MONASH University

MONASH ENGINEERING

Faculty of Engineering

ASPIRE Summer Research Program 2026-2027

Project Title: Biopolymer Nanoparticles for Hydrophobic Anticancer and Parkinson's Drug Delivery

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Objective

Many established drugs fail not for lack of efficacy but because too little of the administered dose reaches its target, a problem that is acute in both pulmonary oncology and neurodegenerative disease. Doxorubicin and related anticancer agents delivered systemically reach lung tumours poorly and carry dose-limiting cardiotoxicity, making local lung delivery an attractive alternative. In Parkinson's disease the therapeutic requirement is replacement of lost striatal dopamine, but dopamine itself does not cross the blood–brain barrier. Levodopa is given as a precursor, but is extensively decarboxylated in the periphery before reaching the brain, so only a small fraction of the administered dose is effective.

Encapsulation in a nanoparticle vector addresses both problems, but the established carriers are poorly suited to repeated dosing. Common nanoparticles such as poly (lactic- co -glycolic acid) (PLGA) degrades to lactic and glycolic acid and provokes local inflammation, while ionisable lipid nanoparticles elicit inflammatory and immune responses on repeat administration. Polyhydroxyalkanoates (PHAs) are 3 carbon backbones biopolymers that offer an alternative: they exhibit low toxicity, degrade to endogenous metabolites and are produced by bacteria that can be grown on waste feedstocks.

In this summer research program, *C. necator* and *P. putida* bacteria will be fermented on oil feedstocks to produce PHAs of differing monomer chain length. These polymers will be sonicated with poly(2-ethyl-2-oxazoline) (PEtOx) to form nanoparticles, and loaded with doxorubicin or levodopa. The objective is to produce the polymers and resulting nanoparticles, and to investigate their size, stability and encapsulation capability.

Project Details

This project spans microbial fermentation, polymer characterisation and nanoparticle formulation, and is structured in three stages.

Stage 1. Biopolymer production: The student(s) will culture *Cupriavidus necator* H16 and *Pseudomonas putida* KT2440 bacteria on oil-based feedstocks under nitrogen limitation in shake flasks to drive PHA accumulation. These bacteria produce medium-chain-length PHA, giving two materials of contrasting crystallinity and chain mobility from the same feedstock. The polymer will be recovered by solvent extraction and the monomer composition determined by GC-MS, with molecular weight and dispersity measured by GPC. This will be completed in the Student Analytical Makerspace and Pilot Lab (SAMPL), while GCMS and GPC will be completed via the Chemistry Core.

Stage 2. Nanoparticle formulation: The recovered PHAs will be formulated into nanoparticles by sonication in the presence of poly(2-ethyl-2-oxazoline) (PEtOx), which acts as a stabiliser and a non-PEG alternative for surface shielding. Doxorubicin and levodopa will be incorporated during formulation. The student(s) will systematically vary polymer type, polymer-to-drug ratio and PEtOx content to map the formulation window.

Stage 3. Characterisation: Particle size and dispersity will be measured by dynamic light scattering and surface charge by zeta potential, with colloidal stability assessed across a physiologically relevant pH range. Encapsulation efficiency and drug loading will be quantified using fluorescence microscopy.

Skills the student will develop: Sterile technique and bench-scale fermentation, solvent extraction and polymer recovery, GC-MS and GPC sample preparation and data interpretation, nanoparticle formulation by sonication, DLS, zeta potential and fluorescence microscopy, quantitative data analysis and scientific reporting.

Project Timeline

TASK	1	2	3	4	5	6	7	8	9	10
Literature Review										
RA & SWI Development										
Training and Inductions										
Bacterial Fermentation										
Polymer Extraction										
Polymer Characterisation										
Nanoparticle Formation										
Nanoparticle Characterisation										
Encapsulation Efficiency										
Write up of work										

Prerequisites

Applicants must be enrolled in third year or above. Preference will be given to students undertaking a double degree in Pharmaceutical Science and Chemistry. Completion of CHE2871 and/or CHE4171 is also preferred.

Student Placement Agreement

A student placement agreement must be signed by the project supervisor and the student prior to commencement of the ASPIRE program.

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Additional Information

Applicants may be required to attend an interview.