MONASH University

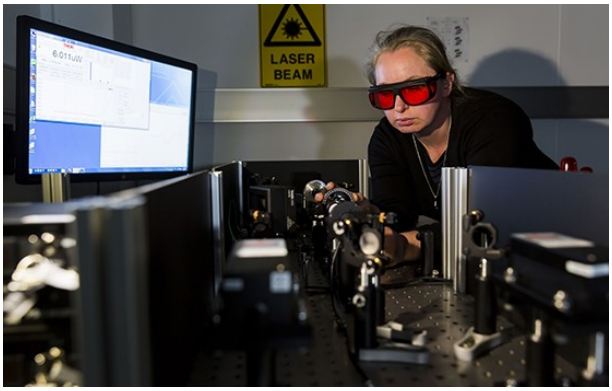
PALS PROCESSING ADVANCED LIGNOCELLULOSICS

BioPRIA NEWSLETTER

Dec 2019

Saving Lives Faster: Monash Develops World-First Laser Incubator for Blood

Researchers from BioPRIA, together with industry partner Haemokinesis have developed the world's first blood incubator using laser technology. This could prevent fatal blood transfusions in critically ill patients, and can detect antibodies in pregnant women that can kill a foetus.



Dr Clare Manderson and research colleagues from BioPRIA, based at Monash University, have developed the world's first blood incubator using laser technology.

According to results published in Nature's Scientific Reports, these findings could bring pre-transfusion testing out of the pathology lab to point-of-care, with blood incubation time slashed to just 40 seconds, compared with the industry gold standard of five minutes. This breakthrough has the potential improve the pre-transfusion testing of millions of patients undergoing blood transfusions across the world, especially those having major surgery, going into labour, or causalities of mass trauma and individual trauma.

The detection of immunoglobulin G (IgG) antibodies requires incubation at 37° C, often for up to 15 minutes. But current incubation technology relies on slow thermal procedures, such as heating blocks and hot-water baths. This delay adds to pathology costs and turnaround time, which substantially affects a patient's chance of survival. To address this problem, BioPRIA's blood diagnostics team developed a laser incubation model where a targeted illumination of a blood-antibody sample in a diagnostic gel card is converted into heat, via photothermal absorption. The laser-incubator heats the 75 µL blood-antibody sample to 37°C in under 30 seconds. Most importantly, no significant damage is detected to the cells or antibodies for laser incubations of up to 15 minutes.

The study was led by **Dr Clare Manderson from the Bioresource Processing Institute of Australia (BioPRIA)**, located within the Department of Chemical Engineering at Monash University, in conjunction with blood diagnostics manufacturer Haemokinesis. "Laser incubation can be extremely valuable when time and accuracy is vital, especially in critical and emergency settings – like mass trauma – where pre-transfusion testing needs to be performed quickly in order to save lives," Dr Manderson said. "We show that red blood cells act as photothermal agents under near-infrared laser incubation, triggering rapid antigen-antibody binding with no significant damage to the cells or antibodies for up to 15 minutes. This study demonstrates laser-incubated immunohaematological testing to be both faster and more sensitive than current best practice, with clearly positive results seen from incubations of just 40 seconds."

The article titled "Photothermal incubation of red blood cells by laser for rapid pre-transfusion blood group typing", was authored by Dr Clare Manderson, Heather McLiesh, Rodrigo Curvello and Professor Gil Garnier (Engineering, Monash University); Associate Professor Rico Tabor (Chemistry, Monash University) and Jim Manolios (Haemokinesis). The research was supported by the Australian Research Council Linkage Project LP110200973 and Haemokinesis Pty Ltd.

To download a copy of the research paper, visit **https://www.nature.com/articles/s41598-019-47646-y**

To hear **Ross & John's 3AW** breakfast show live interview with Dr Clare Manderson click below: https://podcasts.apple.com/au/podcast/3aw-breakfast-with-ross-and-john/id289570515?mt=2

Distinguished Seminar - Colour Engineering: from nature to applications

A/Prof Silvia Vignolini

BioPRIA was proud to host a Distinguished seminar on the 6th of November 2019, by A/Prof Silvia Vignolini from University of Cambridge, UK. The seminar was open to students, researchers and staff of Monash Chemical Engineering, to share insights and further knowledge. It provided a chance to meet with like-minded colleagues and peers.

In this seminar, A/Prof Vignolini introduces some striking example of natural photonic structures [1-3] and review the recent developments to fabricate bio-mimetic photonic structures using the same material as nature. Biomimetic with cellulose-based architectures enables us to construct novel photonic structures using low cost materials in ambient conditions [4-5]. Importantly, it also allows us to understand the biological processes at work during the growth of these structures in plants.

[1] Vignolini, S. et al. (2012). Pointillist structural color in Pollia fruit. PNAS 109, 15712-15716.
[2] Moyroud, E. et al. (2017). Disorder in convergent floral nanostructures enhances signalling to bees. Nature 550, 469.
[3] Burresi M. et al. (2014) Bright-White Beetle Scales Optimise Multiple Scattering of Light. Sci. Rep. 4, 727
[4] Parker R. et al. (2016). Hierarchical Self-Assembly of Cellulose Nanocrystals in a Confined Geometry. ACS Nano, 10 (9), 8443–8449
[5] Liang H-L. et al. (2018). Roll-to-roll fabrication of touch-responsive cellulose photonic laminates, Nat Com 9, 4632

Chemical Functionalisation of Nanocellulose for High-Value Applications

Trends in sustainability have driven the quest to synthesise fine chemicals and functional materials from natural resources. Over the past years, nanocellulose has been considered as promising nanomaterial to design functional materials, owing to its abundance, renewability, excellent mechanical and optical properties, and tunable surface chemistry.

David Mendoza, working on his experiment at the CEBB lab in AgroParisTech

My PhD research project at BioPRIA focuses on exploring novel and green chemical methods to modify nanocellulose with valuable properties. The ultimate goal of the project is to fabricate engineered nanocellulosic materials with novel properties for potential use in a wide variety of applications. These include nanocellulose gels with potential use in biomedical, agricultural and food packaging applications.

As a starting point, I have explored carboxylation reaction to functionalise cellulose as it has been suggested that high degree of carboxylation affects the properties of nanocellulose gels. Together with my colleagues at BioPRIA, I have published work on the development of a one-shot carboxylation protocol that produces low-cost cellulose with controlled level of carboxylation and unique properties. The study also demonstrated how the degree of substitution governs the solubility of carboxylated cellulose. I am investigating how the visco-elastic and optical properties of the resulting nanocellulose gels are influenced by the one-shot reaction; and the functionalisation of nanocellulose with bio-based phenolic compounds.

At the moment, I am undergoing an intensive three months internship at the European Center of Biotechnolocy and Bioeconomy (CEBB) where URD-ABI-AgroParisTech is located. In collaboration with Prof. Florent Allais and Dr. Louis Mouterde, we are exploring novel chemo-enzymatic routes to integrate bio-based phenolic compounds on nanocellulose and impart anti-UV and anti-microbial properties.

This PhD has provided a good platform to hone my technical skills and to connect with experts around the world. I am forever grateful to have my very enthusiastic research team and our industry partners for their constant support.

About David Mendoza

David Mendoza obtained his Bachelor of Science in Chemistry at the University of the Philippines-Los Banos in Laguna, Philippine. He started his PhD study at Monash University in August 2018, under the supervision of Prof Gil Garnier and Prof George Simon. His work focusses on the development of nanocellulose gels from functionalised nanocellulose for high value applications.

Further Reading:

Mendoza DJ, Browne C, Raghuwanshi VS, Simon GP, Garnier G. One-shot TEMPO-periodate oxidation of native cellulose. Carbohyd Polym. 2019:226:115292.

Collaborative Research Abroad at the University of Cambridge

Michael Hertaeg - outside the King's college chapel in Cambridge

Several months ago, I was invited to collaborate with a research team at the University of Cambridge as part of my PhD. This involved spending three months in the UK and working with Prof. Alex Routh's group at the BP institute for multiphase flows (BPI). The BPI is a multidisciplinary research platform within the university with many similarities to BioPRIA in organisational structure and industry-based funding schemes. The research spans a range of subjects including volcano dynamics, ocean mixing, micro-encapsulation and thin film stratification.

At home, my research focusses on the fluid flow behaviour in low-cost paper-based diagnostic devices. However, the goal of my research while overseas was to numerically investigate a different kind of low-cost diagnostic based on visual inspection of dried blood droplets on a range of surfaces. This is intended to assist in the diagnosis of anaemia, however it has applications to a range of blood disorders. Specifically, my work involved developing a numerical model to predict the evaporation induced fluid flow and final height profile of drying blood droplets on different surfaces, and how this is effected by the properties and concentration of red cells.

During my stay I was a part of Gonville and Caius College, this is one of the larger colleges at the university and is known for having several notable alumni including Steven Hawking and a very active and successful rowing team which was a highlight of the trip for me. It was a fantastic opportunity for me to experience life at such a prestigious and historic university. I'd like to thank Prof Alex Routh for the invitation and my supervisors at home, Prof Gil Garnier and A/Prof Rico Tabor for their support. My stay allowed me to develop skills in numerical modelling that will assist me in the remainder of my PhD and my professional life beyond.

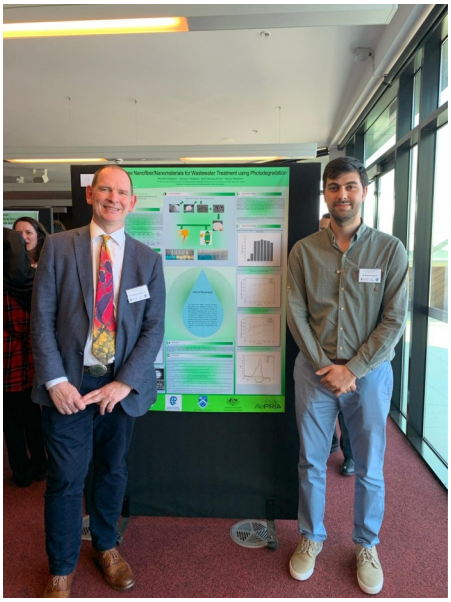
Conferences Highlights

Kirubanandan Shanmugam at the IUMRS-ICA 2019.

A/Prof Warren Batchelor, Dr Christine Browne and BioPRIA student **Kirubanandan Shanmugam** attended the *20th International Union of Materials Research Societies International Conference in Asia* (IUMRS-ICA 2019) in Perth, WA, 22-26 September. This would be the largest gathering of materials-focused researchers in the Asia Pacific region for 2019. The meeting brought together all scientists and engineers interested in all aspects of the field from theory/modelling to experiment including synthesis, fabrication, characterization, processing and manufacturing. Symposia themes will include Electronic and Optical Materials, Energy and Environmental Materials, Biomaterials, and Advanced Functional and Structured Materials, spanning scales from nano to macro and hard materials to polymers. Dr Browne delivered a presentation on "Micropatterning cellulose-based materials for the creation of high performance products", while Kiru presented his work on "Barrier Performance of Spray Coated Cellulose Nanofiber Montmorillonite (MMT) Composites."

9th Annual Chemical Engineering Postgraduate Association (CEPA) Conference

The 9th Annual CEPA Conference was held on 31st October at Monash University, Clayton. It was an opportunity to meet, greet and interact with fellow members of the scientific community of the Faculty of Engineering. Since 2011, the CEPA conference has been run by students as an opportunity to showcase the wide range of research within the department. Chemical Engineering at Monash covers a wide range of topics, from nanomaterials and computational modelling to biotechnology and food engineering. The CEPA conference provides a unique opportunity to learn about research in a range of fields, which encourages cross-disciplinary work.



Mostafa Dehghani, together with Prof Mark Banaszak Holl (Head of Department of Chemical Engineering) at the CEPA poster presentation

This year's conference has been opened up to welcome other Departments within the Faculty of Engineering at Monash University, and other universities conducting research within the field of Chemical Engineering. We had over sixty delegates, ranging from a wide range of different disciplines, over five universities; each presenting within the conference themes of Fuels and Energy, Biotechnology, Food Engineering, Nanomaterials, Modelling, Membranes, and renewable and Sustainable Engineering. In addition, we were grateful to have Dean of Engineering Elizabeth Croft, R&D manager at Simplot Australia - Dr Jocelyn Midgley and Dr Joanne Tanner of BioPRIA to deliver the keynote speeches.

We are very proud with our students' participation and achievements in this conference. Congratulations to the winner of "Biotechnology" theme- **Michael Hertaeg** (BioPRIA) who gave very confident and professional presentations. Michael is awarded with a certificate of congratulations and a $1000 conference travel prize. We also want to congratulate **Mostafa Dehghani** (BioPRIA/PALS) for receiving the people's choice award for his poster presentation. He is awarded with a $75 worth of Chemical Engineering merchandise.

Here are some snapshots from the CEPA conference. Enjoy!