Biochem. Eng. & Pilot Plant Research & Dev. Unit (Eng)

Biochemical Engineering

and

Pilot Plant Research and Development Unit

(BEC)

Background

The Biochemical Engineering and Pilot Plant Research and Development Unit (BEC) was established in 1986 under cooperative program between the National Center for Genetic Engineering and Biotechnology (BIOTEC) and King Mongkut's University of Technology Thonburi (KMUTT). The Unit serves as a center for research and development in biochemical engineering and pilot plant design, with a strong emphasis on applications suitable to local industrial needs. During the initial phase, BEC bec ame one of a number of independent satellite research units of BIOTEC. This allowed the research group to work independent of the bureaucratic system.

During Phase II, (1995-1999), BIOTEC bec ame an autonomous organization and a large number of their graduate scholarship researchers trained overseas returned to Thailand to work in collaboration with the satellite units. Also during this period, administration of the units was undertaken by university staff assigned by BIOTEC for this purpose. BEC's first 5-year plan was implemented during this phase emphasizing collaboration between researchers from both BIOTEC and KMUTT who worked together in the laboratory facilities at KMUTT. This concept of shared resources has proven to be a successful innovation for research profgrams in Thailand , producing a win-win for both parties.

The second 5-year plan was implemented during the third phase (2000-2005). The formal signing of a Memorandum of Understanding on 23 December 1999 had helped to better define the activities and clarify the expected support and roles of both partners. The second 5-year plan provided a framework for research, development and engineering that focuses on the activities of four major research groups; Algal Biotechnology, Sensor Technology, Microbial Bioprocess Development and Waste Utilization and Management. At the end of this 5-year plan, BIOTEC and KMUTT agreed to restructure the scope of BEC's works by spinning-off the Waste Utilization and Management Research group to be Excellence Center of Waste Utilization and Management (ECoWaste).

The fourth phase (2006-2010) is currently being implemented with the formal Memorandum of Understanding started from 1 st October 2005. The framework of the third 5-year plan of BEC focuses on the activities of five major research groups including Algal Biotechnology, Sensor Technology, Microbial Bioprocess Development, Food Technology and Engineering, and Systems Biology and Bioinformatics. Apart from BEC as collaborative research and development unit, KMUTT and BIOTEC have signed a new Memorandum of Understanding to set up the Excellence Center of Waste Utilization and Management (ECoWaste), spun-off R&D group from BEC, at KMUTT.

Dr. Solot Suwanayuen has guided BEC as its Director since the establishment of the Unit in 1986.

{mospagebreak heading=Background&title=Mission
Vision}

Vision

To be a leading research, development and engineering center in biochemical engineering and pilot plant design in the region in order to develop relevant knowledge as well as technologies to serve the needs of society and the country.

Mission

- To carry out R, D&E to generate knowledge and provide products and processes according to industry needs.

- To strengthen and support the competitive position of small to medium enterprises (SMEs) through the application of BEC expertise, developed technologies and human resources.

- To establish and foster university-industry partnerships for mutual benefit.

- To promote / facilitate new entrepreneurs and business development.

{mospagebreak title=Management}

R&D Cluster Management

In cooperation with Industrial Park Center (IPC), Pilot Plant Development and Training Institute (PDTI) and School of Bioresources and Technology (SBT) at KMUTT, BEC manages its research work through the specialized research group under the concept that the strength of any research development system needs two-way communication between demand pull (the technology needs from industry) and supply push (the innovation/ knowledge developed from research institute and academic side). The conventional management system usually found in the universities does not currently facilitate such linkages. One of the essential factors regarding the success of IPC depends on the strength and innovation of research and development (on-going research and maintaining the currently and relevance of R&D). The scope of BEC as a part of R&D Cluster covers research activities to produce high quality R&D, technical services, technology transfer and consultancy, in order to strengthen and support competitive position of SMEs through the application of BEC expertise, developed technologies and human resources.

{mospagebreak title=Funding}

Funding

BEC is operated by funds from various sources: KMUTT, BIOTEC, research grants, contract research, technical services including consultancy, training, pilot plant design, incubators hiring and analytical services

{mospagebreak title=Research
Direction}

Research Direction

Specialized research projects can be initiated through the Unit, with strong scientific and technical support from KMUTT research program. Multidisciplinary project teams can be selected for their relevance to specific research and development projects being undertaken with the research groups.

1) Algal Biotechnology (link to PDTI Lab data)

Research in this group emphasizes the development of mass cultivation techniques and processes, with the aim of obtaining high-value compounds such as phycocyanin and gamma-linolenic acid (GLA). The goal is to enhance cell growth and maximize the production of high-value chemicals in Spirulina platensis . Researchers have focused on finding the correct substrate and environmental conditions for the cultivation of different strains of Spirulina platensis . For example, CO 2 could be used to replace NaHCO 3 in microalgae cultivation, with substantially lower production costs. In addition, the effects of light and temperature on the productivity and photosynthesis of the algae in an outdoor environment have also been investigated. The group also focuses on understanding the gene expression and regulatory mechanisms by which Spirulina produces high-value compounds such as phycocyanin and GLA at a molecular level, in order that we can develop new strains with higher contents of such compounds. Recently, spirulina genome sequencing project has been initiated. The information obtained will be used to develop new generation of research and would be great help for scientists to unveil many novel genes that are involved in biosynthesis of high value compounds that are produced by this organism.

2) Sensor Technology (Bio sensor s and chemical sensor s technology) (link to PDTI Lab data)

Advances in electrochemistry and sensor (bio sensor s and chemical sensor s) research and development have come about due to the need to meet the indigenous demands of the food industry, for environmental analysis, and for biomedical applications. Research is carried out in three areas, for which there is a need to develop existing approaches for better performance of the sensor s, improve analytical methods and explore possible new applications. The bio sensor s and chemical sensor s technology group can be sub-divided into the following lines of study:

• Biosensors: Microbial BOD sensor s, phenol enzyme bio sensor s, screen-printed glucose oxidase electrodes, and simultaneous determination of glucose and sucrose.

• Chemically modified electrodes: Biocompatible redox polymer membrane, metal microparticles in polymer films, inorganic film modified electrodes, and nafion-coated probe in viscous/resistive media.

• Electroanalytical techniques: Pulse amperometric detection, artificial neuron networks for interpreting voltammetric data, and stripping analysis.

3) Microbial bioprocess development (MBD) (link to PDTI Lab data)

The research in microbial bioprocess development involves working in a group of specific laboratories: Animal cell culture , Microbial Fermentation , Solid State Fermentation , Fungal Biotechnology , Pilot Plant Fermentation ; that emphasize microbial metabolism and molecular physiology relevant to the metabolic networks of microorganisms and the modification of pathways. An understanding of the genetic and metabolic networks as well as their regulation and interaction will be used to form rational models of biological production systems. These systems in turn will be used as a device to transfer the technologies in question into efficient, industrial-scale processes. The group also focuses on animal cell culture and microbial ferment ation technology for the production of biological products at a pilot scale, and production orders and process development for the private industrial sector.

Examples of research conducted by the MBD group are the development of alkaline protease from a filamentous fungus Aspergillus oryzae using a solid state ferment ation technique, the production of g -linolenic acid (GLA) from Mucor rouxii , the production of Baculoviruses for biopesticide application, pilot scale production and application of probiotic microorganisms, and process development for the production of bioactive compounds for animal feed.

4) Food Technology and Engineering (link to PDTI Lab data)

This group emphasizes on food properties production improving, food thermal processing and aseptic processing.

5) Systems Biology and Bioinformatics (SBI) (link to PDTI Lab data)

This multidisciplinary research group has applied systems biology and bioinformatics approaches to analyze the –omics data of various organisms such as Saccharomyces cerevisiae , Cassava , Plasmodium , and Tuberculosis . The aim of such research is to understand the biology of these organisms at the systems level, with applications to strains improvement and antibacterial targets identification. The group has at its disposal various tools including mathematical modeling, bioinformatics tools and databases, along with its molecular biology and ferment ation laboratories. With these resources, the group is able to build and improve on in silico models, and verify them experimentally to study cell ular behaviors under changing environmental, physiological and genetic conditions on a personal computer. We hope to generate a better understanding of how these systems work, and our admittedly ambitious goal is to be able to apply the knowledge thus gained to provide better tools for other scientists and engineers, and to work with these scientists and engineers to solve problems relating to agricultural and medical biotechnology in Thailand .

{mospagebreak title=Staff}

Staff

The multidisciplinary team gathered from the R&D cluster research group has been working under the BEC umbrella and is comprised of 20 staff from BIOTEC, including 12 Ph.Ds. and 8 M.Scs., while there is 55 staff (Full Time Equivalent) from KMUTT, including 28 Ph.Ds. and 27 M.Scs.. In addition, there are also 16 Ph.D. students and 54 M.Sc. students who are undergoing researches under the supervision of the Unit's researchers. Assoc.Prof.Dr.Solot Suwanayuen has

guided BEC as a Director since the establishment of the Unit in 1986.

{mospagebreak title=Achivements-
Technology}

Achievements

1. Technology transferred or ready to be transferred to industry

Algal Biotechnology

• Mass Cultivation Technology: Mass cultivation of Spirulina technology has been developed from local strain selection to pilot and industrial scale cultivation. The research involved the use of tapioca starch waste water as substrate for Spirulina cultivation in order to reduce production costs. Four pilot concrete raceway-type ponds equipped with paddle wheels provided encouraging results: the harvested slurry was sun-dried, the final product containing 55% protein and 7% moisture. The investment and annual production cost for Spirulina biomass was estimated for a plant covering a total production area of 1.5 hectares with a productivity of 40 tons per year; the operating cost was between $6,000 and $7,000 per ton. After the completion of the project, the technology developed was transferred to the private sector where dried Spirulina is produced as high-protein feed for animals (e.g. shrimp and fish). As Spirulina biomass can be used either as a food supplement for direct human consumption or as feed supplement for animals, commercial production is likely to increase for the health product market.

Microbial Bioprocess Development and Pilot Plant Fermentation

• Pilot Scale Fermentation for microbial production, Baker's Yeast, Bacillus subtilis : Local strains with high yield have been selected and cultivated from laboratory experimentation to commercial scale with an extensive range of ferment ors from 5 litres up to 1,500 litres. Using locally designed pilot plant ferment ation facilities, the Unit has enabled potential private sector clients to carry out small-scale production runs for feasibility testing, cost predictions or optimization of processing steps and production of prototype products for market testing.

Sensor Technology

• Screen-printed electrodes for blood-glucose determination: Screen-printing seems to be one of the most promising technologies which will enable bio sensor s to be produced on a large scale in the near future. This method boasts several advantages, including compactness, versatility and low cost, thus holding out the possibility of mass production. In this research, screen-printed electrodes have been constructed based on hydrogen peroxide-sensing electrodes. Commercially available rhodium-on-carbon was used as the electrode base material. In addition, glucose oxidase was mixed with catalytic ink to from “biocomposite” ink, which was then screen-printed onto the substrate, producing glucose bio sensor s in a single, one-step procedure. This existing technique offers greater speed and simplicity in the manufacturing process.

Food Technology and Engineering

• Development of thermal processing: A sterilization process for canned food production by retort has been developed. This involved the development of design software using experimental data. A heat penetration database of Thai canned food has been developed following systematic collection of data. This standard database will help reduce the expensive and time-consuming procedure to determine the optimal thermal process for new products. The prototype still retort with over pressure that has been developed will help SMEs to develop their new products with more attractive packaging through the sterilization of pouches, bottles and other plastic packaging using the special retort to maintain their shape and seal during processing.

Systems Biology and Bioinformatics

• Development of software: As lipids have become interesting compounds in biotechnological industries because of their broad functions applicable to medical, pharmaceutical, and oleo-chemical industries, the insightful understanding into the lipid biosynthesis of the producer strains will lead to the rational strain improvement. A prototype of user-friendly genome-scale model of Saccharomyces cerevisiae was developed using systems biology and bioinformatics approach and used to simulate the effect of genes/enzymes on the cellular growth and lipid productions. This in silico approach would enable rational metabolic pathway alterations at the genetic level for improved cellular properties especially the overproduction of certain lipids and essential fatty acids then cut down the time used for laboratory validation experiments.

{mospagebreak title=Achivements-
Services
Patents/Awards}

2. Technical Services and Industrial Linkages

In recognizing the importance of agro-industry and the biotechnology industry as a basis for development in Thailand , particular attention has been given to research and development and transfer of in-house research in these specific areas. BEC has initiated several successful linkages between government and the private sector through contract research, technology transfer and technical services. Technical services offering include design and construction of pilot/industrial scale processes, technical and administrative consultancy, feasibility studies, training and analytical services. BEC has transferred some of the developed technology and provided some technical services to interested private entrepreneurs. Examples are:

- Pilot scale production of pressed yeast for Bioman Co.Ltd.

- Pilot scale production of Bacillus subtilis for probiotics market trial in animal feed industry for Grand Siam Co.Ltd.

- Pilot Plant ferment ation services for microbial production applied to waste water treatment in the shrimp farming industry: Grandness Integration Co. Ltd., Allvet Co. Ltd. and T.C. Union Co. Ltd.

- Incubator hire service for Mighty International Co. Ltd. for yeast production testing.

- Cooperative research with Biowealth Co. Ltd. to conduct fungal ferment ation for enzyme production to be applied for probiotics in the animal feed industry.

3. Training and Workshops

BEC offers high quality technical training, seminars and workshops at both the national and regional levels whereby participants have the opportunity to get hands-on experience and to design experiments suitable to their needs. Those attending these courses are from both the government and private sector. Some of the successful activities and continuing programs are:

- Mass Cultivation of Spirulina

- Regional mini-symposium on bio sensor and chemical sensor technology

- Bioinformatics as a Tool for Gene Manipulation

- Metabolic Engineering and Functional Genomics

- Advanced Fermentation Technology

- Practical approach to ferment ation technology workshop

- Comparative microbial genomics workshop

- Animal Cell Culture and Applications

4. Human Resource Development

During the period 2000-2007, there were 246 graduates (12 Ph.D. and 234 M.Sc. students) affiliated with BEC research groups. At present there are 74 students who are working in the laboratories, 16 Ph.D. and 54 M.Sc. students. BEC expects to maintain a ratio for the number of students to Ph.D. research staff as 4:1 for M.Sc. students and 2:1 for Ph.D. students.

5. Patents

To date, BEC has filed for 6 patents as follows:

- DNA probes specific to Methanogens (1999). [link to ECoWaste]

- Nucleotide and Amino Acid Sequence of D 12 desaturase of Mucor rouxii ATCC 24905 (2000).

- Nucleotide and amino acid sequences of D 6 -desaturase gene of Mucor rouxii ATCC 24905, Thai Patent Filed: September, 2000.

- Nucleotide and amino acid sequences of D 6 -desaturase isoform II of Mucor rouxii ATCC 24905, Thai Patent Filed: January, 2004.

- Development of D 6 -desaturase isoform II enzyme of Mucor rouxii involved in synthesis of essential fatty acids, gamma-linolenic and stearidonic acids by site-directed mutagenesis, Thai Patent Filed: 28 September, 2005.

- Production of Gamma-linolenic aid (GLA) and alpha-linolenic acid (ALA) using the delta-6-desaturases and delta-12-desaturase genes from Spirulina platensis in yeast cells, Saccharomyces cerevisiae , Thai Patent Filed: October, 2006.

6. Awards

- The Thailand Toray Science Foundation (TTSF) Science and Technology Award in 2003 in recognition of the BEC unit on outstanding achievements in science and technology works.

- “High Rate Anaerobic Fixed Bed Reactor for Agro-Industrial Wastewater Treatment”. Research Award in Industrial Research and Engineering field from National Research Council of Thailand. [link to ECoWaste]

- “Thai Biogas Plants – High Rate Anaerobic Fixed Film Technology for Agro-industrial Wastewater”. The Best Program on New and Renewable Sources of Energy (Off-grid) in Year 2003 from Department of Alternative Energy Development and Efficiency, Ministry of Energy. [link to ECoWaste]

{mospagebreak title=Achivements-
Publications
Conference}

7. Publications and Conference Proceedings

During 1993-2003, BEC has published 76 international publications, 5 national publications, 76 international proceedings and 66 national proceedings. The list of international publications is as follows.

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Performance
Index}

Key Performance Index (KPI)

Key Performance Indicators have recently been introduced to BEC as a means to help measure the efficiency, effectiveness, productivity and sustainability of the Unit and its work. Data is generated to provide KPI indicators that demonstrate effectiveness in research and development work. This includes amount and source of research funding, contract research and number of publications, which better helps to show the efficient use of research funds per Full Time Equivalence (FTE) Ph.D. research staff and publications per FTE Ph.D. research staff, although it should be

emphasized that BEC is not a publications-driven research unit. Performance indicators such as total income per total salary and number of M.Sc./Ph.D. students per FTE Ph.D. research staff are also used to measure the productivity and sustainability of the Unit.