



# Potent antimicrobial and anti-viral biopolymers

## Collaboration Opportunities

A\*STAR is seeking interest for partnerships in:



### Potential Industry Sectors

- ✓ Aquaculture & Agriculture
- ✓ F&B

### Proposed Collaboration Model

- ✓ Industry Research Collaboration Projects
- ✓ Technology Licensing

## Technology Overview

- Broad spectrum antimicrobial biopolymers
- Anti-viral properties
- Biocompatibility
- Prevention of resistance development
- Low cost and scalability

## Key Differentiating Features

- Broad spectrum
- Short time frame to deactivate microbes
- Do not induce antimicrobial resistance

## Market Potential & Value Proposition

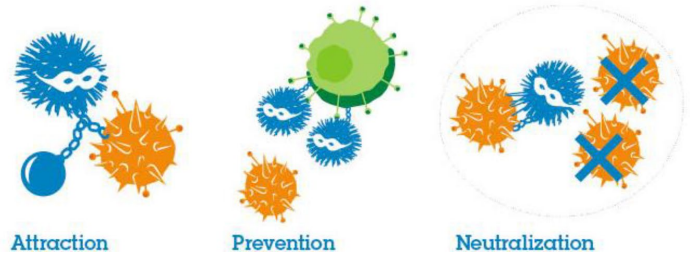
- ✓ Cost-effective antimicrobial and anti-viral biopolymers for aquaculture and agriculture
- ✓ Food security and safety
- ✓ Increase aquaculture and agriculture production through controlling pathogens

## Proposed Products/Services

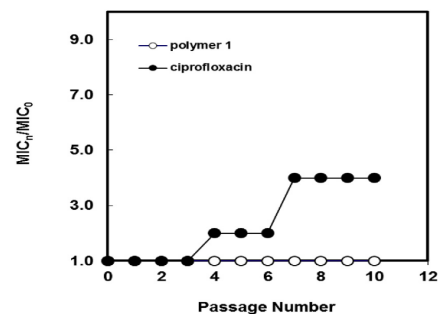
- ✓ Disease prevention
- ✓ Disease treatment

## Intellectual Property

- Patents filed:
  1. Biodegradable polyionenes
  2. Cationic amines for virus treatment
  3. Monomeric ionenes from PET refuse for agriculture
  4. Repurposing PET to functional monomers that can be used to prepare degradable polyionenes



Biopolymer	Minimum Inhibitory Concentration (MIC) (mg/mL)	
	<i>Streptococcus iniae</i>	<i>Vibrio parahaemolyticus</i>
A	32	16
B	4	2



RNA Virus	Virus Family	Cell	Polymer	EC50 <sup>a</sup> (mg/L)	CC50 <sup>b</sup> (mg/L)	Selectivity index (CC50/EC50)
DENV-1	Flaviviridae	LLC-MK2	polymer c	0.20±0.17	>1000	>5000
DENV-2	Flaviviridae	LLC-MK2	polymer c	0.31±0.06	>1000	>3225
DENV-4	Flaviviridae	LLC-MK2	polymer c	0.32±0.02	>1000	>3125
CHIKV	Alfa-viridae	Vero	polymer c	7.0±0.5	>1000	>143
EV71	Enteroviridae	RD	polymer c	1.1±0.1	>1000	>909
Influenza virus (A/H3N2)	Orthomyxoviridae	MDCK	polymer b	1.1±0.3	>1000	>909
Ebola	Filoviridae	A549	polymer a	12.1±6.0	42	3.5
Ebola	Filoviridae	A549	polymer f	4.7±0.8	>1000	>213
Marburg	Filoviridae	A549	polymer f	1.1±0.2	>1000	>909
DNA Virus						
HSV-1	Herpesviridae	Vero	polymer c	1.6±0.2	>1000	>625
HSV-2	Herpesviridae	Vero	polymer c	5.1±0.2	>1000	>196

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# Environmentally Benign Antimicrobial Polymers

## Collaboration Opportunities

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### Potential Industry Sectors

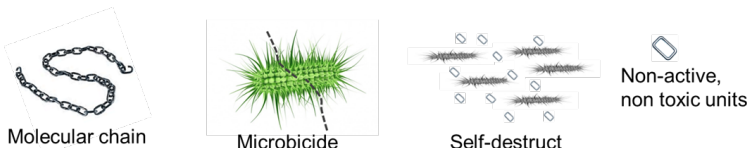
- ✓ Aquaculture & Agriculture
- ✓ F&B
- ✓ Environmental Surveillance

### Proposed Collaboration Model

- ✓ Programmatic Grant Applications
- ✓ Industry Research Collaboration Projects
- ✓ Technology Licensing
- ✓ Technology Validation and Adoption

## Technology Overview

- Broad spectrum antimicrobial polymers
- Eco-degradable under various pH conditions
- Highly water-soluble materials
- Low cost and scalable



## Key Differentiating Features

- Degradation time and conditions can be customized
- Fragments are non-active small molecules
- Do not induce antimicrobial resistance

## Market Potential & Value Proposition

- ✓ Cost-effective green antimicrobial materials for aquaculture and agriculture, F&B and environmental application
- ✓ Contribute to food safety and food security
- ✓ Contribute to mitigate antimicrobial resistance

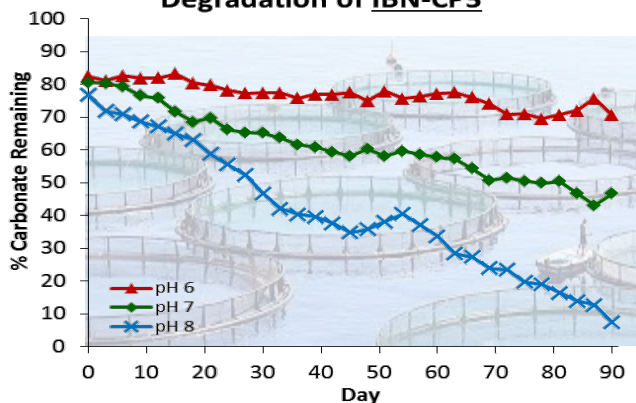
## Proposed Products/Services

- ✓ Disease management and prevention
- ✓ Environment disinfection

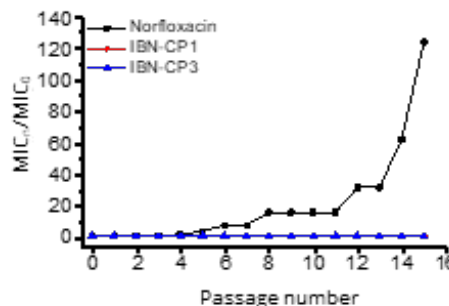
## Intellectual Property

- Patents filed on
  1. Degradable Imidazolium Polymers and Oligomers for Antimicrobial Applications
  2. Acid-Sensitive Degradable Imidazolium Polymers for Antimicrobial Applications

Degradation of IBN-CP3



	MIC (ppm)			
	EC	SA	PA	CA
KY07	8	4	31	16
FMs	2000	2000	>4000	>4000



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# Zebrafish Nutrition and Microbiome Discovery Platform

## Collaboration Opportunities

A\*STAR is seeking interest for partnership in:



### Potential Industry Sectors

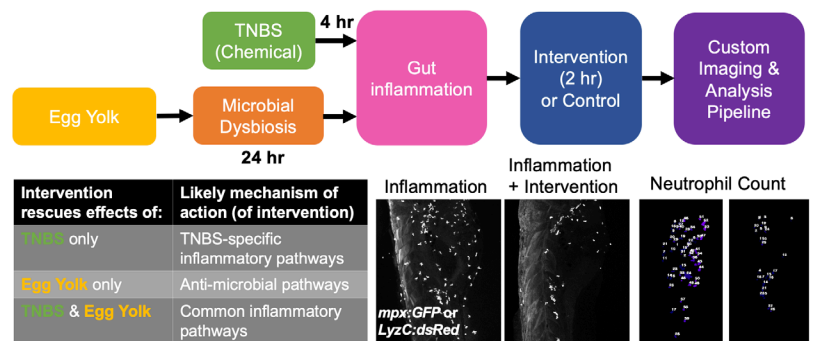
- ✓ Aquaculture
- ✓ F&B
- ✓ Human Health

### Proposed Collaboration Model

- ✓ Programmatic Grant Applications
- ✓ Industry Research Collaboration Projects
- ✓ Technology Validation and Licensing

## Technology Overview

- High-throughput multi-modal zebrafish screening platform
  - Gut Mucosal Immunity
  - Food Intake and Behavior Monitoring
  - Energy Expenditure
  - Growth and Survival
  - Adiposity
- Nutritional / Metabolic Programming
  - Effects on later-life health
- Microbiome
  - Pre- and pro-biotic discovery
- Neuroscience, Neuroendocrinology, Multi-omics and Imaging



**Example of a screening platform for discovery of interventions promoting gut mucosal and microbial health**

## Relevant Publications

1. Cheng, R.-K., Tan, J. X. M., Chua, K. X., Tan, C. J. X. & Wee, C. L. Osmotic Stress Uncovers Correlations and Dissociations Between Larval Zebrafish Anxiety Endophenotypes. *Front. Mol. Neurosci.* 15, 900223 (2022).
2. Wee, C. L. et al. Social isolation modulates appetite and avoidance behavior via a common oxytocinergic circuit in larval zebrafish. *Nat. Commun.* 13, 2573 (2022).
3. Wee, C. L. et al. A bidirectional network for appetite control in larval zebrafish. *Elife* 8, (2019).
4. Wee, C. L., Nikitchenko, M. & Wang, W. C. Zebrafish oxytocin neurons drive nocifensive behavior via brainstem premotor targets. *Nature Neuroscience* (2019).
5. Randlett, O. et al. Whole-brain activity mapping onto a zebrafish brain atlas. *Nat. Methods* 12, 1039–1046 (2015).
6. Purushothaman, K. et al. Feed Restriction Modulates Growth, Gut Morphology and Gene Expression in Zebrafish. *Int. J. Mol. Sci.* 22, (2021).
7. Jordi, J. et al. A high-throughput assay for quantifying appetite and digestive dynamics. *Am. J. Physiol. Regul. Integr. Comp. Physiol.* 309, R345–57 (2015).

## Key Differentiating Features

- High Throughput
- Comprehensive
- Mechanistic
- Discovery of Novel and Effective Dietary Supplements
- Discovery of Novel and Effective Early-life Interventions

## Market Potential & Value Proposition

- ✓ Identification of cost-effective nutritional or probiotic interventions (e.g. natural products)
- ✓ Validation and mechanistic Investigation of screening hits in zebrafish and aquaculture models

## Proposed Products/Services

- ✓ Screening and Validation Services
- ✓ Nutritional / Probiotic Product Development

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# Rapid Microbial Sensors

## Collaboration Opportunities

A\*STAR is seeking interest for partnership in:



### Potential Industry Sectors

- ✓ Aquaculture
- ✓ Agritech
- ✓ F&B
- ✓ Environmental Surveillance

### Proposed Collaboration Model

- ✓ Programmatic Grant Applications
- ✓ Industry Research Collaboration Projects
- ✓ Technology Validation and Licensing

## Technology Overview

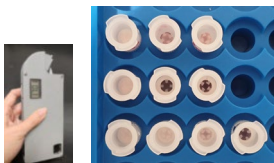
- Nanoparticle based rapid microbial sensors with fast turnover time (< 30 min)
- Coupling microbial cell detection and metabolite detection

## Key Differentiating Features

- Culture-free; enzyme-free
- Customizable nanoparticle reagents' surface functionality for general bacteria counting and for specific bacteria detection
- Portable detector for quantification
- Automated design for remote monitoring

## Proposed Products/Services

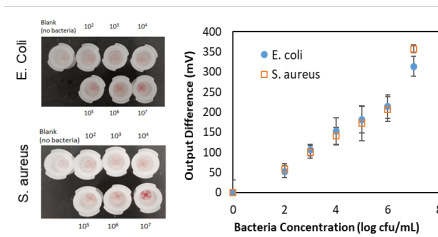
- ✓ On-site bacteria counting for intervention optimization; e.g., aquaculture pathogen control and water treatment analysis



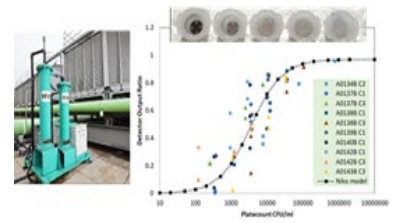
Handheld Bacteria sensor

## Intellectual Property

- ✓ Patents and TDs/Know-hows on:
  - Nanoparticle reagents targeting various bacteria cells
  - Assay protocol for water detection and air detection
- ✓ Prototype handheld sensor and Automated sensors

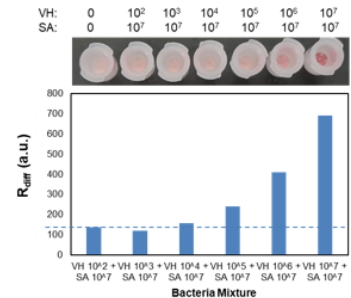


Nanoparticle-based sensor for general bacteria, demonstrated on *E. coli* and *S. aureus*



General bacteria counting from cooling tower water

***Vibrio spp.***  
*V. alginolyticus*  
*V. vulnificus*  
*V. harveyi*  
*V. parahaemolyticus*



Nanomaterial-based sensor for rapid detection of *Vibrio spp.*

## Market Potential & Value Proposition

- ✓ Cost effective and portable device for bacteria counting for in industrial water, environmental water, aquaculture and farm water
- ✓ On-site "sample-to-result" for immediate decision making
- ✓ Coupling with intervention (disinfection, etc.) to provide full mitigation solution
- ✓ Examples: water monitoring in various industries; potentially for air and surface monitoring as environmental surveillance tool.

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# Non-invasive Fish Stress Sensor

## Collaboration Opportunities

A\*STAR is seeking interest for partnership in:



### Potential Industry Sectors

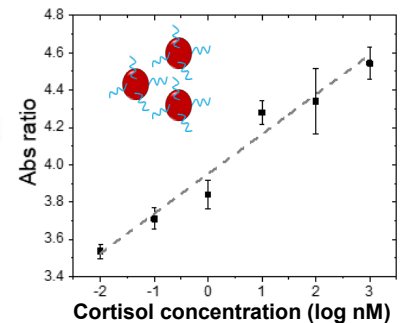
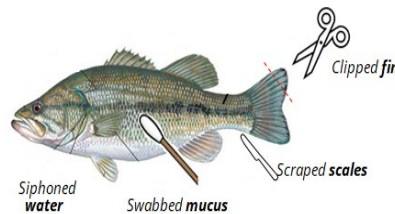
- ✓ Aquaculture
- ✓ Animal welfare
- ✓ Healthcare

### Proposed Collaboration Model

- ✓ Programmatic Grant Applications
- ✓ Industry Research Collaboration Projects
- ✓ Technology Validation and Licensing

## Technology Overview

- Nanomaterial-based sensor targeting fish stress hormone (cortisol)
- Non-invasive stress monitoring with samples from fish fin, mucus, scales, fish tank water
- Tested in Asian seabass samples, with correlation to HPLC/ELISA



Aptamer-metal nanoparticle-based cortisol sensor

## Key Differentiating Features

- Rapid (< 30 min turnover time), faster than ELISA (4 h)
- Single-reagent, one step "mix-and-measure"
- Current limit of detection (LOD) 100 pM (suitable for fish plasma, fin, mucus, scale, fish tank water)
- Enzyme free, robust, not sensitive to pH and temperature changes

## Intellectual Property

- Nanoparticle sensor for fish stress hormone (TD in preparation)
- Fish cortisol sampling methods (TD in preparation)

## Proposed Products/Services

- ✓ Baseline measurement of fish stress
- ✓ Field deployable stress hormone sensor for on-site monitoring

## Market Potential & Value Proposition

- ✓ Non-invasive/less invasive and cost-effective stress monitoring
- ✓ Rapid "sample-to-result" and on-site monitoring for immediate decision making
- ✓ Enhance stress management and farming condition (e.g., water quality management, stocking density, feeding, etc.) towards healthier fish and higher aquaculture productivity
- ✓ Identification and optimization of stress-reducing interventions

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# A Microbial Bioconversion Platform: Valorization of waste biomass into microbial and insect ingredients for use in aquafeeds

## Collaboration Opportunities

*A\*STAR is seeking interest for partnership in Aquafeed & Aquaculture*



### Potential Industry Sectors

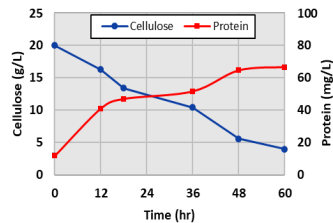
- ✓ Aquafeed producers
- ✓ Aquaculture operators
- ✓ Waste biomass producers
- ✓ Industrial biotechnology industry

### Proposed Collaboration Model

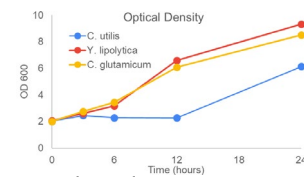
- ✓ Programmatic Grant Applications
- ✓ Industry Research Collaboration Projects
- ✓ Gap funding for co-development
- ✓ Technology Licensing

## Technology Overview

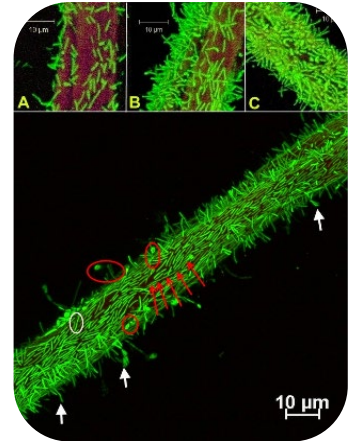
- Two-step bioconversion of waste to single cell protein for use in aquafeed
  - **Step 1:** Anaerobic cellulose conversion to soluble short-chain fatty acids (SCFA)
  - **Step 2:** Culturing of food-grade microorganisms for single cell protein
- Microorganisms can be selected for protein, oil or amino acid production
- Products from either step can be used as feed for insect protein production
- High feed-conversion ratios for insects reared on single cell protein feeds



*Bioconversion of 20g/L cellulose by cellulolytic soil community*



*Food-grade microorganisms cultured on SCFA from cellulose*



*C. thermocellum biofilm formation on cellulose cotton fibers over 48 hrs*

## Key Differentiating Features

- Low/no cost waste biomass as raw materials
- Homogenous products from varied wastes
- Robust technology for varied waste biomass
- Self-sterilizing process & low food safety risk
- High insect conversion rates, quality and yield
- Sustainable process for aquafeed ingredients

## Market Potential & Value Proposition

- ✓ Upcycling of low/no cost waste biomass to single cell protein or insects for use in aquafeed formulations
- ✓ Tunable nutritional profile of intermediate products by varying waste and microorganism in bioconversion
- ✓ Potential for immune-boosting properties in products e.g. antioxidants from waste biomass

## Proposed Products/Services

- ✓ Technology for low-cost single cell protein
- ✓ Technology for low-cost insect production
- ✓ Technology for bioactive aquafeed ingredients
- ✓ Technology for luxury feed for ornamental fish

## Intellectual Property

- E.C. Peterson. "Microbial bioconversion of biomass for single cell protein". 2021. Technology Disclosure SIFBI/Z/12799.
- E.C. Peterson, A. Thong, C. Hermansen. "Production of Single Cell Protein and Oil from Short Chain Fatty Acids". 2022. Technology Disclosure.
- E.C. Peterson, N. Phua, C. Hermansen. "Production of black soldier fly larvae from lignocellulosic single cell protein". 2022. Technology Disclosure.



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# Multi-physics Water Treatment (MWT) for Intensive Recirculating Aquaculture System

## Collaboration Opportunities

A\*STAR is seeking interest for partnership in:



### Potential Industry Sectors

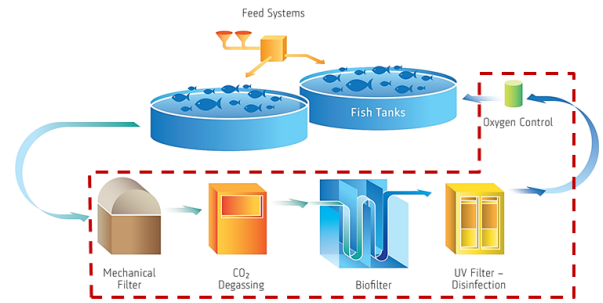
- ✓ Land-based Aquaculture
- ✓ Food Processing
- ✓ Water Remediation

### Proposed Collaboration Model

- ✓ Programmatic Grant Applications
- ✓ Industry Research Collaboration Projects
- ✓ Technology Validation and Adoption

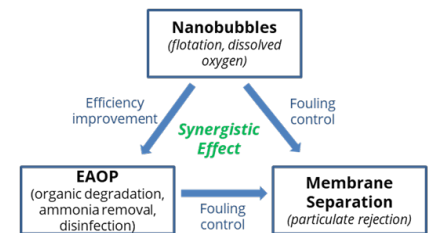
## Technology Overview

- Low energy cost, low chemical input and non-biological solution for water management in recirculating aquaculture system to achieve intensive fish stock density
- Leverage on synergistic effect of electrochemical advanced oxidation process (EAOP), nanobubbles and filtration

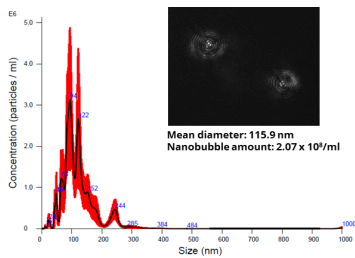


## Key Differentiating Features

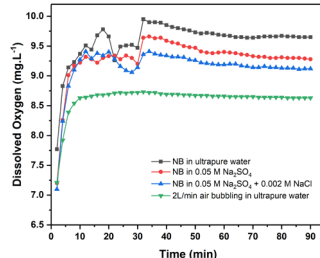
- Non-biological water treatment process to minimize setup conditioning time and bio-sludge generation
- Higher fish stock density in RAS by supersaturated dissolved oxygen in water
- Mechanical filter fouling prevention, higher energy efficiency and higher water recirculating rate through synergistic effect of the hybrid process



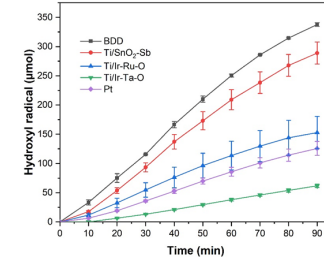
Process illustration



Nanobubbles characteristics



Dissolved oxygen in water



Hydroxyl radical generation by EAOP



Process test bedding

## Market Potential & Value Proposition

- ✓ Energy and water efficient process to improve fish stock density and bridge the gap of long payback period of current RAS
- ✓ Compatibility and scalability to be incorporated into current RAS infrastructure
- ✓ Lower carbon footprint in achieving sustainability of land-based aquaculture

## Proposed Products/Services

- ✓ Process and setup customization to improve the energy and water efficiency in freshwater and seawater RAS
- ✓ Analytics of water quality in aquaculture and urban farming

## Intellectual Property

- Novel anode material for electrochemical oxidation of aqueous ammonia/ammonium and organics
- Prototype for hybrid EAOP, nanobubbles and filtration water treatment process

## Contact Details

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