THEME: RENEWABLE AND SUSTAINABLE ENGINEERING

NOOSHIN ASADI

SCHOOL OF CHEMICAL ENGINEERING, MONASH UNIVERSITY

I am currently a PhD student in my first year, working under the supervision of A/prof. Akshat Tanksale and A/prof. Andrew Hoadley in the "catalysis for green chemicals" group. Before joining my PhD at Monash University, I accomplished my undergraduate and master's degree from Isfahan University of Technology, Iran in 2013 and 2016, respectively. My master's degree research title was "biological hydrogen production from enzymatic hydrolysate of organosolv pretreated rice straw using Enterobacter aerogenes". I received the best master's thesis award at Isfahan University of Technology in 2016. My current research focuses on "optimisation and techno-economic assessment of formaldehyde production via hydrogenation of syngas". I am very keen to enhance my skills in experimental, simulation, and modelling aspects of chemical engineering during my PhD.

IMPROVEMENT OF FORMALDEHYDE PRODUCTION YIELD VIA HYDROGENATION OF SYNGAS USING IONIC LIQUID

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Formaldehyde production from natural gas is associated with a high loss of energy and high CO_2 emissions. Producing formaldehyde from renewable resources such as syngas, on the other hand, has a lack of a suitable yield to be used in an industry scale. Our previous work revealed the possibility of formaldehyde production from syngas in liquid media because of the negative Gibbs free energy in comparison with gas phase. The development of a method based on the use of renewable resources can be considered as a promising alternative to the current technologies based on non-renewable feedstocks. However, given a lower yield, this process is not still competitive with natural gas-based processes. In this research, the effect of 1-Butyl-3-methylimidazolium acetate as a basic ionic liquid in various amounts (0.2-2 gr), temperatures (80-120 °C), and time (8-48 hrs) in 30 ml of methanol solvent using 0.5 gr of Ru-Ni on β-Zeolite catalyst on the synthesis of formaldehyde in liquid phase has been investigated. The highest yield of formaldehyde production was found to be 22.86 mmol L^{-1} g_{cat}^{-1} indicating 49.60% increase compared to the reaction in absence of this ionic liquid.

STEFAN BUERGMAYR

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After my studies in Paper Technology (Beng & Meng) at the Munich University of Applied Sciences, I worked as process engineer in paper production and as start-up engineer in the paper and biogas sector. As my first job was to run a pilot plant for industrial waste water treatment, I decided to join BioPRIA to do my research on a pilot plant for waste water recycling.

NOVEL STRATEGIES OF ADVANCED WATER SYSTEM CLOSURE OF RECYCLED PAPER MILLS

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As global water scarcity intensifies, production costs for water intense industries increase and water system closure becomes a crucial process optimization measure. The pulp and paper industry realized substantial water savings between the 1960's and 2000, making it a great example for successful industrial water stewardship. Nevertheless, the paper sector still counts to one of the largest commercial fresh water consumers. To maintain productivity of high-speed machinery and product quality, every production line has its specific limitation to system closure before negative effects due to highly saturated process waters outweigh ecological and economic advantages from water savings. Currently used technologies efficiently remove suspended solids from process waters but cannot prevent colloidal and dissolved substances from accumulating and consequently adversely affect machine performance and product quality. To overcome limitations to system closure, innovative ideas need to be developed. Visy Industries as one of the world's leading paper recycling companies, designed and built a pilot plant that allows to investigate a novel concept for water reclamation for the ultimate goal of 'zero liquid discharge'.

RABEEH GOLMOHAMMADZADEH

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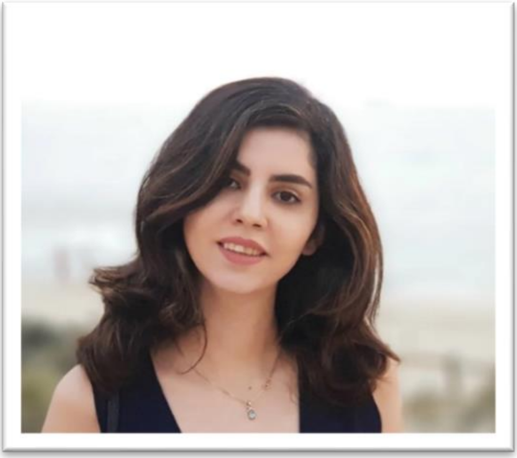

Rabi is a passionate PhD student working in the field of sustainability, focusing on recycling of lithium-ion batteries for high-value products. She has been working on e-waste recycling since 2014 across multiple universities. Her broader interests are production of high purity materials from spent lithium ion batteries applicable in different industries.

SEPARATION OF GRAPHITE AND METAL OXIDES IN SPENT LIBS USING FROTH FLOTATION

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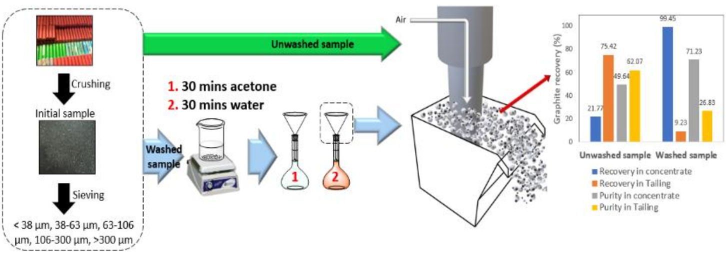
Due to the population growth, recycling of secondary resources such as spent lithium-ion batteries (LIBs) has been increased. This work is significant mostly because of recovering the elements embedded within spent LIBs, toxic materials for humans, flora, and fauna, from a municipal waste, which leads to reducing e-waste sent to landfills. This will also reduce the demand for new precursors from natural resources, which sustains the environment for future generations and drops the frenetic pace of water, soil, and air pollution. However, despite the urgent need of the modern world for such studies, very few research studies have investigated the complete recycling procedure from waste to pure product(s). In this study, a flotation process at room temperature was used to separate graphite and metal oxides based on the surface characteristic of the elements in spent LIBs. Effect of parameters such as particle size (38 µm -500 µm), pH (6-10), type of frother (Eucalyptus oil, MIBC, None), collector and frother dosage (0-2000 g/t), and pulp density (20-100 g/L) on the flotation experiments was studied. Besides, some of the samples washed with acetone and water indicate the elimination of organic binders covering the surface of the particles in the flotation process. The results from flotation experiments revealed that particle size is the most influential parameter as compared to the other parameters. Besides, washing with acetone and water increases the graphite recovery from ca.21.77% to ca. 99.45% and enhances the purity of the graphite from ca.49.64% to ca.71.23%.



LAILA HOSSAIN

SCHOOL OF CHEMICAL ENGINEERING, MONASH UNIVERSITY

Laila is currently a second year PhD student, having completed her Bachelors at Bangladesh University of Engineering and Technology (BUET). She is currently working on a Graduate Research Industry Partnerships (GRIP) PhD project in the Department of Chemical Engineering, in partnership with Meat and Livestock Australia (MLA). Her research interest are absorption phenomenon, rheology, food and environment engineering, and product development. After completing her PhD, she hopes to carry on her passion for research by joining a university or working in an industrial R&D position.

STRUCTURE ANALYSIS AND SWELLING PHENOMENON OF PHYSICALLY AND CHEMICALLY MODIFIED NANOCELLULOSE FOAM

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Nanocellulose (NC) is a renewable and biocompatible nanomaterial with high surface area and low density. Functionalised NC based foam can be used as superabsorbent material for food industry, agricultural section and biomedical application for its availability and renewability. The objective of this study is to develop a technique to successfully quantify swelling behaviour of nanocellulose foam.

NC foam was prepared by TEMPO oxidation followed by high pressure homogenisation and freeze-drying. The swelling of the NC foam is tailored by incorporating the physical (Polyethyleneimine: PEI) or chemical (Hexamethylenediamine: HMDA) crosslinker. The NC foam absorbs the highest water amount of 120 g/g foam. PEI-Cellulose have a water absorption capacity of 60 g/g foam, which further decreases to 50 g/g foam for the HMDA-cellulose. Foam from NC, PEI-cellulose and HMDA-cellulose have variable pore sizes ranging between 10 to 200 nm as observed by SEM. Small angle scattering reveals the individual cellulose ribbon unit is 4-5 nm thick and forms fibre bundles. In water, these bundles swell differently for different types of foams and affects the water absorption capacity of the network. Water penetration in the NC fiber swells up the fibre bundle to 19.5 nm, which increases further for the PEI-cellulose (25 nm). However, HMDA hinders the water penetration in the bundles and the diameter decreases to 15 nm.

This study quantifies fibre size, pore size and structural change for dry and wet foam which can be helpful for NC based superabsorbent application to relate absorption phenomenon with the NC foam structure. Understanding the structure may help to engineer the structure for the desired application.

YE KANG

DEPARTMENT OF CIVIL ENGINEERING, MONASH UNIVERSITY

Ye Kang is currently a PhD candidate in Department of Civil Engineering in Monash University in Melbourne Australia. He received his Bachelor degree in Civil Engineering from Tongji University (China), and his Master in Civil Engineering from Karlsruhe Institute of Technology (Germany). He pursues his research through a combination of laboratory experiment, field monitoring, data analysis and modelling.

QUANTIFY THE INDOOR AIR QUALITY OF PASSIVE HOUSE DESIGN STANDARD VIA LOW-COST SENSING TECHNOLOGIES

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Building sustainability is an important factor in the urban built environment. The concept of Passive House is a holistic approach to attain a quantifiable and rigorous level of energy efficiency within a specific quantifiable comfort level under a "fabric first" design philosophy. While there is an increasing number of projects had attempted to engage Passive House design concepts, the information regarding indoor air quality (IAQ) is very limited.

The recognition of indoor air quality can be attributable to the fact that modern humans spend about 90% of their time indoors. Poor IAQ has been associated with both acute health and well-being effects such asthma, irritation, and headache, as well as chronic effects such as cancer[1].

Air Pollutant concentration is crucial information to evaluate the built environment and assess the potential impacts to human health and well-being. The advancement of low-cost sensing technologies offers a new dimension of collecting indoor air quality metrics[2]. Compared to the instruments in government-operated monitoring network, the low-cost assessment products can be used in the scaled-up monitoring to capture small spatial scale and high temporal variation of air pollutants in complex indoor environments.

References

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WRIJU KARGUPTA

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I have a biochemical engineering background with bachelor's in Biotechnology from NIT Durgapur, M.Tech in Environmental Science & Engineering from IIT Bombay and currently in my second year of PhD in Chemical Engineering.

ENERGY EFFICIENT PRODUCTION OF NANOCELLULOSE

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It is still challenging to cost effectively produce nanocellulose due to the high electrical energy consumption of mechanical treatment. The aim of this study was to investigate the potential to decrease the specific energy consumption (SEC) of mechanical treatment of a i) a softwood, bleached chemical pulp and ii) a bleached eucalypt kraft while optimising strength. Also, three different mechanical treatment methods were investigated: i) an industrial disk refiner, ii) a PFI mill and iii) an homogeniser.

For each mechanically treated sample, fibre quality was determined by i) fibre diameter measured by SEM, ii) aspect ratio measured by sedimentation and iii) fines fraction from screening in a 200-mesh screen. All three mechanical treatments showed that nanofibre quality increased with mechanical energy input. The disc refining process was the most energy efficient, with homogenisation being the least energy efficient process.

The results showed that for each mechanical treatment, there was a plateau beyond which further mechanical energy input did not improve the sheet strength. For example, the plateau strength achievable with disk refining was around 90 Nm/g at 1600 kWh/t. This paper will discuss the possible causes for this plateau and the limits of classical models of paper mechanics to explain the results. In addition, it will discuss and compare the energy efficiency of laboratory scale mechanical treatment with industrial scale refining. Finally, the paper will discuss the application of the results to limit the mechanical energy consumption, and therefore cost, of nanocellulose production.

HUMAYUN NADEEM

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Humayun graduated from University of Engineering and Technology, Lahore, Pakistan with a first class honors in his Bachelor of Chemical Engineering degree. Then he completed his Master of Engineering Science (Research mode) from Universiti Tunku Abdul Rahman, Malaysia in 2017. He became a PhD candidate at BioPRIA under the supervision of Associate Professor Warren Batchelor and Professor Gil Garnier, working on research project funded by “The ARC Industry Transformation Research Hub (PALS)” and in collaboration with AgroParis Tech. Humayun’s research aim is to modify an existing spray coating method for the production of nano-cellulose films and exploring the multidisciplinary applications of nanofibers.

HEAT DRYING AS A NOVEL METHOD TO SPEED-UP THE PRODUCTION OF NANOCELLULOSE-BASED FILMS IN SPRAY DEPOSITION TECHNIQUE

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Nanocellulose (NC) and NC-based composites have gained considerable attention in recent years due to their biodegradability and recyclability. Spray coating has emerged as a potential technique to produce NC films due to the rapidity and simplicity of the process. The major hurdle regarding the efficient production of NC-based films is the drying process. The aim of the current study is to significantly reduce the drying time of NC films and consequently examine the impact of drying on their mechanical characteristics, barrier and environmental performance. The NC films produced by spray-coating were dried at 50° C, 75° C and 100° C and their characteristics were compared with the films produced via the same method at ambient temperature. Heating the films in an oven up to 75° C had negligible effect on mechanical characteristics while slightly improving the barrier properties as compared with the ambient dried films. However, the dimensional stability was only achieved when the temperature was below 75° C. Drying could be accomplished in as low as 2 hours and the NC films found to have lower embodied energy in comparison with the conventional packaging materials.