, respectively, and these paper were treated with AKD. For PCC-treated papers, contact angle measurements illustrated that the PCC modified paper surface had a contact angle of 167.2±3.3° and tilt angle much less than 5°. The self-cleaning property of the PCC-treated papers was also investigated. The results showed that the self-cleaning property was satisfactory. For GCC-treated papers, contact angle measurements confirmed the super-hydrophobic nature of the paper prepared, which showed a contact angle of 156.7±2.4°. SEM analysis was carried out to characterize the surface differences of the coated samples with and without the added cellulose nanofibers and to clarify the binding role of cellulose nanofibers. It was also observed that the rough GCC coating layer lack of enough fine (nano-scale) structure, and thus the prepared super-hydrophobic surface has a relatively large tilt angle (~10°). For MTM-treated papers, SEM analysis showed that the “surface concentration” of MTM on the paper surface was increased with the increase of cellulose nanofibers dosage. Contact angle measurements showed that the MTM-treated papers with single AKD sizing were hydrophilic; these papers became hydrophobic, but not super-hydrophobic after the second AKD treatment. SEM revealed that the MTM coating layer had only nano-scale structures but was smooth and lacked dual hierarchical structures. Given the drawbacks of GCC-treated surface and MTM-treated surface, the combination of GCC and MTM was investigated. SEM analysis showed that the GCC/MTM coating layer had the required dual hierarchical structure. Specifically, the component of GCC provided the micro-scale structure, while the MTM provided the nano-scale structure. The super-hydrophobic properties were confirmed, as the contact angle measurements showed that the MTM/GCC treated paper had a contact angle of 162.4±3.3° and tilt angle less than 5°.
Biography

Xue Zhang is one of BAMI Postgraduates Students engaged in the Bioprocessing Advanced Manufacturing Initiative. She received her Bachelor & Master of Pulp and Paper Engineering from Tianjin University of Science & Technology, Tianjin, and P.R. China. She joined BioPRIA in 2015 and is pursuing a PhD in Chemical Engineering, Monash University. She is working under the supervision of Prof. Wei Shen and co-supervision of Assoc. Dr Warren Batchelor on BAMI project 2 – Superhydrophobic paper for liquid and food packaging. Her project is to investigate and engineer super-hydrophobic packaging materials based on paper and other cellulosic substrates. The aim of this project is to develop new engineering approaches to fabricate and characterize super-hydrophobic packaging materials and to utilise conventional papermaking materials and coating technologies to engineer superhydrophobic paper and board and to investigate other possible surface chemistries, such as nano silica.
ADVANCEMENT OF PAPER-BASED MICROFLUIDICS FOR DIAGNOSTICS – THE ORIGINAL MOTIVATION AND CURRENT STATUS
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Abstract

Paper has shown potential as an ubiquitous material for fabricating micro analytical devices for diagnostic and drinking water screening applications for resource-limited regions; paper-based sensing technology has become a hot research field since 2007. Intensive research in the past nine years has accumulated a large number of scientific publications. However, commercialization of microfluidic paper-based analytical devices (μPADs) for real applications is noticeably lagging behind. The “ASSURED” criteria set by the World Health Organization (WHO) specified the whole spectrum of requirements for a low-cost sensor designed for use in developing countries; they define the technical capabilities (i.e. “ASSR”) and user acceptance (i.e. “UED”) of low-cost sensing technology. While “ASSR” should be taken as the basic requirements of any sensor, “UED” determines whether or not the sensor could potentially be commercialized and gain user acceptance. This review presents a perspective on these two critical aspects of paper-based diagnostics by revisiting the original motivation of the paper-based analytical platform. It is our opinion that “UED” are important requirements that deserve more research to increase the commercialization of paper-based sensors.

Biography

Weirui Tan, pursuing a PhD degree in Monash University after finishing her master’s study in SCUT (China), now studies in Prof. Wei Shen’s group and mainly focuses on development of low-cost, user-friendly microfluidic analysis devices as well as their applications in environmental monitoring and health diagnostics.
CELLULOSE AEROGEL WITH DOUBLE-LAYER STRUCTURE FOR OIL/WATER SEPARATION

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Extended Abstract

Introduction
With the rapid industrial growth, such as in oil and gas, petrochemical, pharmaceutical, metallurgical and food processing industries, a large amount of oily wastewater is generated daily.1 Current techniques for oil/water separation such as flotation and coagulation, are energy-intensive and require complicated machinery.2 Besides, some of them are not applicable to the separation of oil/water emulsion.3 Although traditional hydrophobic/oleophilic absorbent materials are used extensively in practical applications due to their low cost and ready availability, they are still faced with challenges4-6, which are slowly moving researchers’ interest away from hydrophobic/oleophilic materials to hydrophilic/oleophobic materials in this application.7 However, many existing hydrophilic/oleophobic materials are fabricated using petroleum-derived materials, and modified using harmful chemicals such as those with fluoride groups to gain oleophobic properties.8-10 Therefore, there is still large room for improvement to minimize their environmental impact.

Materials and Experimental
Micro fibrillated cellulose (MFC) purchased from DAICEL Chemical Industries Limited (Celish KY-100G) was used as the primary materials for preparing cellulose aerogel. MFC suspensions with various solids content mixed with calculated amount of PAE were prepared and poured slowly into 25ml beakers. They were then placed in freezer at -18°C for 24 hrs in order to maintain the porous structure. Thereafter, the frozen sponge-like aerogel was freeze-dried in freeze-dried for 24 hrs to remove all the moisture while maintaining its porous structure. Then the freeze-dried samples were kept in oven at 120°C for 3 hrs to promote cross-linking. The single layer aerogel membrane was thus fabricated.

A second layer of cellulose nanofiber was deposited onto the single layer aerogel membrane via filtration method. A dilute cellulose suspension was filtered through the single layer cellulose aerogel. Lastly it was again freeze-dried.
Results and Discussions

Schematic of fabrication process of the cellulose aerogel filter and its application in oil/water separation.

Efficiencies of selected Sponges for Surfactant Stabilised Emulsion

- sponge #1
- sponge #2
- sponge #3

Effects of solids content (grammage):
- 0.027 wt% (30 gsm)
- 0.108 wt% (60 gsm)
- 0.216 wt% (60 gsm)
Conclusions
In summary, we reported an oil/water separation process based on an aerogel double-layer produced using cellulose. The aerogel can be easily fabricated on a large scale by filtering dilute suspension of cellulose on a single layer cellulose aerogel which was produced by freeze-drying cellulose suspension, followed by cross-linking with PAE. With the super-hydrophilic and underwater super-oleophobic properties, excellent wet strength, pothole-like surface structure and double-layer structure. It allows excellent oil/water separation efficiency to oil/water mixture, oil/water surfactant-free emulsion and even oil/water surfactant-stabilized emulsion.

Acknowledgements
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Biography
Zhiyong received his bachelor degree in Chemical Engineering (Hons) from Monash University, Clayton in 2013. In 2014 he became a PhD candidate at BioPRIA, under the supervision of Dr. Warren Batchelor and A/Prof. Xiwang Zhang, working on oil/water separation using cellulose aerogel membrane.
FINITE ELEMENT INVESTIGATION OF DENSE GRANULAR FLOW IN SHEAR CELLS
Qi Luo1, Qijun Zheng1,2, Aibing Yu1,2

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Abstract

Sheared dense granular flow can exhibit various unique behaviours as compared to those of common solids, liquids and gases. Shear cells are elementary and widely used apparatus to investigate granular flow mechanics. A lot of important phenomena exist in shear cells, such as shear band, flow transition, dilation, stick-slip and nonlocal rheology, which are still significant challenges in chemical engineering. Using a continuum-based finite element method (FEM), this work investigates velocity profile and stress distribution in several well-developed sheared granular flows. Conventional Mohr-Coulomb and Drucker-Prager elastoplastic theories are applied and further developed to consider the state dependant and rate effect of yield criterion during granular flow. The simulation results are compared with previous experimental data and discrete element modelling. It is shown that classical Mohr-Coulomb criterion can well predict the wide shear band which depends strongly on the rotational speed of cell and dilation of granular material, even though the width of shear band remains an open issue. Visco-plastic Drucker-Prager or μ(I) flow law takes rate effect into account and quantitatively captures velocity profile and stress field in inclined chute flow. The μ(I) friction law is further applied in hopper flow. FEM results of hopper discharge rate and wall pressure agree well with previous theory predictions. In quasi-static regime, flow at a point is affected by local stress as well as flow in neighbouring points, resulted from the so-called nonlocal rheology. The effect of nonlocal rheology on sheared granular flow will be the future work.

Biography

Qi Luo obtained his bachelor and master degree in civil engineering from Beijing Jiaotong University, China. He continues his research in Monash University for Ph.D. degree from February, 2015. His research interests include DEM/FEM in modelling granular flow, engineering structure dynamics and computational mechanics.
INVESTIGATION ON PLUG FORMATION OF COARSE PARTICLES WITH A DRAFT TUBE FEEDER BY CFD-DEM COUPLING METHOD

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\textsuperscript{2}Laboratory for Simulation and Modelling of Particulate Systems, Dept. of Chemical Engineering, Monash University, Clayton, VIC 3800, Australia.

Abstract

Dense phase plug conveying has received considerable attention due to the advantages of low particle attrition, low pipeline wear and low energy consumption. This paper presents an investigation on plug formation of coarse particles with a draft tube feeder (DTF) by an extended 3D CFD-3D DEM model. The model has been validated by total pressure drop, solid mass flow rate and plug flow pattern with good agreements. Numerical results show particle motion in feeder is closely related to fluid flow. The average entrained particle velocity at the riser inlet and the effective depth of the fluid effective influence zone increase linearly with increasing gas superficial velocity. Boundaries of vertical coarse particle plug is defined based on gas pressure characteristics. Plug is formed through a general formation process consisting of three steps i.e. the forming of short cloud, the forming of long cloud and the forming of plug. Merging plays an important role in plug formation. The minimum porosity usually decreases during merging of short clouds, but does not change obviously during the merging of long clouds when it is close to the porosity of dense random packing before merging. This implies that the minimum porosity of plug in this system perhaps would not decrease when it is close to the porosity of dense random packing.

Biography

He Zhang, Ph.D candidate from INET, Tsinghua University, China. Visiting in Laboratory for Simulation and Modeling of Particulate Systems (SIMPAS), Department of Chemical Engineering, Monash University. Focusing on coarse particle motion behaviour in pneumatic conveying and spouted beds.
DEM STUDY ON THE FLOW OF ELLIPSOIDS IN A
ROTATING DRUM

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Extended Abstract

Introduction

Discrete Element Method (DEM) has been widely used to study the granular flow in rotating drums, but mainly focusing on spherical particles. Particle shape could also affect the flow behaviour of granular materials. However, its effect on granular flow in rotating drums has received limited studies. In this work, DEM is used to examine the effect of particle shape on flow behaviour in rotating drums. The results show that the typical flow regimes previously observed for spheres also exist for ellipsoids. However, with the increasing rotating speed, ellipsoids transit faster than spheres from rolling to cascading and from cascading to cataracting regime. When aspect ratio deviates from 1.0, the dynamic angle of repose increases. The repose angle of granules with various aspect ratios increases markedly with the increasing rotating speed and filling level.

Simulation Method

According to the DEM, the governing equations for the translational and rotational motion of particle i with radius $R_i$, mass $m_i$, and moment of inertia $I_i$ can be written as

$$m_i \frac{dv_i}{dt} = \sum_{j=1}^{k_c} (f_{c,ij} + f_{d,ij}) + mg$$

and

$$I_i \frac{d\omega_i}{dt} = \sum_{j=1}^{k} (M_{t,ij} + M_{n,ij} + M_{a,ij})$$

where $v_i$ and $\omega_i$ are the translational and angular velocities of the particle, respectively, and $k_c$ is the number of particles in interaction with the particle. As plotted in Fig.1, the forces involved are: the gravitational force $mg$, and inter-particle forces between particles, which include elastic force $f_{c,ij}$, and viscous damping force $f_{d,ij}$. These inter-particle forces can be resolved into the normal and tangential components at a contact point. The torque acting on particle i by particle j includes two components: $M_{t,ij}$ which is generated by the tangential force and causes particle i to rotate, and $M_{n,ij}$ is generated by asymmetric normal forces and slows down the relative rotation between particles. For ellipsoids, addition torque $M_{a,ij}$ should be added because the normal contact force do not necessarily pass through the particle centre.
Results and Discussions

Figure 2: Particle flow patterns for various aspect ratios at different rotation speeds: (a) rpm= 15; (b) rpm= 40; the colour represents particle velocity magnitude.

Figure 1 shows the flow patterns at different rotation speeds after the flows reach steady states. The typical solid flow pattern can be observed in the rotating drum with ellipsoidal particles. At 15 rpm, for spheres, the flow is clearly in the rolling regime characterised by a flat surface, a thin layer of fast moving particles and the majority of particles moving slowly at the bottom. However, for ellipsoids, they already reach the cascading regime with an S-shaped surface. Further increasing the rotation speed to 40 rpm leads the flow into the cascading regime with a clear shoulder and tail for spheres, but ellipsoids have already started to be thrown off the bed surface, and reaches the cataracting regime [1].

Figure 4(a) shows the effect of aspect ratio on the dynamic angle of repose for different rolling friction coefficients and rotating speeds. (b) Effect of filling level on the dynamic angle of repose for different aspect ratios.

As shown in Fig.4(a), for oblate spheroids, when the rolling friction is 0.04, the angle of repose decreases sharply with the increasing aspect ratio at 15 rpm. For prolate spheroids, the angle of repose grows as the aspect ratio increases from 1.0 to 3.0, which is in good agreement with the experimental results [2]. Due to the more stable bed of ellipsoids, greater repose angle can be seen for ellipsoidal particles.
Additionally, the declination in rolling friction coefficient results in less angles of repose for particles of various aspect ratios. Moreover, while the rotating rate is reduced to 5 rpm individually, the angle of repose decreases for various aspect ratios.

Filling level is an important parameter that affects the angle of repose. Fig.4(b) shows the relationship between the filling level and angle of repose for different aspect ratios. The dynamic angle of repose increases with the increasing filling level individually for ellipsoids, which is similar to the case of spheres. Furthermore, as the sphericity decreases, greater repose angle was observed. By using multi-sphere method to approximate non-spherical particles, Norouzi [3] found that, the beds of spherical, oval, oblong and biconvex particles tended to have a greater angle of repose when the filling ratio increased, which is comparable to the results obtained here.

**Conclusions**

• With the increasing rotating rate, ellipsoids transforms faster than spheres from rolling to cascading or from cascading to cataracting regime.
• When aspect ratio deviates from 1.0, the dynamic angle of repose increases.
• The repose angle of granules with various aspect ratios increases markedly with the increasing rotating speed and filling level.

**Acknowledgements**

The authors are grateful to ARC, BlueScope Steel and Monash University for their support to this work.

**References**


**Biography**

Siyuan He is a first year PhD student in the Department of Chemical Engineering, Monash University. He obtained his bachelor degree in Qingdao Technological University. He finished his master study in Ocean University of China. He currently focus on DEM simulation of flow of aspherical particles in rotating drums.
LATTICE BOLTZMANN INVESTIGATION OF SPHERICAL PARTICLES IN POWER-LAW FLUID FLOWS
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Extended Abstract

Introduction
Fluid-particle systems are frequently encountered in a variety of industrial processes. The interactions between fluid flows and particles in such systems are influenced by many variables related to the physical characteristics of fluid (density and viscosity), size and shape of particles, and particle structure, as well as kinematic variables such as the flow rate, ambient pressure, and temperature [1]. In comparison with numerous studies made for the understanding of the interaction between particles and Newtonian fluids [2, 3], such studies on non-Newtonian fluids are very limited [1, 4]. In this study, the interactions between power-law fluids (a common type of non-Newtonian fluid) and single/multiple particles are studied by a parallel 3D Lattice Boltzmann (LB) model within wide ranges of Reynolds number and power-law index. The validity of the LB model is first verified by the good agreement between the measured and calculated results regarding drag forces on a single particle in different shear-thinning fluid flows. The model is then used to study the dynamic process of single or two interactive particles in power-law fluid flows. The emphasis is given to reveal the effects of Reynolds number and porosity on the drag forces acting on particles in packed beds. The numerical results show that the negative wake has strong dynamic effects on the drag forces acting on a single particle and thus the non-Newtonian flow. Conversely, for the interactive particulate systems, such effects are not significant. And, the impacts of the solid structure, characterised by porosity, on the drag forces on particles become more important. Based on the calculated results, new correlations are proposed to describe the drag forces on a single particle and the mean drag forces on particles in packed beds in power-law fluid flows.

Results

Figure 1: Force distribution of multi-particle-non-Newtonian-fluid systems with different power-law index, Reynolds number and porosity
Acknowledgements
Authors are grateful to Australia Research Council (ARC) for the financial support and National Computational Infrastructure (NCI) for the use of HPCs.

References

Biography
Zheng Qi is a PhD student working under the supervision of Prof Aibing Yu and Dr Shibo Kuang in Chemical Engineering at Monash University. He received his master’s degree in material science and engineering from UNSW in 2014. His main research interests are modelling, and simulation of the multiphase flows in chemical engineering processes at different scales for gaining optimal design and operation.
CFD MODELLING OF PNEUMATIC CONVEYING OF
POWDER THROUGH VARIOUS PIPELINES
Zhen Miao1, Shibo Kuang1, Zughbi Habib2 and Aibing Yu1

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2Bluescope, Port Kembla, NSW, 2505, Australia.

Abstract

Pneumatic conveying is a common operation to transport powders in many industries, such as power plant, mineral, food, and chemical industries. The prediction of the process performance such as pressure drop and transport speed is a longstanding but still challenging task due to the complicated interactions among the gas flow, powder, and pipe wall. The characteristics of the gas-solid flow in pneumatic conveying of powder were therefore investigated using continuous approach under different conditions. The applicability of the model was fully tested against the experimental data for horizontal and vertical conveying pipelines as well as elbows in this study. This was first done for dilute-phase pneumatic conveying, showing the good agreement between calculated and measured results in terms of pressure drop, gas and solid velocities and solid distribution. It is found that in the model, the consideration of particle size distribution combined with the use of our newly developed drag correlation from lattice Boltzmann simulations is useful to achieve better predictions against the measurements. Then, some efforts were made to extend the developed model to predict dense-phase pneumatic conveying based on the physical experiments in the literature and the plant operations provided by BlueScope. The numerical results show that the model can reproduce the complicated slug flow regime. Under the BlueScope conditions, pulverised coal powders are expectedly transported in a suspending mode at a low solid loading ratio (SLR), and they gradually accumulate in the pipe bottom with the increase of SLR. More importantly, an unstable transport pattern is observed when the pressure drop reaches the minimum, which may somewhat account for the unstable operations observed in practice. In this respect, a detailed study is under the way towards the establishment of a comprehensive understanding of the unstable flow behaviours. All the results obtained thus far suggest that this model can offer a convenient way to study pneumatic conveying of powders under different conditions.

Biography

Zhen Miao is currently a PhD candidate in Department of Chemical Engineering at Monash University. He is working on an ARC linkage project of pneumatic conveying with BlueScope. In 2014, he completed his master’s study on the discrete modelling of the raceway formation in blast furnaces at UNSW.
CFD INVESTIGATION OF THE INJECTION OF VICTORIAN BROWN COAL INTO AN IRONMAKING BLAST FURNACE

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Abstract

The state of Victoria in Australia has a large amount of low-rank brown coal resource. Victorian brown coal features in high moisture content, low cost and ash yield, together with a penitential of replacing conventional high-rank metallurgical coals in pulverized coal injection (PCI) in ironmaking blast furnace (BF). In this work, a three-dimensional mathematical model is developed and used to simulate the flow and thermodynamical behaviours of injecting Victorian brown coal at the lower part of BF. The geometry of this model covers lance, blowpipe, tuyere, raceway and coke bed. The model is validated against the experimental data by basic variables, gas compositions and coal burnout. The typical in-furnace combustion behaviours are predicted, in terms of flow, temperature, gas compositions and combustion characteristics. Prediction results indicated that the model is able to simulate the comprehensive combustion phenomena of dried Victorian brown coal under BF conditions. The feasibility of replacing traditional thermal PCI black coal with Victorian brown coal is evaluated and confirmed by comparing their performance under the same PCI conditions. The effect of coal properties caused by different upgrading methods is examined, indicating that upgrading method has a significant effect on the coal combustion characteristics. The influence of typical operational parameters on the performance of brown coal are studied, and a brief summary of sensitivities of these parameters to the combustion of dried brown coal is presented.

Biography

Junhai Liao is a PhD student from group of SIMPAS, his research focuses on the simulation of pulverized coal injection operation under blast furnace conditions.
MODELLING AND ANALYSIS OF THE MULTIPHASE FLOWS IN HYDROCYCLONES
Li Ji, Shibo Kuang, Kaiwei Chu, Jiang Chen, Aibing Yu

Laboratory for Simulation and Modelling of Particulate Systems, Department of Chemical Engineering, Monash University, Melbourne, VIC 3800, Australia

Abstract

Hydrocyclones are an important unit to separate solid particles by particle size in many industries. To date, the design and operation of hydrocyclones largely rely on the empirical models, supported by experimental measurements. Such an approach is simple and portable for use, but valid only for specific conditions. In principle, this deficiency can be overcome by computer models, which have been increasingly used to study hydrocyclones. However, numerical simulations are computationally too demanding for industry applications of hydrocyclones. As such, the liquid-air-solid flows and performance of hydrocyclones were studied in this project over a wide variety of conditions, and on this basis, a prediction model was formulated from the numerical results for the purpose of industrial applications.

First, the efforts are made to compare the Lagrangian particle tracking (LPT), two-fluid model (TFM) and the combined computational fluid dynamics model and discrete element model (CFD-DEM) against the measurements. It is shown that the TFM model is better to predict the measured separation efficiency over a wide range of feed solids concentrations, although it can handle a limited number of particle sizes or/and densities. The former are therefore selected in our study. It is used to quantify the effects of geometrical, operational and material parameters on separation performance. The variables related to material density, body size, and inlet feed way, the effects of which are yet not clear, are focused. The results related to the interaction between cyclone size and material density suggest that ultrafine heavy particles are easily misplaced to the underflow in smaller cyclones, while coarse light particles are more likely to report to the overflow in larger cyclones. A mid-range cyclone size is hence recommended to mitigate the adverse effect of particles. Additionally, the numerical study of inlet feed way shows that the hydrocyclone with a spiral or slope inlet has similar separation efficiency with an involute one, but consumes much less energy. The research on cyclone size, material density, and inlet feed way completes the database, which was used to formulate the prediction model considering nine parameters. The model was validated against experimental data and then used to optimise design and operation of cyclones. It is expected that the findings from this project can be useful to mitigate the misplaced particles, to large extents.
Biography

Li Ji is a PhD candidate in Department of Chemical Engineering at Monash University. She is dedicated to the simulation and modelling of multiphase flow in cyclone separators in chemical engineer and minerals processing.
MICROWAVE ASSISTED XYLAN AND LIGNIN REMOVAL FROM EUCALYPTUS

Negin Amini¹, Victoria Haritos¹, Akshat Tanksale¹

¹Department of Chemical Engineering, Monash University, Clayton Campus

Abstract

Production of biofuels from lignocellulose is essential to reduce the impact global warming caused by petroleum combustion. However pre-treatment of lignocellulose is necessary to remove lignin, which is a cross-linked aromatic polymer protecting the sugars. However, due to the recalcitrance of lignocellulose pre-treatment step can cost as much as 40% of the bio-ethanol production. The emphasis of this study was to use a mild approach which is cost effective and environmentally benign and which can release a large portion of the sugars via enzymatic hydrolysis. Microwave irradiation of *Eucalyptus regnans* sawdust in water was investigated in this study. This novel method was also compared against the conventional liquid hot water treatment to determine the effectiveness of the microwave method. It was found that after 30 minute microwave irradiation 112 mg of total sugars was released per gram of dry biomass, which is 19% of the available sugars. This result was four fold better than the conventional liquid hot water treatment. SEM images showed formation of lignin-carbohydrate complexes on the surface of the pre-treated fibres for both methods. Investigation of enzymatic degradation of the raw and pre-treated sawdust to sugars is under progress but not yet finalised.

Biography

Negin Amini completed her undergraduate double degree at RMIT University in Chemical Engineering and Applied Chemistry and a Masters in Engineering Project Management from The University of Melbourne. She has work experience in the chemical safety industry before she began her PhD at Monash University in 2014 under the supervision of Dr Akshat Tanksale and Associate Professor Victoria Haritos on the project Microwave Pre-treatment of Recalcitrant biomass.
IMMUNOGENICITY AND BIODISTRIBUTION OF NANOPARTICLES IN VIVO

Peter Tsirikis¹, Kirsty Wilson², Sue Xiang², Wei Wei³, Guanghui Ma³, Cordelia Selomulya¹, Magdalena Plebanski²

¹Department of Chemical Engineering, Monash University, Clayton, Victoria, Australia.
²Department of Immunology, Central Clinical School, Monash University, Melbourne, Victoria, Australia.
³National Key Laboratory of Biochemical Engineering, Institute of Process Engineering, Chinese Academy of Sciences, Beijing, China.

Abstract

Nanoparticles have been widely used in vaccine design as both adjuvants and antigen delivery vehicles. In a seminal study, 40-50 nm nanoparticles with conjugated antigen were shown to induce high antibody titers and IFN-γ production in mice but with no added inflammatory stimuli. Subsequent research has shown that similar levels of immunogenicity can be achieved via the co-injection of naked 40-50 nm nanoparticles adjuvants and larger 500 nm nanoparticles with conjugated antigen. Furthermore, recent works indicate that particle shape can also influence the immune response. As such, we investigate the influence of surface morphology using 40-50 nm smooth and rough surfaced nanoparticle adjuvants and report their differential immunogenicity via ELISA, ELISpot and flow cytometry. Further, we determine the biodistribution of fluorescent 40-50 nm nanoparticle adjuvants with smooth and rough surfaces and monitor their drainage using a Carestream FX PRO in vivo imaging system and fluorescence microscopy of lymph nodes sectioned ex vivo. To elucidate the safety profile of this vaccine construct, we also investigate the biodistribution of nanoparticles within the major organs. The outcomes from this study provide key design criteria in the development of novel nanoparticle immunotherapeutics for the treatment of disease.

Biography

Peter Tsirikis is a final year PhD student at Monash University. His research sits at the interface of chemical engineering and immunology and aims to develop novel nanoparticle vaccines for the treatment of disease. In 2015, he won an Endeavour Australia Cheung Kong Research Fellowship and spent 8 months at the Chinese Academy of Sciences in Beijing. He is also a former President of CEPA and winner of the 3 Minute Thesis in the Department of Chemical Engineering.
CREATING TUNEABLE AGGLOMERATES VIA 3D PRINTING

Ruihuan Ge\textsuperscript{1}, Mojtaba Ghadiri\textsuperscript{2}, and Karen Hapgood\textsuperscript{1}

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\textsuperscript{2} Institute of Particle Science and Engineering, University of Leeds, Leeds LS2 9JT, UK

Abstract

It is essential to offer a universally accepted way to systematically evaluate agglomerate breakage propensity and mechanisms. Discrete Element Method (DEM) simulation is a commonly used tool but is limited by the lack of identical, controlled agglomerates to test and validate simple models, let alone replicate the complex structure of real industrial agglomerates.

Our research presents a systematic approach to produce 3D printed agglomerates with tuneable properties. Agglomerates with different mechanical properties and structures were designed and printed by an Objet500 Connex 3D printer. The tensile and shear strength of inter-particle bonds was characterized using Instron tester. Breakage results of agglomerates with simple cubic structures and the design of agglomerates with irregular structures were presented. This 3D printing method will allow more rigorous testing of agglomerate breakage models.

Biography

Ruihuan Ge received the BEng degree from Shandong University, Jinan, China, in 2011 and the MSc degree from the Institute of Thermophysics Engineering, Chinese Academy of Sciences, Beijing, China, in 2014. He is currently a PhD student in the Department of Chemical Engineering, Monash University, Melbourne, Australia. His current research interests include granule breakage, particle technology and 3D printing technology.
VACCINE CARRIER DESIGN: IRON OXIDE NANOPARTICLE SYNTHESIS AND INTERACTIONS WITH ANTIGEN PRESENTING CELLS

Liam Powles1,2, Kirsty Wilson2, Sue D. Xiang2, Cordelia Selomulya1, Magdalena Plebanski2

1Department of Chemical Engineering, Monash University, Clayton, VIC 3800
2Department of Immunology, Monash University, Melbourne, VIC 3004

Abstract

Vaccine design typically focuses on two main areas, the discovery of efficacious antigens and the development of delivery systems which can safely and effectively promote strong immune responses. The latter has become more important in recent times with the increasing use of subunit and DNA vaccines. Strong cytotoxic immune responses have been difficult to induce using traditional delivery vehicles and adjuvants such as alum. Therefore, non-degradable nanoparticles have been investigated as alternatives and have demonstrated an ability to induce both strong cytotoxic and humoral responses against conjugated antigen. Biodegradable substances are clearly preferable for use in vivo and as such this work describes the development of a range of biodegradable pullulan stabilized iron oxide nanoparticles (IONPs). The properties of these particles control their behaviour in different immune environments and consequently their potential as immune carriers. This presentation will focus on two aspects key to particle suitability as vaccine delivery vehicles; the interactions of nanoparticles with antigen presenting cells and the synthesis of a range of nanoparticles with differing degradation behaviour. Using microscopy and flow cytometry, it will be demonstrated that IONPs are preferentially taken up in vitro by CD11c+ dendritic cells via binding to Class A scavenger receptors. Changes in the activation profile of the cells will also be outlined. in vitro degradation and stability assays will be used to highlight how the structure of both the iron core and polysaccharide coating alters IONP behaviour in simulated biological fluids.

Biography

Liam Powles is in the third year of his PhD in the Department of Chemical Engineering at Monash University. His work is a collaboration between this department and the VID lab in the Department of Immunology. Prior to this he completed a double degree in chemical engineering and science at Monash.
PRODUCTION OF HIGH VALUE OLEOCHEMICALS USING CYCLOPROPANE FATTY ACID SYNTHASE BIOCATALYSTS

Melissa Mace and Victoria Haritos

Abstract

Oleochemicals are compounds derived from biological lipids. Traditionally, oleochemicals have been sourced from abundant substrates for the production of soaps and biodiesel. However, in recent years new markets have developed for specialty oleochemicals formed from further derivatisations, functionalisations and polymerisations. Many of these oleo-products utilise the unique properties naturally found in their lipid substrates. Modified fatty acids such as omega-3 and ricinoleic acid have had large-scale commercial success as they are isolated from their naturally abundant algal, fish and plant sources.

Genetic engineering offers the control of metabolite production including modified fatty acids, meaning chemically interesting but rare modifications now have the potential to be produced in previously inconceivable quantities. This in-turn will provide an opportunity for application of these valuable specialty oleochemicals. Of particular interest among the modifications are cyclopropane fatty acids. The strained cyclopropane ring on the fatty acid chain adds both desirable lubrication properties to the compound, and the potential to be a powerful intermediate for further complex modifications. By exploiting the natural accumulation pathway of cyclopropane fatty acids, cyclopropane fatty acid synthase, and genetic engineering of a tractable host, a route to the scaled production of these valuable fatty acids has become possible.

Biography

Melissa is PhD candidate in the Department of Chemical Engineering, Monash University supervised by Associate Professor Victoria Haritos. She research interests lie in the field of the production of biologically derived chemicals and single cell analysis of microbiological cultures. Her current work examines the potential uses of recombinant cyclopropane fatty acid synthase.
IMMUNOMODULATORY ROLE OF FUNCTIONALIZED NANOPARTICLES ON ANTIGEN PRESENTING CELLS

Amlan Chakraborty1,2, Cordelia Selomulya2, Magdalena Plebanski1

1Monash Advanced Particle Engineering Laboratory, Dept. of Chemical Engineering
2Vaccine and Infectious Disease Laboratory, Dept. of Immunology

Abstract

There is a growing interest to know as to how nanoparticles affect in the lung. Particulates in the air are known to promote allergic sensitization and allergic airway inflammation. Exposure to such particles has been associated with inflammation in the lungs. The antigen presenting cells (APCs) in the lung preferentially take up nanoparticles and onsets an immune response. However, exposure to glycine coated polystyrene particles in the lung has been shown to be able to prevent subsequent elicitation of pulmonary inflammation.

In this project, we intend to develop clinically useful glycine coated nanoparticles to prevent lung inflammation as well as to gain insight into the cellular and molecular mechanisms engaged by these particles, and more generally by glycine itself, to provide beneficial anti-inflammatory effects. To achieve this we will create glycine coated superparamagnetic iron oxide nanoparticles (SPION). These will be further encapsulated in glycine microspheres to promote effective lung delivery by inhalation, as well as to enhance immediate beneficial anti-inflammatory effects. Thus far we have developed the glycine coated SPION (G-SPION) and found them to be ~12 nm, crystalline, superparamagnetic $\gamma$-Fe$_2$O$_3$ (maghemite) with amine (-NH$_2$) exposed surface and excellent colloidal stability due to a high positive zeta-potential ($\zeta$). We have also generated glycine microspheres which are hollow, porous, monodisperse and uniform, suitable to encapsulate multiple G-SPIONs. Moreover we have investigated the effect of glycine on different subsets of key antigen presenting cells (APC) from murine bone marrow. We found glycine is able to down modulate bacterial Lipopolysaccharide (LPS) induced pro-inflammatory activation of bone marrow derived dendritic cells (DC: CD11c⁺MHCIİ⁺GR-1⁺), macrophages(Mac:CD11c⁺MHCIİ⁺GR-1⁺CD11b⁺F4/80⁺)and myeloid derived suppressor cells (MDSC: CD11c⁺GR-1⁺CD11b⁺). Glycine showed a titratable inhibitory effect on LPS stimulation, and was not toxic even at the highest concentration tested (300 mmol/l). Future studies will focus on the molecular mechanism which leads to this novel biological effect of glycine, as well as the practical loading of G-SPIONs into appropriately sized glycine microspheres. Once generated these will be tested for their ability to prevent and inhibit allergic airways inflammation (AAI) and chronic obstructive pulmonary disease (COPD) in mice.
Biography

Amlan completed his Master of Technology from Amity University, Delhi, India in Biotechnology. He is in his first year of PhD under Prof. Cordelia (Chem Eng.) in collaboration with Prof. Magdalena (Immunology). His research interest is in expanding nano-engineering platforms for the design of immune-imprinting nanoparticles (iNPs) to understand the immune response generated by these nanoparticles.
Improving the Mixing Process of Dry Powder Inhaler Formulations with the Iron Oxide Colour Method

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² Monash Institute of Pharmaceutical Science, Monash University, Royal Parade, Parkville, VIC, Australia.

Abstract

Blending of one or more powders is critical for many pharmaceutical powders, including formulations used for Dry Powder Inhalers. Dry powder inhalers (DPIs) are mixed dry powder medications (asthma) administered via the lungs (pulmonary route). DPIs generally comprise 1% of API and 99% lactose and are mixed in a tumbler mixer or a high shear mixer. Due to empirical nature of commercial production there are production issues such as failed batches, content uniformity issues, and product performance failures, especially low inhalation efficiency values. This leads to production and economic losses but also a lack of understanding in the blending process.

The iron oxide colour method (IOCM) is a recent technique that involved mixing 1% of red iron oxide and 99% of lactose in different mixers and observing the colour. The colour of the blend indicates how mixed the blend is; as the mixing time continues the blend colour changes from pink to red to orange; this method helps to understand the mixing process and the quality of mixing. This work follows on with the method by mixing and testing DPI formulations. Actual DPI blends, 99% DPI grade lactose and 1% API (salbutamol sulphate) are mixed in a high shear mixer (1L KG5) and samples are taken for time points of the blend and are checked with their corresponding colour points.

This study investigates whether this colour method (IOCM) can predict or determine how much mixing is required for a Dry Powder Inhaler (DPI) blend (lactose/drug) to attain content uniformity (Real standard deviation (RSD) < 5). A High Shear Mixer (HSM) is used to mix DPI blends and samples were taken at different time points for different speeds and the content uniformity was tested. These time points were then compared with their corresponding colour points (lactose/iron oxide) to see if there is a correlation between colour points and content uniformity.

Biography

Kahlil Desai completed his chemical engineering/chemistry degree at Monash University in 2013. Kahlil has interned at GlaxoSmithKline (GSK) and is currently a third year PhD student investigating pharmaceutical powder blending especially in regards to dry powder inhaler (DPI) formulations used in asthma inhaler medication.
REACTIVITY OF VICTORIAN BROWN COAL CO2 GASIFICATION

Baiqian Dai¹, Andrew Hoadley¹, Lian Zhang¹

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Extended Abstract

Introduction

Gasification is the reaction of solid fuels with air, oxygen, steam, carbon dioxide, or a mixture of these gases at a high temperature to yield a synthesis gas, which is rich in CO/H2 and suitable for using either as a source of energy or as a raw material for chemical synthesis [1]. The gasification reactivity is thought to be a fundamental factor for the gasification process. It normally represents the intrinsic chemical characteristics of the reactions, and could be affected by both char-forming conditions, including temperature, pressure, gas environment, and char physical characteristics [2]. This paper aims to clarify the reactivity of a Victorian brown coal char gasification reactivity by using thermogravimetric (TG) analysis under CO2 from 900 to 1300°C. These data contribute directly for the prediction of coal gasification behaviour, which can be used for designing and optimisation of industrial gasification applications.

Materials and Experimental

A Victorian brown coal (Yallourn) experienced was pyrolyzed at approximately 800 °C to obtain a moisture free char. The obtained char was size segregated prior to analysis. The char produced ranged in diameter from less than 100 µm to over 8 mm. Gasification experiments were conducted by using TG-DTA (Shimadzu DTG-60H) using an isothermal method at 900, 1000, 1100, 1200, and 1300°C. For each run, an accurately weighted sample (8±0.5mg) was placed on a platinum pan under an argon stream of 100 ml/min up to reaction temperature with a heating rate of 50°C/min.

Results and Discussions

Five different particle size ranges were obtained from the original pyrolysis YL char samples. The proximate analysis results for each size shows a trend of a decrease in size with a decrease in fixed carbon and an increase in moisture, ash and volatile matter (Table 1). Moreover, the particles less than 1 mm are present as darkish powder like black coal, while the chunk sizes larger than 1 mm are more like woody
charcoal and some fibre texture can be observed as well. This chemical and physical diversity in different size will result in different gasification reactivity. To validate, five original size samples were selected to conduct gasification experiment at 1100°C and 1300°C with 100% CO$_2$ at 1 atm.

**Table 1: Proprétés of the sample**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Proximate analysis (wt %)</th>
<th>Ultimate analysis (wt %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBC</td>
<td>Moist (ar)</td>
<td>Ash, % db</td>
</tr>
<tr>
<td>char</td>
<td>10</td>
<td>7.4</td>
</tr>
</tbody>
</table>

The results (Figure 1) show that the large particle size samples need a longer time to achieve a 100% carbon conversion rate. For example, the 4-8 mm char sample needs more than 200 seconds to complete the reaction at 1100°C, while the sample in size <106 µm needs less than 100 seconds to complete the gasification process. As the temperature increases to 1300°C, the carbon conversion takes place faster than that for 1100°C for all the different size samples. At a specific temperature (both 1100°C and 1300°C), the gasification rate shows a decreasing trend as the particle size increases, indicated by a sequential carbon conversion rate. The sequenced discrepancy of gasification rate for different particle size may due to the chemical properties and the particle diameter. To confirm this, all the samples were crushed and sieved to the same particle size (<106µm), and the same experiment conditions were conducted for all the crushed samples.

![Figure 3: Carbon conversion rate for different particle size sample](image)

The results show that the carbon conversion rates for the crushed samples are not sequentially presented. Instead, different samples shows a quite similar carbon conversion rate to each other, regardless the original particle size. From the results we can see that all the crushed samples can achieve a 100% carbon conversion in 100 seconds at1100°C, and the reaction complete in around 70 seconds at 1300°C. It is noticeable that the particle size effect YL char gasification is significant. In the other words, the gasification of YL char samples is more dependent on diffusion.
Conclusions

The gasification rate for YL char can be increased by grinding the large particle to fine particles. The high reactivity of the YL char due to the physical structure and the catalyst in the ash.

Acknowledgements

The authors are grateful for the support from Monash University Institute of Graduate Research (MIGR) for the PhD scholarship, and Brown Coal Innovation Australia (BCIA) for the top-up scholarship.

References


Biography

Baiqian Dai is a third-year PhD student in chemical engineering, Monash University. His PhD project is the co-gasification of brown coal char and black coal for the production of hydrogen and ethylene glycol. Through both experiment and modelling, he is trying to understand the promoting effect of brown coal char and the interaction between different fuels during the gasification. His PhD study is co-funded by BCIA for a top-up scholarship.
Non-catalytic and catalytic pyrolysis of automotive shredder residue (ASR): In-situ Synchrotron Infrared microscopy (FT-IR) and Thermogravimetric analysis coupled with infrared spectroscopy (TG-IR)

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a Monash University, Faculty of Engineering, Clayton VIC 3800
b Coal Science group
c Corrosion research group

Abstract

Automotive shredder residue (ASR) is 30-35% of vehicle materials remaining after the metal recovery of end-of-life vehicles which is a complex mixture of several plastics, rubbers, foams, glasses, textiles, remaining metals and dirt. Currently, nearly all the ASR is landfilled and small amount is incinerated, thereby wasting valuable resources and causing environmental pollution. In pyrolysis, volatile matter of the ASR waste (plastics and rubber) is decomposed to gases and liquids, which can be used as fuels or chemical sources and the inorganic components can be recovered. In this study, the ASR waste have been characterized using Australian Synchrotron FT-IR and TG-IR techniques. These techniques help understand the fundamental mechanism of the pyrolysis process (i.e. decomposition of aliphatic and aromatics compounds at higher temperature). Furthersome, non-catalytic and catalytic pyrolysis of ASR waste have been carried out in a continuous-feed reactor system at various temperature with three different catalysts. The oil derived have been characterized using GC-MS and GC-FID. The main objective in this study is to pyrolyze the ASR waste to find out the appropriate operating conditions for the optimal yield and higher quality of the products for suitable oil recovery. Thermal cracking of ASR waste decomposed to products into the broad range of C5-C28 with 55% oil yield. For catalytic cracking of ASR using continuous feeding system employees’ higher yield of gasoline (C5-C16) and diesel (C13-C23) range products confirm that it is a desirable way of waste plastics recovery. The results will aid in development of the pyrolysis process in order to enhance the quality of the oil derived from ASR.
Biography

Isha Kohli is a PhD research scholar at Monash University, Australia focusing on thermo-catalytic conversion of mixed waste plastics into liquid fuels. Her abilities include conducting, analyzing and executing experiments at laboratory and manufacturing environments with emphasis on reaction kinetics, simulation modeling and operational research addressing waste to energy techniques with effective.
NOVEL FERULIC ACID ESTERASE FROM FIBROBACTER SUCCINOGENES FOR BIOMASS PRETREATMENT

Cameron Hunt¹, Akshat Tanksale¹, Victoria Haritos¹

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Abstract

Ferulic acid esterases (FAE, EC. 3.1.1.73) hydrolyse the linkage between hemicellulose and lignin and can be used for the enzymatic pretreatment of lignocellulosic biomass. This feedstock can then be utilized for the production of sustainable and green chemicals, energy and fuels. Enzymatic pretreatment offers a milder alternative to current thermochemical methods for biomass such as acid-catalysed steam explosion. Recently, we characterised a novel FAE from the ruminant microorganism, Fibrobacter succinogenes (FibSFaeI) that was recombinantly expressed in SHuffle T7 Competent E. coli. The enzyme contained two domains, a catalytic C domain shown to have FAE activity and an unknown N domain. FibSFaeI showed strongest activity towards the model substrate methyl sinapate of 20.2 U mg(-1) as well as activity against other hydroxycinnamic acid esters. Maximal activity of the enzyme was detected at a pH 8.0 with 80% of that activity at pH 6.5, while the optimum temperature for activity was 60°C, with only a 10% loss in activity after incubation at 40°C for 1 hour. The enzyme was also able to release ferulic acid from sugar cane and wheat straw when combined with a xylanase preparation. The function of the N terminal domain was investigated by tagging the sequence with a green fluorescent protein, eGFP expressed in BL21 E. coli and assessed via adsorption assays. The tagged protein showed preferential binding to insoluble biomass substrates including cotton wool and cellulose. FibSFaeI is a novel FAE with high temperature tolerance and contains a novel N terminal domain with carbohydrate binding properties that are useful for the enzymatic pretreatment of lignocellulose biomass.

Biography

Cameron commenced his PhD study in 2013 under the collaborative supervision of Dr Akshat Tanksale of Monash University and Dr Victoria Haritos of Monash University (previously CSIRO). Cameron’s work is focused around a group of enzymes called ferulic acid esterase (FAE). FAE are utilised by microorganisms to digest and breakdown the links between lignin and cellulose in lignocellulosic biomass, such as wood or grasses. The goal of his work is to characterise novel FAE for their industrial applicability as well as investigate the relationship between sequence, structure and function of this enzyme class.
Abstract

Nano-structural design and elemental alloying are two significant strategies for developing effective non-precious hydrogen evolution reaction (HER) catalysts for water splitting. Herein, we report a novel excellent nickel-molybdenum phosphide (NiMoP) hybrid nanowires catalyst for HER, which is synthesized via in situ phosphidation of nickel molybdate (NiMoO$_4$·$x$H$_2$O) nanowires grown on titanium. Different phosphidation temperatures are applied to transform the NiMoO$_4$·$x$H$_2$O into NiMoP nanowires (denote as NiMoP-X, X=phosphidation temperature), among which NiMoP-700 showed the highest HER performance with a small Tafel slope of 63 mV/dec and a low overpotential of 151 mV to achieve 10 mA/cm$^2$ in both acidic and alkaline conditions. When applied NiMoP-700 as a cathode for long-time electrolysis at a current density of -10 mV·cm$^2$, the overpotential just shifted slightly with 30 mV and 27 mV in acidic (24 hours) and alkaline conditions (19 hours), respectively, which demonstrated a high stability of NiMoP for HER application. The structures of NiMoP-X are also studied to explain their different performance for HER. This study provides a new precursor for preparing nanostructured Ni-Mo alloy phosphide and reveals the relationship between the structures and catalytic activities of NiMoP-X.

Biography

Yang (Daisy) Wang obtained her B. S. degree in Materials Chemistry from Anhui Normal University (2012) and M. S. degree in Inorganic Chemistry from Fudan University (2015). Now she is pursuing her doctor’s degree in Monash University under supervision of Prof. Cordelia Selomulya and Prof. Huanting Wang. Her research area is synthesizing nanomaterials for energy conversion.
EVALUATION OF LIPID STORAGE IN GENETICALLY ENGINEERED YEAST BY FLOW CYTOMETRY
Huadong Peng*, Sheridan Vella, Victoria S. Haritos

Victoria S. Haritos Group, Department of Chemical Engineering, Monash University, Clayton, Victoria, Australia

Abstract

Due the limitation in supply of plant-produced food oils and the high demand for oleaginous feedstocks, microbial sources of lipids have been investigated for their potential to meet demand. However, the production level of microbial oils are, at present, still too low to support the costs of oil via this route for all uses excepting very high value nutrient oils. Our aim is to increase lipid production via metabolic engineering of yeast and in particular, to increase neutral lipid stores and the stability of the lipid droplet, an organelle that stores neutral lipids including triacylglycerol (TAG) and sterol esters within yeast cells. This study aims to evaluate the success of genetic engineering strategies to increase cellular lipid using flow cytometry, a measurement technique that evaluates individual cells for size, granularity/density and through the use of a range of fluorescent dyes, a wide range of metabolic activities and viability can also be determined. Yeast cells were transformed with a highly active diacylglycerol acyltransferase gene sourced from Arabidopsis thaliana (DGAT1) coding for an enzyme that catalyses the final step of TAG formation. Two strains of yeast were compared – a wild type and a related strains that had a triacylglycerol lipase (Tgl3) removed from its genome. This lipase is the key enzyme that catalyses the digestion of TAG from the lipid droplet. Therefore, genetically engineered cells should produce more lipid and in the Tgl3-knockout cells, the lipid should be in a stable form within the lipid droplet. A rapid method for assessing the effectiveness of genetic engineering of yeast cells for increased lipid was established using flow cytometry. For the engineered cells a range of parameters that included size, lipid content and viability; the population distribution of each of these parameters was determined. The development of lipid stores in individual cells were measured during different growth phases in real time. Also, the growth curve, biomass yield, lipid yield and profile of engineered strains were analysed and compared. The strategy to increase TAG formation through expression of DGAT in a TAG lipase-deficient yeast strain was effective in improving lipid production compared with both wild type and the lipase-deficient yeast strains. In addition, flow cytometry provides an understanding of individual cell health and any potential negative impacts of genetic engineering.
Biography

Huadong Peng is currently a 2nd year PhD student, focuses on improving yeast lipid accumulation and storage via metabolic engineering strategies. Before joining Monash University, HP finished master study in the Institute of Process Engineering, Chinese Academy of Science, followed by 1.5 years R&D in Novozymes China Headquarter, Beijing. HP has around five years of experiences in various biomass pre-treatment methods for enhanced bio-ethanol production.
REAGENTLESS FLUORESCENCE BIOSENSOR FOR CONTINUOUS ANALYTE MONITORING

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² ARC Centre of Excellence in Convergent Bio-Nano Science and Technology
³ Australian Institute for Bioengineering and Nanotechnology, The University of Queensland

Abstract

Biosensor development is a rapidly growing market particularly in the area of clinical diagnostics and biomedical science research. Though some biosensors have been commercialised, significant success is yet to be achieved in terms of sensing analytes in real-time, in complex biological solutions. Fluorescence-based immunodiagnostics is an emerging field in biosensor development. Traditionally most disease related proteins are detected by conventional bioassays (e.g. ELISA) which are time consuming, laborious and multistep tasks requiring coating, washing, blocking and labelling. Fluorescence-based affinity biosensors have many advantages over these traditional methods due to shorter assay time, ease of handling and single step detection strategy. While a range of biosensors have been reported, reagentless biosensors that use recombinant antibodies (e.g. scFv) as the biorecognition element for affinity-based interactions to detect proteins using a variety of simple fluorescent methods are in their infancy.

Only a few engineered antibody-based fluorescence biosensors have been developed which can generate signals according to the concentration variation of analytes. However, none of them are capable of reversibility and continuous monitoring. One of the major challenge in fluorescence-based sensor development is the site-specific labelling of target antibody without disturbing structure and functionality. Traditional labelling strategies such as maleimide chemistry, fusion fluorescent proteins and short peptide tags suffered limitations in terms of site specificity, structural perturbation, reduced functionality, cross-reactivity and disoriented immobilisation. Unnatural amino acid labelling technology is a highly efficient method of protein labelling as they can be modified with desired functional group and genetically incorporated in any permissible site during protein synthesis followed by simple conjugation with target fluorophores.
Biography

Jiaul Islam has completed Bachelor of Science (Honours) in Biochemistry and Molecular Biology from the University of Melbourne. He worked as Research Assistant in Sugar Research Australia (SRA) for 3 years. Following that, he started PhD program at the University of Queensland in 2015. After completion of confirmation milestone, he has recently transferred to Monash University.
Growth of Graphitic carbon nitride nanosheet on TiO$_2$ mesoporous spheres with highly improved photocatalytic activity under visible light irradiation

Xiaofang Chen, $^{1, 2}$ Zongli Xie, $^2$ Yonggang Zhu, $^2$ Huanting Wang, $^1$

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Abstract

Growth of graphitic carbon nitride on mesoporous TiO$_2$ spheres with well-controlled structures was achieved by melt-infiltrating dicyandiamide (DICY). In particular, melting of a precursor of g-C$_3$N$_4$ into a mesoporous TiO$_2$ (M-TiO$_2$) enables growth of g-C$_3$N$_4$ with controllable coverage and thickness. The precursor of g-C$_3$N$_4$, DICY, can be melted at 190 $^\circ$C and thus used to fill the mesopores of TiO$_2$. Subsequently, during carbonization of DICY, g-C$_3$N$_4$ could be controlled to grow on M-TiO$_2$ spheres. The melt-infiltration of DICY results in better fusion of g-C$_3$N$_4$ into M-TiO$_2$ and thus a strong interfacial connection between TiO$_2$ and g-C$_3$N$_4$, which are important in promoting both visible light adsorption and photo-generated electron transfer. TiO$_2$/g-C$_3$N$_4$ composites exhibited much higher photocatalytic activity than TiO$_2$ and g-C$_3$N$_4$ towards the degradation of Rhodamine B under both UV light and UV-vis light irradiation. The heterostructured combination provided a synergistic photocatalytic activity through an efficient electron transfer process. Based on the experimental results, a possible mechanism for the improved photocatalytic performance was proposed. The factors affecting the photocatalytic activity were also discussed based on the result of structure analysis, optical and photoelectric characteristics, and photocatalytic reactions. This work provides a simple and effective method to reduce the barriers in composites to promote utilization efficiency of solar energy.

Biography

Xiaofang Chen is the PhD candidature under the supervision of Prof. Huanting Wang.
CAN CARRAGEENAN IMPROVE THE FAT ENCAPSULATION EFFICIENCY IN MILK POWDER PRODUCTION?

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Abstract

In both industrial and laboratory scale production of milk powder, the surface of the spray-dried particles is typically dominated by fat. This negatively influences the shelf life due to increased susceptibility to fat oxidation and impedes further processing because of lower water solubility and flowability. As previously reported, the surface fat is formed in the course of the atomization step of the spray drying process and hence cannot be reduced by adjusting the spray drying conditions. Instead, a modification of the emulsions to be spray-dried seems to be most promising for better fat encapsulation. In this study, it was investigated whether the surface fat can be reduced by adding λ-carrageenan to milk model emulsions at different concentrations (0-0.5 % w/w). Emulsion analysis revealed that the emulsions were most stable for λ-carrageenan contents of 0.3-0.4 % w/w. This agreed with minimal fat globule sizes of 0.657 and 0.626 micrometre at 0.3 and 0.4 % w/w, respectively. The respective spray-dried powders also featured an optimum at intermediate λ-carrageenan concentration in terms of surface fat amount. By fat extraction, for instance, a surface fat content of 4.7 % of the total fat content was found for 0.3 % w/w carrageenan, in comparison to 13.8 % and 10.0 % for 0.0 and 0.5 % w/w carrageenan, respectively. This suggests that the anionic carrageenan can reduce the amount of surface fat by acting as a stabilizer inside the emulsion, forming a multilayer interfacial protein-polysaccharide membrane around the fat globules.

Biography

Martin Foerster has studied Chemical Engineering at the Karlsruhe Institute of Technology, Germany, and the University College London, UK. After graduating (Dipl.-Ing.) in 2013 and acquiring industry experience at BASF (China) in Shanghai, he came to the Department of Chemical Engineering at Monash University, Australia. Supervised by A/Prof Cordelia Selomulya and Dr Meng Wai Woo, he is now in his third year as a doctoral student, being interested in the systematic investigation of microencapsulation processes during spray drying.
Ultrathin two dimensional MOF nanosheets: Towards a high-performance molecular sieving membrane
Meipeng Jian¹, Huanting Wang¹, Xiwang Zhang¹*

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Abstract

The unique class of ultrathin two dimensional (2D) materials has been explored for numerous promising applications as a result of their many exotic properties, including advanced membrane separations.¹ 2D nanosheets have been proven to be the most promising materials for the fabrication of ultrathin membranes.² In this respect, groundbreaking advances have been achieved on 2D nanomaterials based membranes such as graphene membranes in recent years.³ However, the above materials still suffer from the impermeable nature and unprecisely controlled interlayered space, constraining the ultimately ultrafast separation. For this purpose, employing ultrathin metal organic frameworks (MOF) nanosheets as building blocks endows the preparation of ultrathin molecular sieve membranes with great potentials to achieve an ultrapermeable molecular separation, by relying on the inherent properties with highly regular and ultraporous structure.⁴,⁵ This research will focus on developing a high performance membrane which shows the enhanced permeation and selectivity for the separations by assembling ultrathin MOF nanosheets.

Reference


Biography

Meipeng Jian received his B.Eng. (in 2011) and M. Eng. (in 2014) in Environmental Engineering from East China Jiaotong University. Afterward, he applied as a research assistant in Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences in 2015. He is currently a Ph.D candidate at Monash University advised by A/Prof. Xiwang Zhang and Prof. Huanting Wang.
ENGINEERING NANOCYLULOSE GELS
Llyza Mendoza¹, Warren Batchelor¹, Gil Garnier¹

¹Bioresource Processing Institute of Australia (BioPRIA)

Abstract

Hydrogels are fascinating soft materials possessing polymeric networks which entrap substantial amounts of water. Cellulose has emerged as a promising material to produce biodegradable, biocompatible, and easily functionalised hydrogels that can be used for various food and biomedical applications.

Herein, TEMPO-oxidised cellulose nanofibres are used to produce hydrogels. A combination of techniques – rheology and dynamic light scattering (DLS) – were employed to characterise the structure and understand the mechanism of hydrogel formation. Rheology was used to characterize the viscous and the elastic moduli of the gels, while DLS served to identify the onset of gelation. We have found that the hydrogel properties are dependent on fibre concentration, temperature, pH, and ionic strength. With this knowledge we intend to produce modified hydrogels to suit applications by optimising fibre content, and additives.

Biography

Llyza has a Bachelor and Master of Engineering in Chemical and Materials Engineering from the University of Queensland, Australia. In 2015, Llyza has joined BioPRIA as a PhD student. Llyza is currently working on the development of nanocellulose gel and its potential applications under the supervision of Prof. Gil Garnier and Dr. Warren Batchelor.
INVESTIGATION OF MODIFIED ORGANOSILICA CORE-SHELL NANOPARTICLES FOR STABLE pH SENSING IN BIOLOGICAL ENVIRONMENTS

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3ARC Centre of Excellence in Convergent Bio-Nano Science and Technology

Abstract

The development of biosensors for continuous monitoring of biomarkers in biological environments is a key challenge1. Ion-selective polymeric nanoparticles (“optodes”) have emerged as sensitive and tuneable biosensors, using chromo/ionophores to generate analyte-responsive changes in fluorescence spectra in a dynamic and reversible manner. However, key limitations of these materials include leaching of reagents from the nanoparticles over time, combined with poor colloidal stability in biological fluids. Organosilica is a promising material for developing stable biosensors, allowing simple control over size, interfacial chemistry and porosity. This presentation will describe the development of a core-shell nanoparticle containing a mixture of covalently incorporated pH-sensitive (shell) and pH-insensitive (core) fluorescent dyes. Fluorescent analysis of the resulting nanoparticles reveal that the ratio of the fluorescent intensities is highly sensitive to pH over a physiological range. Anti-fouling polymers can also be coated onto the surface to reduce aggregation and biofouling. Here we will present our latest results developing this organosilica platform.

Reference


Biography

Kye completed his BSc in chemistry with 1st Class Honours at the University of Queensland. He then commenced his PhD in nanoparticle-based biosensors in the ARC Centre for Bio-Nano Science, moving to Monash University and joining the Nanosensor Engineering Lab.
**NOVEL ADSORBENT-CELLULOSE FIBRE COMPOSITES FOR LIQUID FILTRATION**

Aysu Onur¹, Warren Batchelor¹, Gil Garnier¹

¹BioPRIA

**Abstract**

Liquid filtration is widely used in food and beverage applications. Depth type composite filter mediums, which are porous materials heavily loaded with adsorbents, find a range of applications. These adsorbent filled filter products remove contaminants from liquids by both mechanical entrapment and adsorption. Even though existing products are commercially available, there is still a need of development for high performance filter products with selective adsorption.

In this study, absorbents were fabricated by embedding zeolite particles into cellulose fibre matrix, where composites were structured into flat sheet configuration by papermaking technique. A retention mechanism for the zeolite particles was developed to achieve composites with high loading of adsorbents. Characterization on mechanical properties and structure was performed. The effect of polyelectrolyte addition on wet strength was quantified. Adsorption and filtration characteristics were quantified by using a laboratory benchmark system on removal of suspended particles and solute molecules from aqueous solution. Furthermore, relationship between permeation flux, porosity, pressure drop and adsorption/filtration characteristics was quantified. The performance of products with nanocellulose as a potential full or partial substitute for the fibre matrix was also investigated.

**Biography**

Aysu completed her Bachelors degree in Chemical Engineering department at Istanbul Technical University in 2013. She also received a Masters degree in Engineering Management from Deakin University in 2015. Aysu is currently working on a GRIP (Graduate Research Interdisciplinary Program) PhD project- Novel structured adsorbents for liquid filtration, under supervision of Dr. Warren Batchelor and Prof. Gil Garnier, with 3M industry partnership.