Cohort (2020-2022) ARC ITRH PALS
Project descriptions

Project 1: NSSC/Kraft Lignin as building block for value chemicals and polymers
Main supervisor: Antonio Patti
https://research.monash.edu/en/persons/antonio-patti

This project aims to transform pulp lignin into valuable chemical intermediates and polymers. Lignin will be recovered from model and industrial pulping liquor and selectively processed into well-defined monomers using robust and scalable chemistry and technology solutions. Lignin-derived molecules will be characterized and explored to determine their potential for strategic chemical transformation into value chemical intermediate or product. Applications of interest include: paper coating, phenolic replacements for adhesive, and agriculture aids.

Project 2: Engineering paper and cellulosic materials for biomedical applications
Main supervisor: Gil Garnier
https://research.monash.edu/en/persons/gil-garnier

This project aims to develop cellulose-based performant and cost-effective medical and biomedical devices and products. Laminate and coated paper materials will be developed for biomedical application products including surgery gowns and sterile drape sheets. Cellulosic gels will be developed for biomedical applications including organoids growth, cell culture and bio-diagnostics. Nanocellulose and hemicellulose oligomers may also be investigated in conjunction with the paper and gel materials to develop advanced solutions to key challenges in the biomedical industry.

Project 3: Lignocellulosic fibres for sustainable agriculture
Main supervisor: Gil Garnier
https://research.monash.edu/en/persons/gil-garnier

This project aims to develop circular economy solutions to produce performant and cost effective agricultural solutions using recovered biomass, wood residue and fibre. Challenges on a global scale with significant and expending markets (over 100T/D) that address the changing needs of Australia will be targeted. Example applications include the use of lignocellulosic materials, bio-polymers (cellulose, lignin), wood fibres, and forest residues as soil hydro-retentor, controlled release fertilizer substrates, and intelligent mulch for weed control. These solutions will offer improved biodegradability and improved water and fertilizer uptake or release, optimizing action of fertilizers and the micro-organism cycle.

Project 4: Processing recycled fibres into high value products
Main Supervisor: Joanne Tanner
https://research.monash.edu/en/persons/joanne-tanner

This project aims to recover and reuse cellulose fibres that are below the required quality for paper production. Applications may include novel concrete composites for the construction industry, blending with various clay and natural polymer materials to produce a green plaster-board substitute and use as a raw material for the production of micro-fibrillated cellulose (MFC). MFC will subsequently be investigated for its potential for integration into paper products to improve strength while maintaining industrially acceptable sheet drainage times and preserving re-pulpability and recyclability.

Project 5: Functional paper packaging (2 students)
Main supervisor: Warren Batchelor
https://research.monash.edu/en/persons/warren-batchelor

This project aims to produce high performance packaging materials and functional barriers from cellulose fibre to replace current synthetic polymer and plastic layers and barriers in used in current paper packaging solutions to provide air and moisture barriers. Laminate paper for intelligent packaging will be created to control ripening and maturation of food (cheese, meat, fruits). Selective coating barriers (air, O_2, water vapour, water, blood, oil/fat) will be investigated for application on paper packaging products. Wax will be explored as a recyclable coating or additive that provides waterproofing properties to a corrugated paper board structure. Replacement of mineral oils used as barrier additives in recycled papers. Developing fibre-based packaging solutions for high humidity performance while maintaining mechanical integrity.

Project 6: Paper as a performant construction materials
Main supervisor: Gil Garnier
https://research.monash.edu/en/persons/gil-garnier

This project aims to develop paper materials with competitive insulation properties for noise, heat, fire and electricity for application as construction materials. Structured paper and nano- or micro-fibre applications will be explored for heat insulation and noise dampening. Mechanically strong and water resistant paper and board materials will be developed for panelling applications. The wet and dry strength relationships for various MFC and NFC materials will also be investigated.

Project 7: New functional molecules from lignocellulose for advanced applications
Main Supervisor: Kei Saito
https://research.monash.edu/en/persons/kei-saito

This project aims to investigate new functional molecules and explore emerging technologies for the transformation and upgrading of lignocellulose-derived molecules. UV curable and depolymerized monomer reaction schemes with a basis in lignin chemistry will be investigated for self-healing and other advanced coating applications. Functional chemicals and materials will be developed by applying a combination of enzymatic and other green reaction methods to lignin, hemicellulose and cellulose components of lignocellulosic biomass. Lignin from industrial pulping liquor will also be used as a starting material to investigate its potential for recovery of hemicellulose, nanocellulose fibres and gel-forming compounds.

Project 8: Hemicellulose as a chemical intermediate
Main supervisor: Joanne Tanner
https://research.monash.edu/en/persons/joanne-tanner

This project aims to extract, characterize, fractionate and process hemicellulose from Australian lignocellulosic biomass (pine and eucalypt) for chemical conversion and direct applications. Biomass pre-treatment method will be developed, optimized and applied to extract hemicellulose prior to mechanical pulping, with sufficient subtlety to retaining the cellulose and lignin fractions in a near-native form. The extracted hemicellulose will be subjected to enzymatic reactions to produce oligomers and specific molecules of commercial interest in the biomedical, food, surfactant and fine chemicals industries.

Project 9: Engineering nano/micro-cellulose fibre and production processes
Main supervisor: Warren Batchelor
https://research.monash.edu/en/persons/warren-batchelor

This project aims to develop a range of micro- to nano-sized cellulosic materials production processes and investigate and optimize the specific product properties and opportunities. Processes and parameters that deliver the full range of micro- to nano-sized fibrillated fibres with respect to length, aspect ratio and specific surface area will be pursued for a range of feedstocks. The feedstock-property relationships will be determined, and mechanical processing will be targeted due to its potential to reduce energy, fibre and water utilisation.

Project 10: **Surface engineering of nanocellulose and nanoparticles for applications**
Main Supervisor: Warren Batchelor
https://research.monash.edu/en/persons/warren-batchelor

This project aims to develop sustainable, biodegradable and recyclable alternatives for polymer films and aluminium laminate composites via surface application of nanomaterials and biopolymers. Spray coating will be the main mechanism of formation of the product sheets and coatings. Material permeability, strength, wettability, conductivity and optical properties will be ascertained and tuned for specific applications.