ISSCT COPRODUCTS WORKSHOP 2012

Bangkok, THAILAND

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R E P O R T

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Abstract

The ISSCT Coproducts Workshop 2012 was held in Bangkok, Thailand from 19-22 March 2009 and attracted 65 participants from 10 countries.

Two days were dedicated to 28 presentations covering present and future production of coproducts of the cane sugar industry in several countries. On the third day, we visited the Saraburee factory of the Thai Roong Ruang Sugar Group (including a cellulosic ethanol plant from bagasse). On the last day, the Supan Buree factory complex belonging to the Mitr Phol Group was visited (largest sugar and coproducts plant in Thailand).

All papers were well presented and generated discussion and interaction among the participants. Many are considered suitable for expansion to full presentations at the 28th ISSCT Congress in Sao Paulo in 2013.

Some of the most interesting topics discussed were:

- High-value fatty acids can be produced using an aseptic dark reactor where sugar from cane juice is transformed into triglycerides by particular algae ("Solazyme" process). A full-scale plant is being built in Brazil.
- Diversification is possible as shown by Andhra Sugars, India who have been producing 12 byproducts (ethanol, acetic anhydride, salicylic acid, aspirin, methane, ethanol and others) for many years.
- Production of advanced biofuels (butanol, biodiesel), as well as specific biopolymers, bulk chemicals and health and wellness ingredients, based on sugars is technically proven and is slowly becoming commercially viable.
- Production of lactic acid, glutamic acid, lysine, and furfural based on sugar is already well established in several countries and commercially successful.
- The bioplastics market is growing from approx. 0.4 million tonnes in 2007 to an estimated 3.5 million tonnes worldwide as conventional plastic bags are being banned or heavily taxed in a growing number of countries. However, the price of bioplastic production from sugar is still comparatively high.
- Extractive fermentation of bioethanol using the vacuum fractionation technique in a pilot plant at the Suranaree University, Thailand has shown that ethanol at 90% wt concentration can be produced without further distillation, implying huge cost savings.

Introduction

The ISSCT Coproducts Workshop 2012 was held at the Centara Grand Hotel, Ladprao, Bangkok, from 19 - 22 March 2012 and was hosted and mainly sponsored by the Thailand Society of Sugar Cane Technologists (TSSCT), the Office of the National Research Council of Thailand (NRCT), Kasetsart University (KU), Mitr Phol Group and Thai Roong Ruang Sugar Group. Some commercial companies active in Thailand, such as Büchi, DKSH, Sithiporn, Toyo, TG-Pro, BASF, SU-Enco and Korach, also provided sponsorship.

Associate Professor Dr. Klanarong Sriroth, Kasetsart University in Bangkok, was the key organiser and contact person for the workshop attendees. He and his team are to be congratulated for the perfect organisation, choice of hotel, venue of the workshop and the logistics and choice of site visits.

The overall theme of the workshop was “Successful Utilization of Co-Products in the Sugar Industry”. Several theme blocks were chosen, including keynote subjects as well as fermentation ethanol, cellulosic ethanol, vinasse treatment, gasification and torrefaction of bagasse, chemicals and derivatives based on sugar substrates and particle boards from bagasse. A total of 28 presentations were made during the first two days.

Wednesday was used to visit the Saraburee factory of the Thai Roong Ruang Sugar Group, which has a anhydrous ethanol plant from molasses and a small cellulosic ethanol plant from bagasse. On Thursday, the Supan Buree factory complex belonging to the Mitr Phol Group was visited. This is the largest sugar factory in Thailand and includes a major cogenerating plant employing excess bagasse, an ethanol-from-molasses plant, a liquid-sugar plant and a particle board plant.

The workshop was attended by 65 participants from 10 countries: Thailand (37 persons), as well as from Australia (4), Brazil (4), France (1), Germany (5), India (4), Iran (5), Pakistan (1), UK (3) and USA (1).

Technical Sessions

Session A – Overview speeches

Transforming sugar into vegetable oils (Miguel Angel Oliveira, Bunge, Brazil)

The Bunge-Solazyme project will produce special oils that are rich in fractions used by the chemical industry for the production of surfactants. The technology is too expensive at this stage of its evolution to be used for the production of biodiesel.

When the use of cellulose to produce simple sugars becomes common place and the development of microorganisms has taken yields and speed of production to new levels, one may see this process generating biodiesel raw materials.

Main features of the Bunge-Solazyme process are:

- Modified algae technology (aseptic dark reactor with cane juice as input – no need for sunlight)
- Producing triglycerides from sugar – the same way that most animals do
- Product of entry for Bunge: oil rich (>85%) in C14 (myristic) and C12 (lauric) fatty acids for the chemical industry
- Mass/energy balance theoretical yield: 31% in mass and 65% in energy.

Coproducts operation at a cane sugar plant (Narendranath Mullapudi, Andhra Sugars Ltd., India)

Andhra Sugars Ltd, located in southeastern India, commenced operation in 1952 with cane sugar production and diversified into the production of various products based on by-products from the Sugar Factory.

Twelve coproducts, as well as electricity, are produced based on by-products from the Sugar Plant. Molasses is used to produce industrial alcohol and ethanol. Carbon dioxide, which is a by-product at the alcohol plant, is collected, scrubbed to +99% purity and used in the production of salicylic acid and also in the sugar factory for carbonatation.

From the alcohol, acetic acid, acetic anhydride and ethyl acetate are produced. Aspirin is produced using acetic anhydride and salicylic acid as raw materials. The spent wash from the alcohol plant is put through a bio-digester, and the biogas generated is collected and used as fuel in the boiler. The liquid that leaves the bio-digester is sprayed on the press mud from the vacuum filters at the sugar plant to produce 'bio-earth' that is given to the cane farmers for use as fertiliser on their farms.

Bagasse from the cane diffusers is pre-dried with flue gas dryers and fired in high-pressure boilers using bagasse and cane trash as fuel. Andhra Sugar's Unit II generates low cost electricity for all its factories.

Biorefineries: Multi product approach to de-risk the sugar industry (Samrat Bose, Praj Far East Co. Ltd., India)

Praj Industries Ltd is a provider of bioethanol solutions that licenses technology, design and builds plants for their customers. They have now started focusing on second-generation biofuels from which the concept of ‘Biorefinery’ has emerged.
Several conversion technologies are already under commercialisation to produce energy, chemicals, pharmaceuticals, food, detergents, and commonly used polymers.
Many of these bioproducts, along with biofuels, would be manufactured in bio-refineries using carbohydrates derived from agricultural raw materials. It is expected that bioderived chemicals will come from three technology approaches: direct production using thermo-chemical technologies, green-chemistry-based catalytic processes and fermentation bio-technologies.
The presentation gave a good overview of different bio-based feed stocks, their availability, compositional variations, seasonal trends and their distribution. Different examples of conversion technologies were presented. Critical aspects in development of future biorefineries were also discussed.

The Recent Situation of the Thai sugar industry and the National Bioethanol policy (Assoc. Professor Klanarong Sriroth, Department of Biotechnology, Kasetsart University, Bangkok, Thailand)

The Thai Sugar Industry structure and regulation were reviewed. The national plan for both sugarcane plantation and mill efficiency was discussed. Within the Roadmap of Renewable Energy Development Plan (REDP), a production of bioethanol at 9.0 ML per day is expected in 2022.

The pricing policy of ethanol by the Government is the main subject for the sugar industry in order to be able to compete with the ethanol from the starch (cassava) industry. The formulation of ethanol price correlated to molasses price was shown in the paper comparing it to the cassava price.

At present, ethanol still plays a relatively minor role in the automotive fuel mix, where cars capable of using an E20 or E85 mix represent only about 18% of the passenger car fleet. The major portion works with an E5 mix. The demand for diesel fuel for trucks and buses is 2.5 times higher than for gasoline, and biodiesel (B5) accounts for nearly 40% of consumption.

Potential and Future of Thai bioplastic industry (Dr Pipat Weerathaworn, President of Thai Bioplastics Industry Association -TBIA)

Plastics and the petrochemical industry have for too long relied on petroleum as the critical building block and raw material. As a result, we are faced with a global development which uses far too many resources causing environmental degradation and pollution. The inefficient use of plastics creates not just regional problems but now also global supply chain effects which amplify the challenge. A key part of the larger solution of this profligate waste is the production and promotion of bioplastic. Bioplastic has recently been produced in America and Europe and now has seen an emerging interest from Asian businesses seeking to diversify their knowledge base and improve their environment. Thailand has been seen for many years as a potential global hub for the production of bioplastics due to its abundance of sugar, cassava and other agricultural raw materials that support production of bioplastics. This, combined with Thailand and SE Asia's robust economic growth and developing customer awareness, has increased demand for bioplastics in the region.

However, the production cost of bioplastic is still comparatively high. Therefore, it is critical to increase research on reducing production costs to improve the economics of the industry and increase consumer demand.

Virtual Sugarcane Biorefinery – Computational tool to compare different production strategies in a biorefinery context (A. Bonomi et al., CTBE – Campinas, Brazil)

A comprehensive strategy to evaluate the sustainability of different biofuels production routes using sugarcane as raw material is under development at the Brazilian Bioethanol Science and Technology Laboratory (CTBE). This integrates different computer platforms such as Aspen Plus, SimaPro and electronic spreadsheets. This tool, the so-called Virtual Sugarcane Biorefinery (VSB), allows the comparison of technical, economic, social and environmental impacts of different production technologies for the production of bioethanol, sugar, bioelectricity and other products, such as the ones derived from thermochemical conversion, sugar chemistry, alcohol chemistry and lignochemistry. Since the agricultural phase is also being modelled and integrated with the industrial phase, the impacts of the agricultural technologies on the industrial phase (and vice-versa) are also evaluated in the VSB.

The first results obtained with the VSB were shown in this presentation. The evaluation of first-generation ethanol production coupled, or not, with electricity and sugar production was presented, along with process optimisation and an analysis of the flexibility of annexed plants and harvest extension using sweet sorghum. Second-generation ethanol production from sugarcane bagasse and trash through the biochemical route was also evaluated and compared with electricity production. The integrated first- and second-generation ethanol production from sugarcane was compared with stand-alone second-generation factories using sugarcane bagasse and trash as feedstock.

The results obtained with the VSB allow comparison of different technologies for first- and second-generation ethanol production from sugarcane, through evaluation of technical, economic and environmental impacts.

Session B (Advances in ethanol fermentation from juice and molasses)

Extractive fermentation of bio-ethanol from concentrated sweet sorghum juice using vacuum fractionation technique (Asst. Professor Apichat Boontawan et al., Suranaree University of Technology, Thailand).

The technology in bench scale studies at Suranaree University aims at removing ethanol at the time it is produced during the fermentation process, therefore avoiding ethanol production inhibition. The concept is that keeping ethanol concentration low in the bioreactor, the reaction equilibrium shifts forward, resulting in an increase of the product yield. In the work, extractive fermentation of ethanol was carried out by using a vacuum fractionation technique developed at the university. Boiling of fermentation broth at 35°C was achieved by reducing pressure down to 45 mmHg. Ethanol produced from the fermentation broth was fractionated to approximately 90 wt% before leaving the column. As a result, the distillate product could be directly dehydrated without further distillation, thus dramatically reducing production costs. The system has the potential to achieve a higher ethanol production rate, faster glucose consumption rate, and longer activity of the yeast cells. Experiments showed lower substrate concentration and higher yeast viability with time, when compared to the conventional fermentation process. Further studies are planned, including computer simulation and pilot plant scale tests (reactor size of 1000 litres) to understand several aspects of the process engineering, before going to a demonstration commercial scale plant.

Investigation of fermentable sugars ratio in molasses during storage (Chaiwat Ngasan et al., Mitr Phol Sugarcane Research Center and Kasetsart University,Thailand).

Deterioration of stored molasses occurs basically with the inversion reaction of sucrose, producing fructose and glucose, further leading to the so-called Maillard reaction (froth fermentation) with losses, undesirable processes and products. The work studies the fermentable sugar in molasses during storage, analysing the factors affecting the losses of sugar. The study was conducted at Mitr Phol Sugar Factory in Danchang. During a period of storage of 5 months, fermentable sugars in molasses were found to be unstable and reduced. The reduction was about 1.14% per month at the ambient environment, with significant revenue losses.

Session C (Advances in cellulosic ethanol fermentation)

A brief review of developments for the production of cellulosic ethanol (Dr Bryan Lavarack, Mackay Sugar, Australia)

This presentation provided a brief overview of the developments toward the commercial production of cellulosic or second-generation ethanol, based on information published in the open media. Two main technological pathways were mentioned: Thermochemical (gasification) and Biochemical process. The process of gasification needs further chemical conversion with catalysts (Rangefuels) or Biochemical conversion with microbes (Coskata and Lanzatech) to produce ethanol. It is reported that gasifier equipment and gas clean-up for biomass feeds have been considered complex and expensive. Companies dealing with this technology have gone bankrupt or moved focus. Studies by SRI suggest it is not commercial in Australia (for the moment). On the other hand, several biochemical processes are nearing commercialisation. The best is to attach it to an existing ethanol plant to integrate processes and reduce investment. Poet, DDCE, and BP Biofuels (formerly Verenium) are major contenders. The conversion of the C5 sugars from hemicellulose is regarded as key to making the process economic. The effort of Australia in the biofuels arena was mentioned, with Ethtec (NSW) using a concentrated acid pre-treatment, the Microbiogen yeast for C5 fermentation, and the QUT process at a pilot plant facility at Racecourse mill, where the project is nearing completion. QUT is also investigating developing new varieties of cane with Syngenta, with focus on cellulosic biochemical conversion to biofuels.

Instrumentation and control experience at a cellulosic ethanol plant (Bernd Langhans, Siemens, Germany)

Siemens' experience in supplying the complete electrical, instrumentation and control system of an INBICON second-generation ethanol demonstration plant in Kalundborg, Denmark, was described in this presentation. The plant was designed to produce lignocellulosic ethanol using as feedstock baled straw at a rate of 4 tonnes /hour, with a total of 30 000 tonnes/year. The challenge was to design the instrumentation and control package in a way which would allow various trials, expansion or even complete relocation of the plant. This was an important decision and lesson learnt, since it made possible a wide range of experiments and to get information on the various process conditions. In only one year, all the system was designed and implemented, including the entire automation part, starting with power supply and distribution, distributed control system, up to all instrumentation.

Sessions D & E - Energy efficient distillation schemes and Treatment of vinasse by biodigestion, concentration and incineration

Distillation and integrated evaporation for waste concentration (Parag P. Kolte, PrajIndustries Ltd., India)

The presentation gave an overview of different schemes and possibilities for the reduction of energy consumption, basically steam, and water recycling and reuse. Praj has worked extensively on this industry requirement and has developed energy efficient schemes towards integration with the aim of zero liquid discharge. Technologies such as vacuum distillation, multipressure distillation, integration of efluent treatment, multi-effect evaporation, falling film evaporation, assisted falling film, and forced circulation have been utilised by the company in several projects worldwide.

Session F – Status of cogeneration in Thailand

Overview of bagasse cogeneration development in Thailand (S Kamolpanus, Mitr Phol Bio-Power Company, Thailand)

Thailand is the fourth largest producer of sugarcane in the world, producing nearly 100 Mt in 2011. In addition, there are many other sources of agricultural waste fuel, of which wood waste and biogas dominate. A 2000 report estimated that the three fuels combined could support 4 GW of electricity production, nearly half of which was from bagasse.

There are currently 47 factories in Thailand with a total installed capacity of 1 GW and an export capacity of almost 400 MW. Of those, most have relatively low HP steam conditions and only two have high pressure boilers. Those two, however, account for just over one-third of the estimated 1626 GWh of annual export.

A table was presented showing the increase in electrical output as the HP steam conditions are increased. It demonstrated the impact of the thermodynamics, including the ability to improve the efficiency by diverting what would otherwise be condensing load by applying more feedwater heating at high conditions. What it does not discuss is the increased capital cost of adopting higher conditions.

The author's own company has two high efficiency stations, one of which was visited later in the week. The two have 146 MW installed capacity between them. Their original turbines are twin shaft machines in order to achieve higher efficiencies, each shaft running at its optimised speed. The stations currently achieve 70 kWh per tonne cane whilst the paper suggested that it should be possible to achieve 130 kWh, at which point, if all of the Thai industry was that efficient, then 13 TWh of electricity would be exported to the national grid.

Session G – Gasification of bagasse and cogeneration potential

Torrefaction of bagasse for additional coproducts at AB Sugar (T Brewer, AB Sugar, UK)

This was an interesting paper as the author originally comes from a beet sugar background. Torrefaction is similar to pyrolysis but is undertaken with much milder conditions so that the water is driven off but as much as 95% of the energy value is retained.

A comparison of charcoal manufacture – termed a ‘low technology approach’ – with torrefaction – the ‘high technology approach’ – was presented. Making charcoal from surplus bagasse at a 2 Mt per annum per factory might achieve 50 000 tonnes of bagasse but, with torrefaction, the same factory could achieve twice as much by-product creation. Torrefaction is clearly more efficient with a better product but the higher technology equates to higher capital cost and is really only suitable to large scale operations.

Although AB Sugar has investigated torrefaction, it has not made the case to develop the concept any further at the moment but is watching related activity in the industry with interest.

The potential for the gasification of bagasse (Dr Bryan Lavarack, Mackay Sugar, Australia)

Gasification is the conversion of carbon-containing feed into gas at elevated temperatures with metered quantities of oxygen and steam. Conditions are much more aggressive than torrefaction, with temperatures typically in excess of 700°C. The resulting gas can be used as a chemical feedstock in a number of ways or can be used as an energy source.

Gasifiers can range from the simple – upflow or downflow – to the much more complex fluidised bed units. The more complex units are better suited to higher throughputs. Many processes are taking place in the gasifier: the water is first driven off and then vapourisation and pyrolysis occur before the more traditional producer gas and water gas processes occur.

The main issues with gasification of bagasse are related to the bagasse characteristics [low energy density and difficult to feed to a high pressure reactor] and the nature of the gas driven off which is very dirty and needs a lot of cleaning up to remove tars and similar components.

Nonetheless it is a technology worth pursuing. Australia’s SRI considers that gasification with a combined cycle power station should give 50 to 100% more energy than a conventional station. It reports that ash in bagasse can crack tar at lower temperatures but it doesn’t believe that the technology will be viable under Australian economic conditions.

Bagasse gasification : combined cycle (Dr Mike Inkson, Thermal Energy Systems, UK)

This paper picked up on the theme of the previous one to explore further the idea of integrating a combined cycle power station with gasification on the assumption that gas clean-up will eventually be solved.

A combined cycle is exactly what its name implies: a thermal cycle combined with a conventional steam cycle. The thermal cycle is usually based on a gas turbine but it could be a diesel engine for instance. Gas turbines in particular are not efficient [40% at best] so the exhaust temperature is 400 to 500°C with oxygen contents of 13 to 14%. A secondary gas burn boosts the temperature and reduces the oxygen content to optimise the steam cycle and overall efficiency.

Such stations are already in use in the sugar beet and refining sectors as they both rely on fossil fuel. They could also be appropriate for the sugarcane sector but the normal rules of cogeneration still apply: anything which results in excess process steam and hence generation with a condensing turbine is less than efficient. Equally, any scheme which requires auxiliary fuel is also less than efficient.

Charcoal from sugar cane bagasse (Dr Helmut Bourzutschky,CBTC, Switzerland)

Bagasse used to be a byproduct of sugarcane processing with little utilisation in the past. For a long time, its use as fuel for the steam boilers was its only meaningful application. More recently, its advantages as raw material for alternative products (pulp and paper production, particle board as well as cogeneration) were recognised.

In this context charcoal production ranges on a smaller scale. It can be produced either from surplus bagasse or by using conversion processes, which yield extractable charcoal as commercial product and process gas as usable gaseous fuel in the factories' steam boilers. There is also the option of producing a liquid combustible fuel, which condenses at lower process temperatures from the gaseous components.

The process of converting biomass to charcoal is based on pyrolysis, which uses a wider range of process options from fairly primitive systems to sophisticated ones depending on which final products are targeted and which efficiency level is selected.

The presentation dealt with these various aspects and described in greater detail a charcoal production process, which was developed for and installed in a development project in Jamaica. Useful data and background know-how became available and the acceptance as household cooking fuel of this type of charcoal compared to the traditional was established.

Biomass utilization: ISBUC and initiatives in Brazil (Suleiman José Hassuani CTC, Brazil)

Biomass has been playing an important role in the sugarcane industry during recent years, and there are even greater possibilities for its utilisation in the future. Several initiatives regarding increasing biomass availability and its use are being carried out over the world. ISSCT had the initiative to create the International Sugarcane Biomass Utilization Consortium – ISBUC, aiming to organise some of these initiatives and gathering efforts towards a common industry objective. Gasification has been identified as one of these important initiatives. Brazil has been working towards trash recovery and its use for energy generation in the past years, and commercial application of some technologies is starting to take off. Gasification is also on the Brazilian agenda, and a Brazilian Gasification Consortium has been formed with governmental support. A joint participation of ISBUC in the Brazilian Consortium is under discussion. This presentation gave a broad idea of how the biomass subject is evolving in Brazil and the importance of ISBUC joining this initiative.

<u>Session H - Chemicals and derivatives from cane sugar and molasses.</u>

Fructose from sucrose using simulated moving bed (Dr Methinee Prongjit et al., Mitr Phol Sugarcane Research Center Co., Thailand)

The hydrolysis of sucrose solution into fructose and glucose rich solutions was described in this presentation. The fructose and glucose solutions were prepared by hydrolysis with a strong acid resin and continuous separation with a simulated moving bed (SMB) system. A laboratory sized unit for the continuous chromatographic separation was shown. About 2.5 L/h of sucrose feed and 3.5 L/h of eluent (water) produces about 3 L/h each of fructose and glucose solutions in the laboratory scale demonstration of the process. Purities of 92% in the fructose stream and of 89% in the glucose stream were obtained. Mitr Phol (Thailand) is investigating upgrading the process to pilot scale later during 2012.

Experiences in pilot scale D-lactic acid production from sucrose (Ms Pisittinee Chapaya et al., Mitr Phol Sugarcane Research Center Co., Thailand)

The production and purification of D-lactic acid were reported in this presentation. The study involved collaboration between AIST (Japan), Kasetsart University (Thailand) and Mitr Pohl (Thailand) to screen and optimise the D-lactic acid homo-fermentative microbe. The non-GMO micro-organism, Tokami-9, was selected for the study. Preliminary laboratory results were given for the fermentation of refined sugar, pure juice, mixed juice, clarified juice, raw syrup, invert sugar, raw sugar, final molasses, high test molasses and A molasses. Larger scale trials were reported for raw sugar and raw syrup since these feeds had high yields. In addition, the use of raw sugar and raw syrup conform to sugar policy regulations of the Thai government. The raw D-lactic acid produced by fermentation was purified in further work undertaken by Mitr Phol. The purified product conforms to commercial specifications.

Effect of nitrogen source on production of L-lactic acid from sugarcane syrup (Dr Walaiporn Timbuntam et al., Thai Bioplastic Association)

Lactic acid and poly lactic acid (PLA) are viewed as major growth industries and present a major opportunity. The production of L-lactic acid from microbes requires a nitrogen source which for commercial applications is likely to be yeast extract. However, this nitrogen source is very expensive and accounts for about 30% of the production costs. The project investigated yeast extract, silkworm pupae, beer yeast, dry beer yeast and shrimp waste as nitrogen sources. Shrimp waste was found to be an effective and low cost nitrogen source for the production of L-lactic acid. The study was undertaken through collaboration between Kasetsart University (Thailand), Thai Bioplastic Association and AIST (Japan).

Synthesis of poly* (D-*co*-L-lactic acid) *block copolymers (Prof Weraporn Pivsa-Art et al., Rajamangala University of Technology, Thailand)

This work examined block copolymers produced from low molecular weight D-lactic acid oligomers and low molecular weight L-lactic acid oligomers. The block copolymer products are subjected to thermal and physical property investigation with DSC (differential scanning calometry) and GPC (gel permeation chromatography). Results were presented on the thermal properties for various block copolymers. The enantiometric block copolymers show advantages over the phase separation of stereocomplex systems. The work was undertaken at Rajamangala University of Technology (Thailand).

Separation of DL-Lactic acid by filtration processes (Dr Anan Boonpan et al., Rajamangala University of Technology, Thailand)

Racemic mixtures of DL-lactic acid are prepared in chemical synthesis; whereas fermentation processes tend to produce pure lactic acid enantiomers. The PLA polymers prepared from either pure D- or L- lactic acid enantiomer give better thermal and mechanical properties than the PLA polymers produced from racemic mixtures. This work examined the separation of racemic mixtures of DL-lactic acid into the respective enantiomers.

β-Cyclodextrin was found to be an effective chiral selector for enantioseparation. In addition, the two-stage filtration process can be applied to practical D, L-lactic acid enantioseparation. The process was developed at Rajamangala University of Technology (Thailand).

Sugarcane wax: novel renewable nano-biomaterials for neutraceutical and cosmeceutical applications (Dr Kittiwut Kasemwong, National Nanotechnology Center, Thailand)

Sugarcane wax is of interest for commercial applications, in particular for the cosmetic and pharmaceutical industry. The wax is a potential source of long chain primary aliphatic alcohols that find applications such as cholesterol-lowering products. In addition, colloidal carriers, made from sugarcane wax, offer many advantages as a delivery system for poorly water-soluble bioactive compounds. These colloidal carriers consist of a lipid matrix that should be solid at both room and body temperatures and have a mean particle size between 50 and 1000 nm.

The National Nanotechnology Center (NANOTEC) in Thailand has developed nanoparticles of sugarcane wax with high colloidal stability, low cost and scalable manufacture processes that would provide a rapid product development pathway. Advantages include the composition (physiological compounds), effective production process and avoidance of organic solvents. This novel approach can be applied in the neutraceutical and cosmeceutical arena.

Session J – Particle boards from bagasse

Co-products from bagasse and the plans in Iran (E. Rezaei-Araghi et al., Sugar Cane & Byproducts Development Co., Iran)

Iran has over 68 000 ha under cane and produces about 5.7 Mt of sugarcane per year, although it has the potential to produce about 10 Mt/year. The country is relatively poor in terms of forestry and, therefore, bagasse is a useful source of fibre. It has MDF (medium density fibre board) and particle board plants plus animal feed production units, all from bagasse.

The bagasse from the Iranian mills is remarkably moist at virtually 55% moisture. Although this is not appropriate for energy production, it is appropriate for board plants as the bagasse is stored wet before processing using the Ritter process.

A new 132 000 m^3 per annum MDF plant was commissioned in 2011. The plant requires 8 MW, 400 m^3 per hour of water and 20 000 m^3 of gas per day to operate. The total investment was 1167 billion Rial [US$95 million] with the machinery originating in Western Europe.

Bagasse is de-pithed only during the 150 day crop and sent to pile storage but from then on the operation is on an annual basis, the bagasse being reclaimed, cleaned, dried and mixed with resin for feeding into the board machine. The board produced conforms to the relevant ANSI standard.

Iran also has a bagasse energy focus and is considering enhancing its existing power stations. It did look at the possibility of gasification and combined cycle but concluded that the technology is, as yet, not sufficiently advanced.

Site Visits

Saraburee Factory, Thai Roong Runag Group, Wang Muang, approx. 200 km Northeast of Bangkok

This is a 23 000 t/d factory producing 60% refined sugar (including several specialty sugars) and 40% raw sugar for export. Since 2008, an adjunct anhydrous ethanol plant with a production capacity of 110 000 L/d from final molasses and a cellulosic ethanol plant with a capacity of 10 000 L/d from bagasse have been installed. The ethanol plants were funded by the Japanese companies TSK and Marubeni. Bagasse at a rate of 130 t/d is hydrolysed with H_2SO_4 and separated into liquid and solid fractions. The liquid fraction is neutralised with gypsum and added to the molasses wash and sent to a batch fermentation process. KO11 enzyme is used to treat the liquid fraction in a C5 fermentation process. The solid fraction (hydrolysed bagasse with 80% moisture) is mixed with mill bagasse for combustion in the boilers.
The resulting vinasse from the distillation process is biodigested and the biogas is burnt in the boilers and helps to produce 4.5 MW of additional power. Digested vinasse is given to the farmers as fertiliser. Problems were reported with cleanliness of the bagasse, contamination in fermentation of the C5 hemicellulose part, and gypsum contamination of the fermented mash. Due to the high cost of production of ethanol from bagasse, this plant was not producing at the time of visit.

<u>Supan Buree complex</u>, Mitr PholGroup,Dan Chang, approx. 200 km Northwest of Bangkok

This is a 46 000 t/d sugar factory complex with 3 milling tandems, a major electrical bio-power export station, and adjunct anhydrous ethanol, liquid sugar and particle board / melanine paper plants. The third milling train and VHP sugar line was installed recently and just started operation for this crop.

The ethanol plant has 3 lines of 200 000 L/d each and uses only final molasses as feedstock. Continuous fermentation is followed by conventional distillation units and molecular sieve dehydration and vinasse concentration to 33% dry substance. The concentrated vinasse is cooled, mixed with filter mud and employed as fertiliser by the farmers. Total steam consumption of the distillery is approx. 3.8 kg/L.
The bio-power station of the mill consists of 2 boilers of 120 t/h and 70 bar pressure plus a new boiler of 170 t/h and 105 bar, 530°C of Indian origin. There are 3 turbogenerators of 41, 32 and 10 MW installed capacity. The electrical power consumption of the factory is approx. 50 to 60 MW and up to 35 MW are exported. The bagasse stockpile is sprayed every day and is compacted by front-end loaders to avoid losses by wind.

Appendix A - Workshop Programme

ISSCT CO-PRODUCTS WORKSHOP
19-22 March 2012
Centara Grand at Central Plaza Ladprao Bangkok, Thailand

Monday: March 19th 2012

08:00 – 09:00	Registration
09:00 – 09:30	- Welcome Remarks by : - **Mr. Kitti Choongawong** President of Thailand Society of Sugar Cane Technologists (TSSCT) - Opening remarks by : - **Dipl.-Ing. Pedro Avram-Waganoff** ISSCT Co-Products Chairman - Group Photo
Session A : Overview **Chairman : Dipl.-Ing. Pedro Avram-Waganoff**	
09:30 – 09:55	• **Transforming Sugar into Vegetable Oils** Miguel Oliveira , Bunge (Brazil)
09:55 – 10:20	• **Coproducts Operation at a Cane sugar factory** Narendra Mullapudi (India)
10:20 – 10:45	• **Biorefineries : Multi Product Approach to Derisk Sugar industry** Santosh Vyas, Praj Industries (India)
10:45 – 11:15	**Coffee break**
11:15 – 11:40	• **The Recent Situation of the Thai Sugar Industry and the National Bioethanol policy** Assoc. Prof. Klanarong Sriroth, Kasetsart University (Thailand)
11:40 – 12:05	• **Potential and Future of Thai Bioplastic Industry** Dr. Pipat Weerathaworn, Thai Bioplastic Industry Association (Thailand)
12:05 – 12:30	• **Virtual Sugarcane Biorefinery – Computational Tool to Compare Different Production Strategies in a Biorefinery Context** Dr. Antonio Bonomi – CTBE – Campinas (Brazil)
12:30 – 14:00	**Lunch Break**
Session B : Advances in ethanol fermentation from juice and molasses **Chairman : Suleiman Jose Hassuani**	
14:00 – 14:25	• **Extractive Fermentation of Ethanol from concentrated sweet sorghum juice**

	Asst. Prof. Apichat Boontawan, Suranaree University of Technology (Thailand)
14:25 – 14:50	• **Investigation of fermentable sugars ratio in molasses during storage** Chaiwat Ngasan, Mitr Phol Sugarcane Research Center Co., Ltd. (Thailand)
Session C : Advances in cellulosic ethanol fermentation **Chairman : Suleiman Jose Hassuani**	
14:50 – 15:15	• **A brief review of developments for the production of cellulosic ethanol** Dr. Bryan Lavarack, Mackay Sugar (Australia)
15:15 – 15:45	**Break**
15:45 - 16:10	• **Instrumentation & Control experience at a cellulosic ethanol plant.** Dipl.-Ing Bernd Langhans, SIEMENS (Germany)
Session D: Energy efficient distillation schemes **Session E: Treatment of vinasses by biodigestion, concentration and incineration** **Chairman : Suleiman Jose Hassuani**	
16:10 – 16:35	• **Distillation and Integrated Evaporation for Waste Concentration** Yotsapark Ruangrat , Praj Far East Co. Ltd, India
Session K : Special Topic and plant visit **Chairman : Assoc. Prof. Klanarong Sriroth**	
16:35 – 17:00	• **Patented Heating Technology** Cem Osman Aygün, BWS Technologie GmbH (Germany)
17:00 – 17:30	• **Overview of coproduct production at the Saraburee and Supan Buree plants** Mitr Phol Group and Thai Roong Ruang Sugar Group
18:00 – 20:00	**Welcome: Cocktail**

Tuesday: March 20th 2012

Session F: Overview of cogeneration in Thailand **Chairman : Dr. Michael Inkson**	
09:00 – 09:25	• **Overview of bagasse cogeneration development in Thailand** Suwat Kamolpanus, Mitr Phol Bio-Power Company (Thailand)
Session G: Gasification of bagasse and cogeneration potential **Chairman : Dr. Michael Inkson**	
09:25 – 09:50	• **Torrefaction of bagasse for additional coproducts at AB Sugar** Thomas Brewer, AB Sugar (UK)

09:50 – 10:15	• **The potential for the gasification of bagasse** Dr. Bryan Lavarack, Mackay Sugar (Australia)
10:15 – 10:40	• **Bagasse gasification: combined cycle** Dr. Michael Inkson, Thermal Energy System (UK)
10:40 – 11:10	**Coffee break**
11:10 – 11:35	• **Charcoal from Sugar Cane Bagasse** Dr.-Ing Helmut C.C. Bourzutschky, CBTC Suisse (Switzerland)
11:35 – 12:00	• **Biomass utilization: ISBUC and initiatives in Brazil** Suleiman José Hassuani, CTC (Brazil)
Session H: Chemicals & derivatives from cane, sugar and molasses **Chairman: Dr. Bryan Lavarack**	
12:00 – 12:25	• **Production experience of Fructose from Sucrose using simulated moving beds** Dr. Methinee Prongjit, Mitr Phol Sugarcane Research Center Co.,Ltd. (Thailand)
12:25 – 13:30	**Lunch Break**
13:30 – 13:55	• **Pilot scale D-Lactic acid production from sucrose** Ms. Pisittinee Chapanya, Mitr Phol Sugarcane Research Center Co.,Ltd. (Thailand)
13:55 -14:20	• **L-Lactic Acid Production from Industrial By-Product as Inexpensive Nitrogen source** Dr. Walaiporn Timbuntam, Thai Bioplastic Industry Association (Thailand)
14:20 – 14:45	• **Synthesis of poly(D-*co*-l-lactic acid Oblock copolymers** Dr. Weraporn Pivsa-Art, Rajamangala University of Technology Thanyaburi (Thailand)
14:45 – 15:10	**Break**
15:10 – 15:40	• **Separation of D,L-Lactic Acid by Filtration Process** Dr. Anan Boonpan, Rajamangala University of Technology Thanyaburi (Thailand)
15:40 – 16:05	• **Sugarcane Wax: Novel Renewable Nano-biomaterials for Neutraceutical and Cosmeceutical Applications** Dr. Kittiwut Kasemwong, National Nanotechnology Center (Thailand)
Session J : Particle boards from bagasse **Chairman : Dipl.-Ing. Pedro Avram-Waganoff**	
16:05 – 16:30	• **Co-Production from bagasse & the plans in Iran** Hamid Etezadi, Sugar Cane & By-products Development Co-SCBPDC (Iran)

<u>Wednesday</u>: March 21st 2012
08:00-17:00 Site visit: Saraburee ethanol factory
(Ethanol from bagasse hemicellulose and molasses)

<u>Thursday</u> : March 22nd 2012
08:00-17:00 Site visit: Mitr Phol Sugar Corp., Ltd., Supan Buree
(Cogeneration, ethanol and invert syrup plants)

Farewell Party

Appendix B – List of Attendants

INTERNATIONAL SOCIETY OF SUGAR CANE TECHNOLOGISTS
List of Participants (Foreigners)
CO-PRODUCTS WORKSHOP
19-22 MARCH 2012, THAILAND

No.	First Name	Last Name	Country	Company Name	Position	E-mail	Group
1	Dipl.-Ing. Pedro	Avram-Waganoff	Germany	IPRO Industrieprojekt GmbH	Commissioner and Section Chair ISSCT Coproducts Section	Avram@ipro-bs.de	B
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20	Dipl.-Ing Bernd	Langhans	Germany	SIEMENS	Manager Global Sales	bernd.langhans@siemens.com	A
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28	Mr. Anthony	Castorina	Australia	North Queensland Bio-Energy	Director	aecastorina@bigpond.com	B

ITERNATIONAL SOCIETY OF SUGAR CANE TECHNOLOGISTS
List of Participants (Thai)
CO-PRODUCTS WORKSHOP
19-22 MARCH 2012, THAILAND

No.	First Name	Last Name	Company Name	Position	E-mail	Group
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