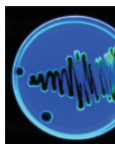


## Technologies transferred / in development

MPTD has transferred several technologies on fermentative processes for production of microbial metabolites. This include the patented process for production of L-Lysine using *Corynebacterium glutamicum*, Phytase enzyme for feed applications, Xylanase for paper and pulp applications, Cellulase for paper and pulp applications etc. Most of them are non-exclusive licenses and are available for transfer. Besides, we have processes for production of industrial enzymes and other metabolites under active development, and available for testing and evaluation to potential clients. There are also possibilities of co-developing industrially important microbial products like enzymes, bioactives, bio-fertilizers and bio-control agents.

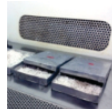


## Processes with commercial potential, in development



**$\beta$  Glucosidase (BGL):** for biomass hydrolysis. BGL is a critical ingredient in the enzyme blends used for biomass hydrolysis during bioethanol production. Worldwide there are only very few suppliers of BGL for biomass hydrolysis. Addition of BGL to cellulases enhances significantly, their potential to hydrolyze cellulose. NIIST is developing process for large scale production of BGL using fungus

**Cellulase:** for biomass hydrolysis. Cellulase enzyme is the most expensive consumable in biomass conversion for biofuels. NIIST is developing a cellulase blend which currently perform at par with world's best enzymes.



**Poly-L-glutamic acid (PGA):** PGA is the polymer of amino acid-glutamic acid and finds applications in various fields from food to water treatment. NIIST is engaged in R&D on the microbial production of PGA and has currently a lab process which yields high amount of PGA.

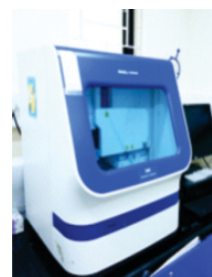


**Exo-polysaccharide from probiotic bacteria:** These are high molecular weight food grade carbohydrate polymers produced by lactic acid bacteria. NIIST is developing EPS from *Weissella* sp, a probiotic bacterium which produces food grade EPS, upto 20 g/L. The EPS is of use in food and baking industry and can inhibit syneresis up to 75%



## Services Offered

- Fermentation process development for microbial metabolites and proteins including media formulations and parameter optimizations employing DOE concepts
- Fermentation process testing and evaluation up-to semi pilot scales (175L) for SmF and pilot scale (~50kg level) for SSF, with scale-up parameters.
- Down stream process development for microbial products
- Enzymatic processes development
- DNA sequencing (Sanger method) services



- Microbial culture identification through molecular methods
- Use of lignocellulosic bioethanol pilot plant fully, or in part.
- Use of Solid state fermentation pilot facility (Koji room)
- Analytical services for HPLC, GC, HPTLC, Particle analysis, Spectroscopy etc

## Contract Research

We undertake contract research programs in different areas related to industrial biotechnology and microbial technology. We have state of the art facilities for solid state fermentation (SSF) with a 50kg capacity pilot plant and fermenters in size ranging from 0.5-175L working volume and take up programs on process development and scale up. Exploratory research is also undertaken as per client's demand. Microbial screening, bioactivity testing, biopesticide development, bio-inoculants etc are some other areas where we offer R&D support.



## Academic

Besides excellence in R & D, NIIST-MPTD also is recognized for the high quality training it imparts to the students who join here for PhD as well as for their PG projects. Both applied and basic science projects are being operated and the students gets hands on training on modern biological techniques and tools. Most of our alumni are well placed, and several have opted for post doctoral studies abroad.

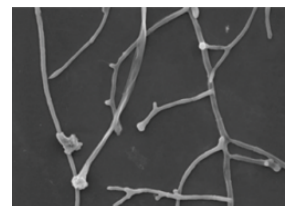


- PhD Programs in cutting edge research fields
- Expert faculty in industrial biotechnology and molecular biology
- Access to most modern biotech R & D infrastructure & equipment
- Interdisciplinary support
- Wide network of collaborations in India & Abroad
- Student exchange programs with other countries
- Academy CSIR Registration

- Project work for Masters Dissertation that are aligned to industrially relevant topics.
- Hands on training in modern techniques and tools
- Transparent selection criteria based on merit



Enrolling for PhD program or planning to do masters dissertation at MPTD, CSIR-NIIST? Details available on our web site : <http://www.niist.res.in/english/academics>



## Bioprocesses & Products Biofuels and Biorefineries

### Contact Details

Head  
Research Planning & Business Development Division  
CSIR-National Institute for Interdisciplinary Science and Technology  
(CSIR-NIIST)  
Thiruvananthapuram 695019, Kerala, India  
Email: [rpbdbd@niist.res.in](mailto:rpbdbd@niist.res.in)  
Phone: +91 471 2515270, Fax: 471-2491712

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सीएसआईआर-राष्ट्रीय अंतर्विषयी विज्ञान तथा प्रौद्योगिकी संस्थान  
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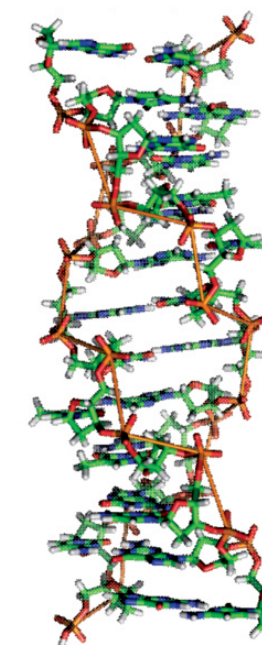
CSIR-NATIONAL INSTITUTE  
FOR INTERDISCIPLINARY SCIENCE  
AND TECHNOLOGY

CSIR-NIIST

THIRUVANANTHAPURAM



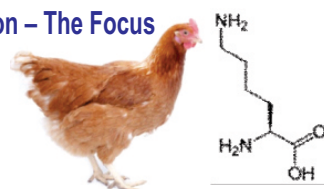
Microbial Processes & Technology



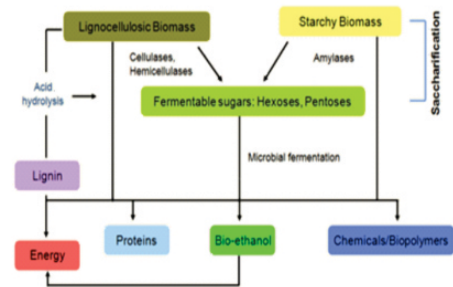
Bioprocesses & Products  
Biofuels and Biorefineries

## Microbial Processes and Technology Division – The Focus

The major R&D focus is on bio-based processes and products. The division concentrates on the microbial metabolites and bio-actives, bio-derived alternatives to industrially relevant compounds, and development of fermentative and biocatalytic methods for their production. The divisional R & D and industrial consultancy activities are linked with programs of national importance through networking with national and international organizations.

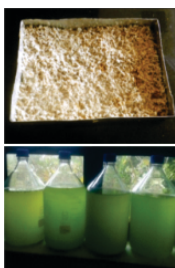


**L- Lysine**  
Feed additive through microbial fermentation



R&D at the biotechnology division is centered around the theme of biological products, industrial chemicals and building blocks from renewable and sustainable biomass residues. Research at the division is grouped into two major activity areas—Bioprocesses & Products and Biofuels and Biorefineries. These also form the two sections under the MPTD

## Bioprocesses and Products



The Bioprocesses and products section focuses on R & D in the area of Industrial Biotechnology. The section is developing microbial enzymes—especially the technical grade enzymes for applications in the area of food and feed (amylases, proteases, textile enzymes, detergent enzymes etc), biopolymers, amino acids, bio-inoculants and bio-pesticides). MPTD is an internationally recognized centre for R&D on solid state fermentation (SSF) for production of whole cell products and enzymes. We have successfully transferred technologies for amino acid production, phytase for feed applications, cellulase free exo-xylanase and endo-cellulase for paper & pulp applications.

### Major Activity Areas

Industrial Enzymes | Biopolymers | Plant growth promoting rhizobacteria bioinoculants & bio-pesticides | Probiotics & Nutraceuticals | Genomics, Transcriptomics and Protein Engineering | Micro-algal Biotechnology | Process development for fermentative production of microbial metabolites

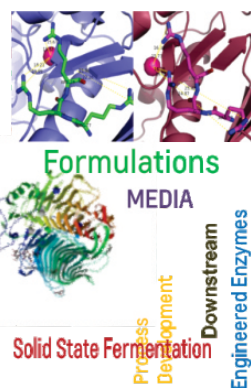
## Biofuels and Biorefineries



NIIST -MPTD is among the pioneering labs in India to work on lignocellulosic biorefineries. The Centre for Biofuels was established in 2008 for exclusive R&D on 2<sup>nd</sup> generation biofuels and biorefineries and since then is very active in the field. The lab has been in the forefront of bioethanol research and has been working on all upstream and downstream operations for biomass conversion to fuels. Besides, the centre has been working on enabling technologies including enzyme production and formulation, fermentation process development, organism development for pentose sugar conversion, and value addition of by-product streams.

## Industrial Enzymes

Enzyme Technology is one of the core strengths of MPTD. R&D is focused on developing novel enzymes with improved characteristics through classical and modern biotechnological approaches. Processes for production, scale up recovery technologies, formulation and blending are different areas where active research is being carried out. The division also works on engineering enzymes for imparting desired properties and on cloning and over-expression of enzymes which are difficult to be expressed from their natural hosts. Several of the technologies for enzyme production developed at the division has been transferred to industry. The division is also an expert centre for solid state fermentation technologies for production of industrial enzymes.



## Transferred Technologies

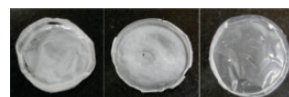
<b>Endoxylanase</b> Applications in kraft pulp processing, textile, and food industries. Technology for xylanase production using <i>Bacillus pumilus</i> transferred to industry on non-exclusive basis  <b>α-Amylase</b> Important enzyme used in food industry. Technology for amylase production using <i>Aspergillus oryzae</i> transferred to industry on non-exclusive basis  <b>Chitinase</b> Applications as bio-control agent against insect pests, utilization of fishery waste. NIIST chitinase is undergoing lab and field trials as bio-insecticide in collaboration with industry	<b>Phytase</b> Improves phosphate utilization by poultry and livestock. Additive in animal cattle feed. Technology for phytase production using <i>Aspergillus ficuum</i> transferred to industry on non-exclusive basis  <b>Cellulase</b> Applications in biomass deconstruction. Enzyme blends with excellent performance on a range of biomass. Technology for production of cellulase for pulp refining transferred on non-exclusive basis  <b>Other Enzymes</b> Lipases L asparaginase Substrate specific amino peptidases β-glucosidases
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## Biodegradable Polymers



- Production of Biopolymers
- Organism Development for Biopolymer production
- Enhanced Biodegradation of biopolymers
- Biopolymers for drug delivery

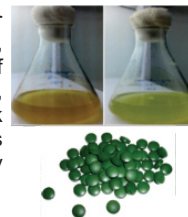
Poly Lactic acid (PLA) and Poly hydroxy butyrate (PHB) are bio polymers that do not pose environmental problems since they are completely biodegradable and fully recyclable. We work on different aspects of the production of lactic acid and PHB from renewable lignocellulosic and starchy biomass and industrial waste glycerol using microbes optimized to perform the job. Also we are collaborating with other divisions and other leading laboratories in the country for polymerization of lactic acid to produce PLA and for creating reinforced hybrid plastics from these raw materials.



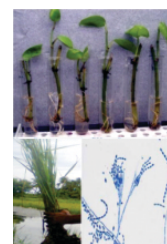
## Probiotics & Nutraceuticals

The focus of these activities is the development of probiotics and nutraceuticals for improving the health benefits. We work on fermented foods produced using food grade microorganisms, addition of nutraceuticals produced by food grade

bacteria as ingredients and on developing probiotic bacteria for direct (oral) delivery to stimulate food digestion and assimilation, and to improve the bioavailability of nutrients. Major areas of work include solid acid production by probiotic bacteria, exopolysaccharides as food additive etc. The division also work on polyunsaturated fatty acids (PUFAs) and seleno proteins from microalgae for nutraceutical applications. Omega 3 fatty acids from marine microalgae is being pursued actively



## Plant microbe interactions



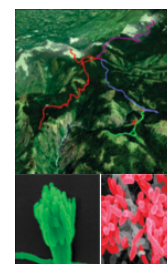
MPTD is looking into the beneficial roles played by plant rhizosphere associated microbes through advanced molecular techniques and use these knowledge to develop efficient bio-inoculants for plant growth promotion. The role of microbes in enhancing stress tolerance in plants, potential benefits like nitrogen fixation, phosphate solubilization etc are being investigated.

There is also active research in the area of biopesticide, especially on entomopathogenic fungi. We have tied up with a leading manufacturer of bio-inoculants and bio-pesticides in India, to co-develop efficient formulations of bio-inoculants and bio-pesticides

## Bio-inoculants - Bio-pesticides Formulations Stability testing



### Biodiversity



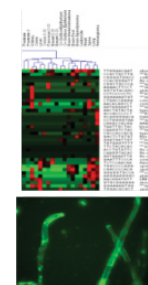
Being located in an area rich in microbial biodiversity and in a state home to biodiversity hot spots, NIIST biotechnology is actively involved in exploration and exploitation of this microbial biodiversity with potential to provide several industrial and pharmaceutically important metabolites. NIIST culture collection centre (NIC) was established for preservation and maintenance of microbial cultures and isolates. It is an affiliate member of the World Federation for Culture Collections (WFCC) and is registered with the World Data Centre for Microorganisms (WDCM).

The main objectives of this national facility are to act as a depository especially for actinomycetes, agricultural and industrial important microbes, novel taxa, to supply authentic microbial cultures and to provide related services.



## Molecular Biology, Genomics and Transcriptomics

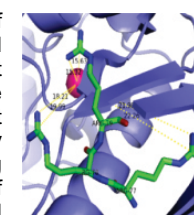
MPTD is not just looking at the fermentative production of metabolites, but we explore the genetics of microbes to make them better. This includes the understanding of metabolic pathways, gene regulatory networks, gene responses to external stimuli etc. Mass production of proteins and metabolites often involves cloning of individual genes or group of genes and over expression from suitable hosts. MPLD has



successfully developed recombinant microbes capable of utilizing non-natural substrates, and those capable of enhanced expression of desired products. We are working on the genomics of fungi to understand the regulation of carbohydrate active enzymes so as to over produce them without catabolite repression. Global protein synthetic response to external stimuli are being studied through 2D electrophoresis and mass spectrometry. We have also successfully cloned several genes relevant for industrial production of proteins and metabolites

## Protein Engineering

Structure of the proteins and the spatio-temporal organization of amino acid side chains of the protein determines its activity and the physical properties. Often natural proteins/enzymes are not optimally suited for industrial applications and might require features like higher temperature or salt tolerance, solvent stability, higher turn over rates etc and these can be imparted by targeted engineering of the protein(s). At MPTD, we are using site directed mutagenesis a tool to modify the properties of enzymes, to make them better suited for designated applications.



## Centre for Biofuels

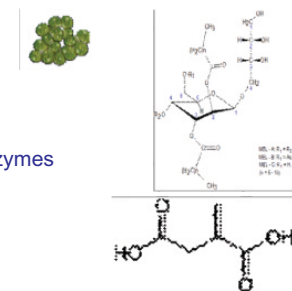


The Centre for Biofuels (CBF) is a virtual entity under the Biofuels and Biorefineries Section. It is a national facility for exclusive R&D activities in the area of Biofuels and Bioenergy. Established in 2008 with support from TIFAC (DST) and CSIR, the centre is actively involved in research on developing alternative

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## Research Focus

- Biomass availability, characterization, logistics
- Biomass pretreatment technologies
- Bio-prospecting for novel biomass hydrolyzing enzymes
- Enzyme production and blending
- Hydrolysis process development
- Organism development
- Alcohol production and recovery
- C5 sugars to value added products



## Biofuel Pilot Plant

CBF has set up the Nation's first multi-feedstock, multi-process biomass to alcohol & chemicals pilot plant in the NIIST campus. The plant can process 80kg of biomass per day and is a research facility for pilot testing and technology development for biorefineries

