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BioTimes®

INNOVATION AND ENZYMES LEAD TO ACRYLAMIDE REDUCTION

– NOVOZYMES AND PAVAN GROUP COLLABORATE ON THE QUEST TO CONQUER ACRYLAMIDE

Novozymes is the world leader in bioinnovation. Together with customers across a broad array of industries we create tomorrow's industrial biosolutions, improving our customers' business and the use of our planet's resources.

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ENZYMES THAT CUT – A WIN-WIN FOR LAUNDRIES

Today's laundries are constantly looking for new sustainable solutions that can enable cost savings yet achieve superior-quality textiles. With Novozymes Cellusoft® CR, you get the solution that skips a step and saves you time.

Increasing consumer demands for sustainable processes is heightening the pressure for textile companies to be environmentally friendly. In a troubled financial climate, laundries have had to look far for affordable solutions, but now they need not look any further for an answer to their concerns. Novozymes has recently established a new application that enables textiles to be bioblasted and dyed simultaneously in the dyeing bath. Cellusoft CR is the solution that gives laundries the winning hand and makes competitors work hard to match its results.

Working flexibility at no added cost

Cellusoft CR is a robust neutral bioblasting cellulase that prevents pilling and increases the smoothness and softness of fabrics. The enzyme works at a broad pH range of 5–8 which means that it can reduce the need for harsh chemicals or an acidic solution in the bioblasting process.

The enzyme was originally launched to replace traditional acid cellulases. With its flexible working conditions, scientists at Novozymes' laboratory explored the applicability of Cellusoft CR to processes pertaining to textile laundries – and with great success. "Because there's no residual peroxide before the dyeing in laundries, it's not necessary to use a product that has the ability to remove residual peroxide and bioblast – like the patented Cellusoft Combi does. The enzyme Cellusoft CR has a broad pH range and is stable with dyeing auxiliaries, which makes it ideally suited for combined dyeing and bioblasting in laundries," explains Len Tai Ng, Formulation Chemist at Novozymes.

So while traditionally, laundries bioblast in a separate process before or after dyeing, Cellusoft CR can be applied simultaneously at any stage of the process prior to alkali addition for reactive dyes. It is a flexible approach that decreases time spent on textile processing by eliminating an entire processing step. Considering how many processes a laundry runs per day, this can save a lot of time. And let us not forget that time is money: Cutting down on production time decreases labor costs and consumption, and leaves room for creating additional batches, thus increasing output. For laundries that means fast and efficient fashion creation! "Cellusoft CR in dyeing has allowed us to increase our throughput by 25%, and as a bonus on top of that we're now producing garments with an increased level of quality," says Mr. Xie, Production Director of Novozymes' customer, the Co-prosperity laundry in China.

Get softer, smoother, and more radiant fabrics

The "CR" in Cellusoft CR stands for "Color Retention" because the enzyme has proven to ensure greater color retention compared to typical bioblasting with an acid cellulase. In addition to conventional use of Cellusoft CR it can now also be used in combined dyeing and bioblasting as it is compatible with most

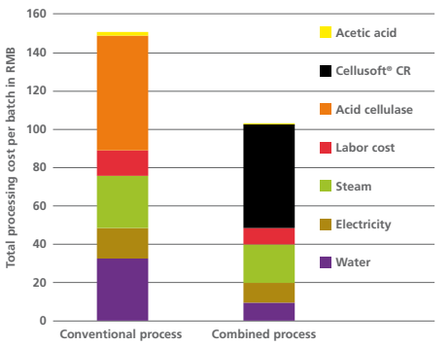
FIG. 1. TIME SAVINGS WITH DIFFERENT DYES

Type of dye	Estimated time needed in minutes		Savings (min)	Savings (%)
	Conventional process	Combined process		
Direct dye	101	54	47	47
Pigment dye	146	99	47	32
Reactive dye	161	114	47	29

Novozymes Cellusoft® CR saves production time in combination with different dyes.

TO THE CHASE

FIG. 2. COMPARISON OF TOTAL PROCESSING COST



Novozymes Cellusoft® CR is the sustainable alternative that decreases the usage of and costs associated with steam, electricity, water, and labor as well as the need for acidic applications. Case: China.

Bioblasting in a combined process ensures removal of fuzz and pills on fabric while light or thin fabric is better protected from tearing.

dyes that laundries use to obtain different colors, shades, and fashion looks, for instance a worn look for pants. "Because Cellusoft CR has features that allow it to withstand harsh chemicals, the solution functions optimally in a combined bath with many types of dyes. It's definitely also worth considering that, in some cases, the combined approach can cut down processing time by up to 47%. That's almost half of the average standard processing time, which could mean a substantial optimization of processes for many laundries," explains Han Kuilderd, Customer Solutions Manager at Novozymes.

Fabrics are often prone to pilling and fuzz after wash and wear by the consumer. Cellusoft CR significantly reduces the risk of this happening by reducing the risk of pill formation on the fabric. "Cellusoft CR leaves the garment smoother, softer, and nicer to wear. So it's not only a cost and time advantage to bioblast garments in the dye bath for laundries, it's indeed also an added value for the end user and ultimately the producer," says Han Kuilderd.

Another interesting benefit of Cellusoft CR is that it minimizes the risk of friction. Normally, thin or light fabric is often prone to being torn at the seam lines during washing due to mechanical action and fabric friction, but because this process is combined and shorter, Cellusoft CR leaves the fabric much stronger.

Go the enzymatic way

The combined approach to dyeing and bioblasting garments can in some cases reduce water usage by up to 70% per batch. "There lies a great potential in solutions like these that can combine processes. Imagine a textile laundry industry that exclusively uses this approach for bioblasting garments – that can amount to a lot of additional water in a world where clean drinking water is becoming scarcer," says Han Kuilderd and continues: "Now the focus for Novozymes is on getting good traction with some of the key players in this tough and fragmented industry to showcase what we're capable of. We can really make a difference, so I'm very optimistic about that," he concludes. ■

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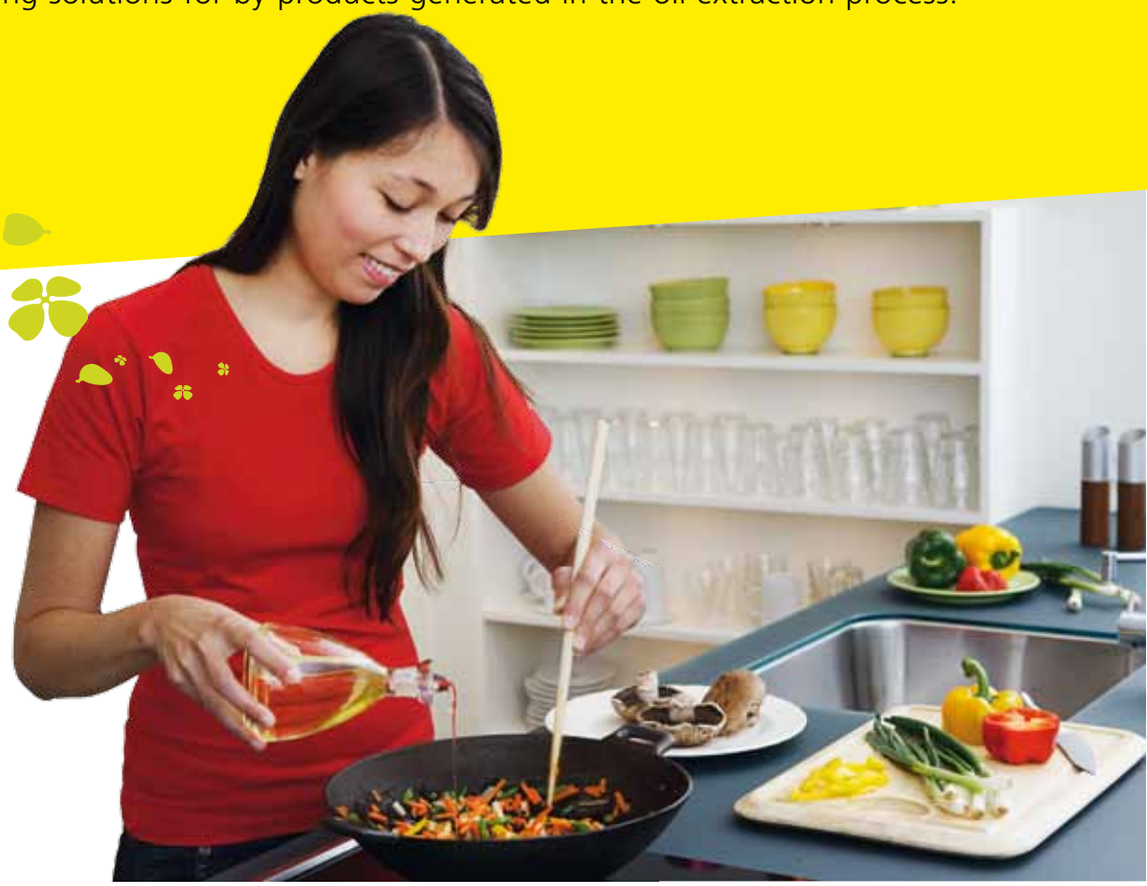
WELL-OILED PARTNERSHIPS

More and more businesses around the world form strategic alliances as a way to gain a competitive edge. The oil refining company A.P. Solvex Ltd., India, found an excellent innovation partner in Novozymes and could take rice bran oil refining to new levels. The cooperation gave better yields and a high-quality oil; it also spurred forward-looking solutions for by-products generated in the oil extraction process.



Enzymatic degumming is one of the application areas in the oils and fats industry that has grown rapidly over the last decade. In India, many of the important market players have already adopted the new way of refining oils, and it is not hard to understand why: Shifting to enzymatic degumming can lower refineries' energy demand and oil loss, and reduce by-products and chemical usage. "These benefits are in themselves great opportunities for oil producers. But we also offer our customers new product opportunities and the chance to be at the forefront of bioinnovation," says Hans Christian Holm, Global Marketing Manager for Oils & Fats at Novozymes.

Enzymes are on a roll in the oil business

Novozymes gives its customers not only a great product, but also the added value of a vast know-how. The company works closely with the customer to ensure a smooth implementation of the new degumming process and products. "When a potential customer approaches us, we look at their needs. Together we define a project where we examine the customer's raw materials and the goals the customer wants to reach. In some cases, when the customer has very specific needs, we also fine-tune the enzymatic degumming process to fit these goals," says David Cowan, Application Scientist at Novozymes.

The next step is to upscale lab tests to more real-life refining scenarios. Together with the engineering company DeSmet Ballestra, Novozymes has developed a pilot plant that can be set up on-site in the refineries, allowing the customer to do more realistic plant trials.

Getting the most out of lucrative rice bran oil

Novozymes' work with rice bran oil is a good example of how a good partnership can lead to problem-solving and beneficial solutions. Rice bran oil, known to balance cholesterol levels, was until recently extracted in limited amounts only. High yield losses, compared to other vegetable oils, meant that a large share of the oil was not used for human consumption. "These losses can be reduced with acid refining, but 1.6% of the oil is still lost in the degumming process. The industry simply lacked a cost-effective technology that could improve the refining process. Thanks to Novozymes' enzymes, refineries can now improve the yield by 1%. But the producer doesn't only get more oil, the degumming results are better and more consistent, and that gives a higher-quality product,"

INCREASE YIELDS

Rice bran oil is a very healthy oil extracted from the bran of the rice kernel.

says Lakshmi Narasimhan S., Account Manager at Novozymes.

Pioneering the field in India

The largest producer of physically refined rice bran oil in India, A.P. Solvex, was impressed with Novozymes' innovative approach and started a close collaboration with Novozymes as early as 2002. Back then, A.P. Solvex pioneered the attractive rice bran oil market by introducing enzymatic degumming at its plants. The company could quickly harvest the higher yields and better quality of its oils. "We've worked intensely to make A.P. Solvex a frontrunner in innovation since we introduced enzymatic degumming in 2002. Our hard work has paid off, and in 2007 we received a prestigious national award for our R&D activities from the Indian prime minister," says A.R. Sharma, A.P. Solvex's Managing Director.

Today, Novozymes and A.P. Solvex work closely together and have, over the years, substantially improved the enzymatic degumming process. The joint research has led to an innovative way of handling one of the by-products of the process. "When degumming, lecithin converts into lysolecithin, which is a really good emulsifier. It's obtained in a diluted form, and companies spend a lot in drying costs to concentrate the lysolecithin. Thanks to our close collaboration we were able to recycle and concentrate the lysolecithin that comes out from the centrifuge. After drying, A.P. Solvex can sell this product as an emulsifier to be used in, for instance, animal feed," says Asha Kembhavi, Customer Solutions Consultant at Novozymes. "In Novozymes, we're now looking at how we can extrapolate this learning and develop similar solutions for other customers and oil types, like mustard and soybean oils."

In A.P. Solvex's top-notch labs, teams from both companies developed innovative solutions that take rice bran oil refining to new levels.

Another novel application that arose from the Novozymes–Solvex cooperation is improved recovery of rice bran oil wax – the vegetable wax extracted from bran oil. "The wax contains a lot of oil, so extracting it means improved yield. But we're working on a solution that will give both more oil and a better rice bran wax that can be used in a wide range of products," says Asha Kembhavi.

"Our close work with A.P. Solvex has made these innovative solutions possible. A.P. Solvex has a very competent team, and we were able to benefit from their knowledge and gain access to their highly sophisticated labs. The collaboration is a perfect example of how new ideas prosper when you combine vast enzyme knowledge with industry experience." ■

WHAT IS ENZYMATIC DEGUMMING?

Crude oil is extracted from oil seeds and is then refined to remove impurities that can impact the oil's stability, color, and flavor. Each refining step results in a loss of yield, and it is therefore important to limit the loss as much as possible. Gums in vegetable oils need to be removed to ensure a stable and good oil quality. Enzymatic degumming converts nonhydratable lecithin (gums) to water-soluble lysolecithin, which is separated by centrifugation. All the lecithin is removed with the wastewater in a one-step centrifugation stage. Enzymatic degumming is an economical alternative to chemical and physical degumming. It provides higher yields and significant cost saving and is an environmentally friendly process.

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With the European Chemicals Agency (ECHA) adding acrylamide to its list of hazardous chemicals in April 2010, the focus is turning once again to the food industry – in particular to the measures being taken to reduce the concentration of acrylamide in food products.

COLLABORATING TO CONQUER

Pavan Group, a worldwide provider of process technology solutions for the food industry, recently collaborated with Novozymes to assess the effect that Novozymes Acrylaway® has on extruded pelleted potato snacks. And this collaboration proved once more that innovative thinking and enzymes can help future-proof the food processing industry.

Pavan was founded over 60 years ago, initially specializing in pasta production and diversifying into snack pellets and breakfast cereal production during the late 1970s. The company's recent trials together with Novozymes have focused on its technological developments in extrusion equipment, which offers the perfect processing environment in which to add Acrylaway when creating snack pellets. Extruded potato snacks are primarily based on potato-based raw materials such as potato flakes, potato granules, and potato starch and are manufactured by low-shear extruders. Snack pellets are dry, semifinished products that need to be expanded by frying or hot air and flavored to create the final snack product.

To develop snack pellets, the mixture needs to be cooked, usually using extrusion cooking technology, and shaped and dried to make a compact product that can easily be preserved for up to a year under normal storage conditions at room temperature. These snack pellets offer snack manufacturers a multitude of benefits – including the possibility of using a wide range of raw materials, such as cereals, legumes, and tubers in addition to potato granules and flakes, and greater flexibility in the variety of potential shapes. Pavan's technology enables snack pellet manufacturers to pass on these significant advantages to their customers and, combined with Novozymes' know-how, the ability to create snack pellets with reduced levels of acrylamide.

Innovation and enzymes – The perfect partnership

"At Pavan, we strive to offer our customers innovative ways to add value to existing products," says Luisito Virtucio, Innovative Products Manager in Pavan's Research and Development department. "Whether it's adding antioxidants or soluble fibers, or – as in this case – a solution to reduce acrylamide, we want to ensure that our customers can create snack pellets with a difference."

Such continuous innovation is key to Pavan's values – and one of the reasons why it is a natural collaboration partner for Novozymes. "We've learned so much about acrylamide reduction through our relationship with Novozymes. Whether it has been working with Peter Müller from Customer Solutions or having Benjamin Thieringer's meticulous support with the analytical work," continues Luisito Virtucio, "we couldn't have progressed so much in this area without them."

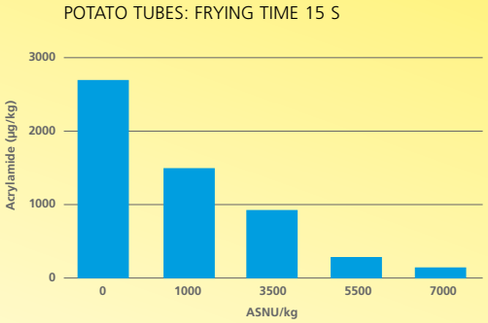
The versatility offered by snack pellets means that this market, traditionally based in Europe, has spread to Asia, Mexico, and the Middle East. "We're not just selling machinery to our customers, we're also selling ideas for new products," says Luisito Virtucio. "Valin, our industrial partner, produces these new snacks based on our prototypes. Our potential customers can buy these ready-made snack pellets and experience exactly what our technology can achieve."

Pavan believes that its customers are very much aware of the acrylamide debate and have shown an interest in suggested reduction methods. "Many of our customers have specifically asked what we're doing when it comes to reducing acrylamide," says Luisito Virtucio. "As consumers are becoming more aware of the issue of

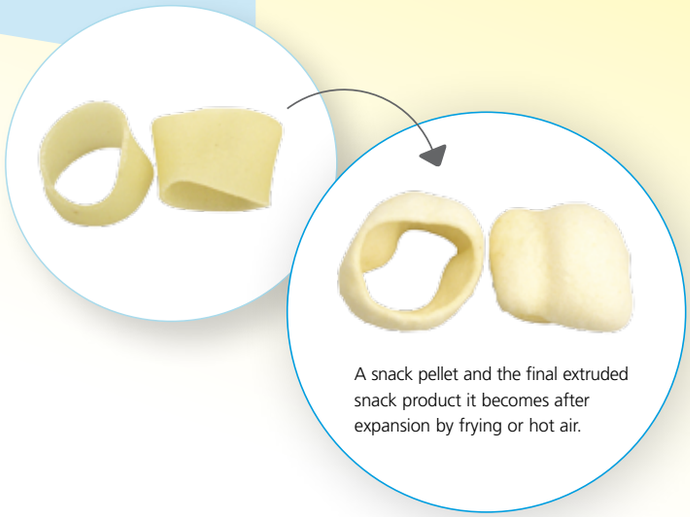
The Pavan team involved in the Novozymes–Pavan trials standing in front of Pavan's innovative equipment developed for the extrusion cooking process.

HOW ACRYLAMIDE IS FORMED

The main mechanisms that cause the formation of acrylamide are commonly found in starchy foods: reducing sugars and the amino acid asparagine. During the baking or frying stage, a process called the Maillard reaction occurs – essential for important color and flavor developments in baked, fried, and toasted foods. Through a cascade of reactions, the side chain of asparagine is converted into acrylamide.



A trial demonstrating the amount of acrylamide remaining in potato snack pellet tubes after frying for 15 seconds. Four samples were treated by different Novozymes Acrylaway® dosages, and one sample was untreated.



A snack pellet and the final extruded snack product it becomes after expansion by frying or hot air.

ACRYLAMIDE

acrylamide, manufacturers are growing more concerned about how to reduce it effectively."

Pavan recently introduced new innovation to the extrusion cooking process, which includes a screw configuration that significantly reduces the mechanical energy applied to the dough. "It's very easy to use Acrylaway with our technology," says Theresa Piromalli, Analytical Laboratory Technician at Pavan. "The solution is added to the dough mixture during the preparatory stage, so it works perfectly with our process," agrees Germana Zurlo, head of Pavan's Analytical Laboratory.

This advanced technology appeals to snack pellet manufacturers who are seeking to maintain the nutritional value and flavor of the natural raw material – and the addition of Acrylaway offers entirely new innovation to a high-quality product.

Results worth sharing

During the Novozymes–Pavan production trials on the effect of Acrylaway on potato-based snacks, the acrylamide levels in the final snack products were analyzed by an independent certified laboratory. "One particular trial used four different Acrylaway dosages," says Peter Müller, Customer Solutions Manager at Novozymes. "And depending on the dosage, it led to an acrylamide reduction of 44–94%."

Acrylamide in foods is formed as a by-product of the Maillard reaction during frying or baking. The amino acid asparagine reacts at temperatures above 120 °C and at low moisture with reducing sugars such as glucose and fructose to form acrylamide. Acrylaway converts the amino acid asparagine into the amino acid aspartic acid, thereby reducing the level of acrylamide without altering the tempting taste and appearance of the end product. The asparagine levels remaining in the potato-based snack pellets after treatment with Acrylaway were analyzed in-house at Novozymes, Switzerland, and they demonstrated a very good correlation between asparagine and acrylamide reduction.

Fortifying the future through reducing acrylamide

As the public eye is focusing once more on acrylamide and consumers are growing ever more conscious about what they eat, manufacturers are posed with the challenge of how to effectively reduce its concentration in their products. Asparaginases such as Acrylaway are one of the more appealing solutions suggested by the Confederation of the Food and Drink Industries of the EU (CIAA) in its acrylamide mitigation toolbox. Their allure is due to the fact that they work effectively, yet enable the final products to retain their tempting flavor and appealing look.

The recent trials by Pavan and Novozymes prove once again that this asparaginase truly works – and preserves the taste, texture, and color of the final product. With innovative enzymatic solutions such as Acrylaway and progressive companies such as the Pavan Group combining their strengths, a proven solution to significantly reduce acrylamide in extruded potato-based snacks is available for snack producers. ■

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PRECISE IODINE COLOR CONTROL OF LIQUEFACTION IN DISTILLERIES

When Ivan Georgievich Baloga of the Red Sloboda distillery in Ukraine borrowed a kit from Novozymes for monitoring liquefaction, he did not want to give it back.

The production of beverage alcohol is similar to starch processing to make sweeteners or fuel ethanol. To start with, the grain used as a source of starch is milled and cooked to hydrolyze the starch molecules into dextrins. The first step is liquefaction where alpha-amylases are used. Obviously the processor aims to convert as much of the starch into dextrins as possible in order to obtain the highest alcohol yield.

To measure the degree of starch hydrolysis during liquefaction, an iodine test is used. Iodine turns blue in the presence of starch. However, in a solution of pure glucose, it turns yellow. There is a whole spectrum of colors in between to indicate the varying degrees of polymerization (Dp). All the color changes occur between Dp^{12} and Dp^{45}.

Color confusion

The difficulty for operators is to describe these colors accurately and to know which color indicates when liquefaction is optimal. Color descriptions can be highly subjective, and misinterpretation can lead to errors. For example, the words "purple" or "plum color" might be used to indicate when liquefaction is optimal. However, "purple" or "plum" can mean different things to different people.

That is why Novozymes invented a foolproof testing kit launched in 2005. It has proven to be very popular with the starch processing industry. After some modification of the operating procedure, a kit called the Liquefaction Dextrose Analyzer (LDA) is now available to Novozymes' customers in the beverage alcohol industry. Since March 2010, it has been rolled out to customers primarily in the CIS region (countries of the former Soviet Union).

Method for milled grains

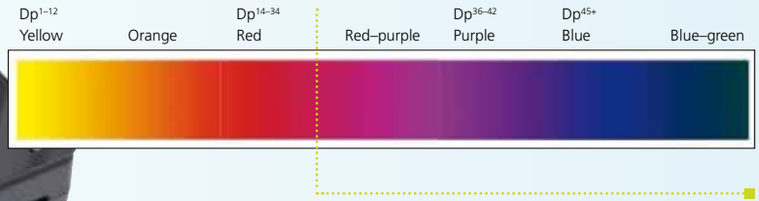
The people responsible for the adaptation research work at Novozymes were Erik Andersen, Customer Solutions Application Manager, and Rita Feiring, Senior Lab Technician in Grain Processing. They were advised by a technical consultant to Novozymes, Alexander Fedorenko, who is responsible for the beverage alcohol industry in the CIS region.

The problem with analyzing hydrolysates for whole grain is the variability of the samples and the effect of nonstarch impurities, which tend to influence the iodine color so that it is not a true representation of the pure starch and maltodextrin content. Novozymes has been able to develop a method of preparing samples that overcomes these difficulties and is optimal for use with the LDA in mashes where the raw material is milled grains.

A wheel of colors

"With this kit, you compare the color obtained from the iodine test to a color wheel consisting of 10 colors in the critical range," says Erik Andersen. "As a customer, you know which color indicates when the process is ready. If your result is bluer

The Liquefaction Dextrose Analyzer avoids mistakes when analyzing samples from liquefaction in distilleries.



The lower the degree of polymerization (Dp), the more yellow the result is from an iodine test. The higher the Dp, the more blue. The ideal result is a red–purple shade in between these two extremes.

Erik Andersen, Customer Solutions Application Manager, and Rita Feiring, Senior Lab Technician in Grain Processing, Novozymes, developed an accurate and simple method for analyzing the iodine color in liquefied mash made from milled grains. This method was developed especially for the beverage alcohol industry.

Ivan Georgievich Baloga (left), Chief Technologist of the Red Sloboda distillery, and Alexander Fedorenko, Novozymes' technical consultant for the beverage alcohol industry, standing next to the Liquefaction Dextrose Analyzer.

than this, you know that you're adding too little enzyme or you may need to let the process run for longer. If the color is at the red/yellow end of the scale, you know you're adding too much enzyme. Therefore, the LDA allows customers to optimize the enzyme dosage as well as to avoid low alcohol yield due to the problem of undercooked mashes."

The critical part of the kit is a color wheel turned by a dial until it matches the color of the sample on the Petri dish. The light-box ensures that all evaluations are based on readings with the same background light.

Each color in the wheel has a number making it easy to describe the color observed and giving a consistent color description from one operator to another.

Each plant can work out the ideal number to indicate when liquefaction is optimal. It is also easier to track iodine color development in the plant over time, and the color numbers can be entered into databases.

Red Sloboda was first

The first beverage alcohol customer to put the kit to the test was the Red Sloboda distillery in the town of the same name in the Zhitomir area of Ukraine. With an output of 30,000 liters per day, it is one of the largest distilleries in Ukraine. The alcohol it produces is used in Hortizya, a well-known brand of vodka in Ukraine.

During a visit by Novozymes representatives in May 2007, the distillery had a chance to borrow the LDA for a trial period.

More accurate, less enzyme

"At once, the LDA showed us all the mistakes we were making in the liquefaction process. These weren't clear to us before when we only used the traditional iodine test," says Ivan Georgievich Baloga, Chief Technologist of the Red Sloboda distillery. "The first test showed us a result of DE 8–10 that wasn't good enough. After seeing this, we decided to make some adjustments to the liquefaction process by installing recycling pumps. That allowed us to obtain DE 15 with the same enzyme dosage of the alpha-amylase Novozymes Termamyl® SC.

"With the help of the LDA, we have a fast method for analyzing samples from different stages of the process. Using the traditional iodine test, it wasn't possible to measure the degree of hydrolysis exactly, and mistakes were often made. The new LDA method is very accurate and quick. We can avoid human error and are able to enter exact numbers into our DE lab database."

The new LDA has allowed the distillery to optimize its dosing of enzymes, and they were able to reduce the dosage of the liquefaction enzyme Termamyl SC. This enzyme breaks down the starch into smaller dextrin molecules with 5–40 glucose units. In the next step, these polysaccharides will be converted into glucose by means of a gluco-amylase such as Novozymes Saczyme®.

At Red Sloboda, the raw materials corn and rye are first placed in a slurry mixing tank at a temperature of 70 °C for 40 minutes. Then the slurry is placed in one of two liquefaction tanks and held at a temperature of 85–88 °C for 210 minutes. Termamyl SC is added in both stages.

More kits available

In 2007, Novozymes had only a few LDAs available in Ukraine. When it was time to give the LDA kit back at the end of the trial, Ivan Georgievich Baloga was very reluctant to relinquish it. "The kit became very important for managing our liquefaction process, especially when starting up the process, changing raw materials, and so on," he recalls.

Novozymes decided to let him keep the kit on a long-term loan and has since produced more LDAs and extended this service to many other customers in the region. ■

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PARTNERSHIP TO TURN SUGAR INTO PLASTIC

A new partnership based on Novozymes' fermentation technology and Braskem's expertise in chemical technology and thermoplastics will develop a green alternative to polypropylene derived from oil.

Polypropylene (PP) is a plastic we come across all the time in a wide range of everyday products – from food containers, drinking straws, and water bottles to washing machines, furniture, and car fenders. It is the second most widely used thermoplastic (after polyethylene) with a global consumption in 2008 of approximately 44 million tons. Though it is currently derived from oil, that could change in the future if the brains at Braskem and Novozymes succeed in developing new technology to convert sugar into polypropylene.

In all physical respects, polypropylene made from sugar is identical to polypropylene made from oil: same chemical composition, same flexibility, same durability. The important difference is that one originates from renewable sugarcane while the other comes from a resource that contributes to global warming and is destined to run out one day. Importantly, the use of sugarcane results in reduced greenhouse gas emissions when used as a substitute for petroleum in polypropylene production.

In addition, because the price of oil fluctuates, the price of polypropylene fluctuates with it. More stable and cheaper prices are therefore expected to be other advantages of using sugar instead of oil to make polypropylene.

First-generation green PP

Given its green credentials, there is a large potential market for the new sustainable polypropylene derived from sugar. Braskem of Brazil is one company determined to explore this new market after having certified the first worldwide green polypropylene made with first-generation technology at laboratory scale two years ago. They have ambitious plans to commercialize the product and go into full-scale production with more advanced and competitive technology in future, and that is why they contacted Novozymes.

Their joint research with Novozymes' scientists in Denmark and the US led to a partnership agreement announced during the COP15 conference in Copenhagen in December 2009. Novozymes will use its technology and know-how to help Braskem develop large-scale production of polypropylene from sugarcane. Braskem is the largest petrochemical company in Latin America and is the first major chemical company to sign a partnership with Novozymes.

"This partnership is an important step toward creating a bio-based economy, in which oil-based products are gradually replaced with bio-based products," says Thomas Grotkjær, Business Development Manager in the Conversion of Renewables department at Novozymes and a key person in the partnership with Braskem. "Novozymes has traditionally been in the enzyme business but it became obvious to us that we could use our microorganisms and fermentation technology in other applications to expand the whole bio-based economy. Here is a prime example and the aim of the partnership is to put a new polypropylene product onto the world market."

Ethanol to plastic

In the mid-1970s, Brazil was the first country in the world to blend gasoline for cars with fuel ethanol made on a large scale from homegrown sugarcane. Today, Brazil is the prime producer of

Thermoplastics derived from renewable sugarcane are being developed in Brazil by Braskem in collaboration with Novozymes.

ABOUT BRASKEM

Braskem is a Brazilian petrochemical company headquartered in São Paulo. It is the largest petrochemical company in Latin America and the third largest thermoplastics producer in the Americas after ExxonMobil and Dow Chemical. It makes a range of petrochemical products with the focus on PE, PP, and PVC. The company employs around 4,700 people and had net revenue of BRL (Brazilian real) 15.3 billion in 2009, without considering the recent acquisition of Brazilian company Quattor and Sunoco Chemicals' PP business in the US.

ethanol from sugar and has become the largest exporter of fuel ethanol in the world.

Sugarcane grows efficiently in Brazil with little need for fertilizer, and there is a plentiful supply of ethanol made from sugarcane on the Brazilian market. Indeed, one of Braskem's sister companies within the Odebrecht Group is a sugar and ethanol producer. So ethanol was the natural choice as the starting point for the production of green polypropylene.

The new polypropylene conversion process under development will require a new fermentation process with new microorganisms, and that is where Novozymes' know-how comes in.

Novozymes has a strong research team in what is known as the "Renewable Chemicals and Metabolic Engineering platform." The Metabolic Engineering group at Novozymes was set up to support projects for the development of proprietary organisms to enable novel metabolic pathways to ferment sugar into valuable chemicals.

Under the terms of the joint development agreement with Braskem, initial development work will run for at least five years. Upscaling and further commercial development will take place in a pilot facility before a large-scale plant is constructed in Brazil and commercial products enter the market. So it is still early days before a product is manufactured and ready to be sold.

From PE to PP

This is not Braskem's first venture into green plastics. In April 2009, Braskem began building a 200,000 tons/year green polyethylene (PE) plant in Brazil. Ethanol from sugarcane will be used as the raw material, and the plant will be fully operational by the second half of 2010.

Polyethylene can be made economically from ethanol and that makes it competitive with polyethylene made from oil. Its investment in the plant for green polyethylene encouraged Braskem to investigate the production of another thermoplastic, polypropylene, from ethanol.

"Braskem was the first company in the world to produce a certified 100% renewable polypropylene on an experimental basis. The partnership with Novozymes will further boost Braskem's technology development and be a key step in the company's path to consolidate world leadership in green polymers," says Bernardo Gradin, CEO of Braskem.

His counterpart at Novozymes, Steen Riisgaard, adds: "We live in a world where oil is limited and expensive, and the chemical industry is looking for alternatives to its petroleum-based products. Novozymes' partnership with Braskem is a move toward a green, bio-based economy in which sugar will be the new oil." ■

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GET BEHIND THE SCENES **WITH NOVOZYMES TV**

Live pictures bring stories to life and fire up the message. If you tune in to Novozymes TV, you will get a chance to meet some of our partners, experts, customers, and the people who work at Novozymes.

At Novozymes we create solutions for our customers that drive the world toward a more sustainable tomorrow. But only by listening to the world around us and only by spreading the word about how our solutions help our customers improve their business will we succeed. Through Novozymes TV we want to share these stories by taking an outside-in perspective on our industry and our customers.

Numerous stories to share

"It's important for us to reach a large number of stakeholders to present ourselves and our technologies," says Mads Madsen, Head of Corporate Positioning. "Web TV is a step further in that direction. We have numerous fantastic stories about how our customers benefit from our solutions and how we make a positive impact on the world. But we also want to invite people behind the scenes and get a better feeling of the people who work at Novozymes," says Mads Madsen.

Meet the passionate professor and the general

Novozymes TV aired last fall and has since been far around. We have invited lifestyle expert Christine Feldhaus inside the headquarters buildings to analyze our surroundings, we have taken a tour at the world's largest cellulosic biofuel demonstration plant, Inbicon, and we have met Dr. Robert Bruck, a very passionate professor from North Carolina State University and listened to his view on global warming. Furthermore we have met the cochairman of Growth Energy, General Wesley Clark, and discussed sustainomics with Nobel Peace Prize Laureate Mohan Munasinghe. So join in and find the themes and people that interest you the most. ■

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