Bio-Based Packaging Opportunity Assessment

Final Report

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Agriculture and Rural Development

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KEATING BUSINESS STRATEGIES LTD.

Growing Forward

Government of Alberta

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Executive Summary

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Biomass can be converted in the following pathways:

Sugar beet > Glyconic acid > Polyglonic acid

Starch > (fermentation) > Lactic acid > Polylactic acid (PLA)

Biomass > (fermentation) > Bioethanol > Ethene > Polyethylene

Biopolymers are renewable, sustainable, and can be carbon neutral. Biopolymers are renewable as they are made from renewable plant materials which can be grown year on year indefinitely in the case of crops and within ten years with trees. Polymers derived from petrochemicals will become increasingly more expensive as the technology is well established but the raw material source supply diminishes. It has also been demonstrated by various companies and researchers that biopolymers have the potential to cut carbon emissions as it takes less energy to produce and process them. As well, the CO_2 released when they degrade can potentially be reabsorbed by crops grown to replace them.

Some biopolymers are biodegradable and also compostable. When biodegradable biopolymers degrade they break down into CO_2 and water by microorganisms. The CO_2 can then re-enter the carbon cycle. As well, some biopolymers can be compostable at home or in industrial facilities. There are legislative requirements around identifying products as compostable but standards are set and certification is in place for both. This will be presented in detail.

Major factors influencing future markets and demand for bio-based products includes:

- Limited availability and increased cost of non-renewable resources;
- Policy development in countries around the globe with emphasis on climate change mitigation, sustainable production practices and industrial policy;
- Changing consumer demand based on environmental awareness, convenience, product/packaging lifecycles and sustainable production systems;
- Support to rural communities and biomass producers;
- Ability to reduce carbon and water footprints in industrial production while increasing competitiveness with innovative products;
- Often low toxicity, high bio-degradability and better recycling options.

According to a recent report from Pike Research (www.pikeresearch.com), worldwide packaging-industry revenues will increase from $429 billion in 2009 to $530 billion by 2014, representing a growth rate greater than that of the global economy itself.

But growing even faster than packaging overall is the new field of sustainable packaging. Pike Research anticipates that environmentally-friendly packaging will nearly double in revenues between 2009 and 2014, from $88 billion to $170 billion.

Plastics will be the fastest-growing segment of the sustainable packaging sector through 2014, Pike predicts. "More eco-friendly plastic packaging will have a huge impact," says Pike managing director Clint Wheelock, *"because it represents more than a third of the total global packaging industry, second only to paper packaging."*

In the European report, *"Taking Bio-Based from Promise to Market",* published on November 3, 2009. The list of positive benefits of bio-based packaging included:

- Use of renewable and expandable resources
- Less dependency on limited and increasingly expensive fossil resources
- The potential to reduce greenhouse gas emissions (carbon neutral / low carbon impact)
- The potential for sustainable industrial production
- Potentially better recovery and recycling options
- Often low toxicity
- Often high bio-degradability or compostability
- Less resource-intensive production (water, energy, waste)
- Potentially improved population health
- Support to rural development
- Increased industrial competitiveness through innovative eco-efficient bio-based products

Bio-Packaging in Alberta SWOT Analysis

As part of the opportunity analysis Keating Business Strategies conducted a SWOT analysis of the bio-packaging industry in Alberta as outlined below:

Strengths

- Abundant and high quality raw materials
- Excellent research and development resources
- Highly trained and skilled workforce with skills and knowledge transferability from the oil and gas industry
- Funding programs available for R & D
- Strong provincial research and innovation focus in Alberta
- Excellent market location and market access
- Excellent distribution network through road, rail and air

Weaknesses

- Limited commercialization expertise and funding in province in proportion to research and development expertise and funding
- Limited commercial management and operations expertise in biopackaging industry
- Funding programs and assistance are targeted towards pre-commercial activities and not commercialization
- Lack of commercialization capital for biobased ventures
- Limited understanding of industry potential in Alberta
- Market growth is somewhat restricted by higher production costs of biopolymers

Opportunities

- Potential for the production or blending of biopolymers with Alberta produced polyethylene
- The consumer is becoming more *"green",* which is driving the supplier/manufacturer to change their ways. An Alberta based biopackaging facility would help suppliers present these options to consumers in hopefully a more affordable and environmentally friendly way than sourcing from the US, Europe or Asia.
- As regulations become predominately detailed by government, bio based packaging would be more viable.
- Cup manufacturers including lids in Alberta.
- Development of a resin that could be processed well and be as clear as PET.
- Development of biobased fibres for packaging

Threats

- Competition from the large multinationals that have already gained a strong and ever increasing foothold on the bioplastics and biopackaging market
- Increasing international regulations and standards
- Consumer backlash from utilization of food based ingredients (starches and oils) in production of biopolymers

Polyethylene in Alberta

Polyethylene describes a huge family of resins obtained by polymerizing ethylene gas and it is by far the largest volume commercial polymer. This thermoplastic is available in a range of flexibilities and other properties depending on the production process, with high-density materials being the most rigid. Polyethylene can be formed by a wide variety of thermoplastic processing methods and is particularly useful where moisture resistance and low cost are required.

Polyethylene resins, both high and linear low-density, are produced at the Nova Chemicals Inc. facility in Joffre and at the Dow Chemical Canada facility in Prentiss. Most of the polyethylene resins produced at these facilities are exported to the United States and some volume does go to Asia. Total polyethylene produced at the two locations is estimated to be 1.1 million tonnes per year, which is equivalent to 2.5 billion pounds.

There may be opportunities for Nova Chemicals to expand its markets for its poly-ethylene resins for the manufacture of large-shape plastic product in Alberta. As transportation costs are high relative to the value of product shipped, a regional manufacturer may have a competitive advantage to be located in Alberta versus manufacturers from outside of Alberta. In addition to the two major polyethylene producers there are plastic product users and plastic recyclers in Alberta.

Nova Chemicals makes ethylene, polyethylene, and performance styrenics used in the manufacture of plastic and foam products. Applications include rigid and flexible packaging, plastic bags, appliances, electronics, housewares, and plastic pipe. The US and Canada account for 80% of Nova Chemicals' sales. In 2008 worldwide sales were estimated at $7.4 billion with 2,850 employees. Abu Dhabi's International Petroleum Investment Co. (IPIC) owns Nova Chemicals Inc. IPIC purchased the company in 2009 for $2.3 billion.

Blending Polyethylene with Biopolymers

There have been some attempts to blend polyethylene from the petrochemical industry with biopolymers to achieve a lower cost polymer and/or to improve the properties of the polymer (ie. impact resistance). Much research is still required in this area but there is promise. In 2008 a summary of research for blending polylactide and polyethylene was published in Polymer Reviews titled ‘Toughening Polylactide”.

Recommendations for Industry Development

It is evident there is opportunity for the development of the bio-packaging industry in Alberta. Alberta has a number of key competitive advantages with an abundance of raw materials, access to research and development infrastructure and expertise, synergies with the oil and gas industry, skilled labour force, a competitive tax regime and direct access to a market of more than 50 million people. The biopackaging industry is in a relatively early stage of development and opportunities exist for Alberta to enter this industry. In particular, research indicates there may be an opportunity for the commercial production or blending of biopolymers with Alberta produced polyethylene. It is also clear that opportunities exist for the commercial development of natural fibre based packaging products or manufacturing utilizing Alberta based agriculture and forestry feed stocks.

The following outlines key recommendations which include:

- Renew focus on producing biopolymers from biomass based in western Canada such as canola and forestry
- Approach petrochemical companies to blend biopolymers and develop new market offerings similar to DuPont and BASF product offerings
- Monitor research efforts into developing biopolymers from lower-cost cellulosic raw materials, residual biomass such as wheat straw and non-food plants.
- Develop a targeted investment attraction program of bio-industrial companies to identify potential partnerships, corporate interest and potential commercial investment
- Meet with the three main biopolymer companies in the US to determine potential partnerships and expansion opportunities in Alberta: NatureWorks, Cereplast and Telles.

1. Background

This report focuses on biopolymers (often referred to as bioplastics or renewable polymers) for the packaging of cosmetics and personal care products, food products and bio-medical ingredients.

Biopolymers for use in the packaging industry are non-food products derived from renewable biomass such as plants, crops, trees, animals and food production. It does not include food, fuel, feed or energy products. There is invariably a link among these sectors in the bio-economy and this will be examined briefly.

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Some biopolymers are biodegradable and also compostable. When biodegradable biopolymers degrade they break down into CO_2 and water by microorganisms. The CO_2 can then re-enter the carbon cycle. As well, some biopolymers can be compostable at home or in industrial facilities. There are legislative requirements around identifying products as compostable but standards are set and certification is in place for both. This will be presented in detail.

> "In the U.S., demand for biodegradable plastic is forecast to expand 15.5% per year to 720 million pounds in 2012, valued at $845 million."
>
> Source: The Freedonia Group report on biodegradable plastics

A growing number of bio-based chemicals, such as the biodegradable bioplastic PLA (polylactic acid) made from dextrose that is derived from plant starches (primarily corn in North America), are already in commercial production. Many established chemical companies, as well as new startups, are positioning themselves to make bioplastics and other emerging bio-products where they see significant new market opportunities. One company, NatureWorks, a wholly-owned Cargill company with manufacturing in Blair, Nebraska, makes 90% of the world's supply of biodegradable plastic PLA from corn. Their long-term plan is to lower the cost of the PLA by utilizing lower-cost cellulosic raw materials, residual biomass (ie wheat straw) and non-food plants.

The potential benefits seen in biopolymers made from renewable resources are environmentally friendlier, more efficient products and processes with less dependence on high-cost crude oil and natural-gas liquids for feedstocks and energy.

Major factors influencing future markets and demand for bio-based products includes:

- Limited availability and increased cost of non-renewable resources;
- Policy development in countries around the globe with emphasis on climate change mitigation, sustainable production practices and industrial policy;
- Changing consumer demand based on environmental awareness, convenience, product/packaging lifecycles and sustainable production systems;
- Support to rural communities and biomass producers;
- Ability to reduce carbon and water footprints in industrial production while increasing competitiveness with innovative products;
- Often low toxicity, high bio-degradability and better recycling options.

Biopolymers can come from various biomass sources and thus create different types of plastic. There are starch based plastics, polylactic acid (PLA) plastics, poly-3-hydroxybutyrate (PHB), polyamide 11 (PA 11), bio-derived polyethylene, genetically modified bioplastics and on the horizon are plastics utilizing nanotechnology. A summary of each of these types of plastics is presented in the following Table 1 – Summary of Types of Plastics.

Table 1: Summary of Types of Plastics

Starch based plastics
Constituting about 50 percent of the bioplastics market, thermoplastic starch, such as Plastarch Material, currently represents the most important and widely used bioplastic. Pure starch possesses the characteristic of being able to absorb humidity and is thus being used for the production of drug capsules in the pharmaceutical sector. Flexibiliser and plasticiser such as sorbitol and glycerine are added so that starch can also be processed thermo-plastically. By varying the amounts of these additives, the characteristic of the material can be tailored to specific needs (also called "thermo-plastical starch").
Polylactic acid (PLA) plastics
Polylactic acid (PLA) is a transparent plastic produced from cane sugar or glucose. It not only resembles conventional petrochemical mass plastics (like PE or PP) in its characteristics, but it can also be processed easily on standard equipment that already exists for the production of conventional plastics. PLA and PLA-Blends generally come in the form of granulates with various properties and are used in the plastic processing industry for the production of foil, moulds, tins, cups, bottles and other packaging.
Poly-3-hydroxybutyrate (PHB)
The biopolymer poly-3-hydroxybutyrate (PHB) is a polyester produced by certain bacteria processing glucose or starch. Its characteristics are similar to those of the petroplastic polypropylene. The South American sugar industry, for example, has decided to expand PHB production to an industrial scale. PHB is distinguished primarily by its physical characteristics. It produces transparent film at a melting point higher than 130 degrees Celsius, and is biodegradable without residue.
Polyamide 11 (PA 11)
PA 11 is a biopolymer derived from natural oil. It is also known under the tradename Rilsan B, commercialized by Arkema. PA 11 belongs to the technical polymers family and is not biodegradable. Its properties are similar to those of PA 12, although emissions of greenhouse gases and consumption of non-renewable resources are reduced during its production. Its thermal resistance is also superior to that of PA 12. It is used in high-performance applications like automotive fuel lines, pneumatic airbrake tubing, electrical cable anti-termite sheathing, flexible oil & gas pipes, control fluid umbilicals, sports shoes, electronic device components, and catheters.
Bio-derived polyethylene
The basic building block (monomer) of polyethylene is ethylene. This is just one small chemical step from ethanol, which can be produced by fermentation of agricultural feedstocks such as sugar cane or corn. Bio-derived polyethylene is chemically and physically identical to traditional polyethylene - it does not biodegrade but can be recycled. It can also considerably reduce greenhouse gas emissions. Brazilian chemicals group Braskem claims that using its route from sugar cane ethanol to produce one tonne of polyethylene captures (removes from the environment) 2.5 tonnes of carbon dioxide while the traditional petrochemical route results in emissions of close to 3.5 tonnes.
Braskem plans to introduce commercial quantities of its first bio-derived high density polyethylene, used in a packaging such as bottles and tubs, in 2010 and has developed a technology to produce bio-derived butene, required to make the linear low density polethylene types used in film production.
Hydroxyl-terminated polybutadiene
Hydroxyl-terminated polybutadiene is a polyol used to produce polyurethane. Polyester polyols from vegetable oils, known as natural oil polyols or NOPs, are replacing some epoxide-based polyols.
Genetically modified bioplastics
Genetic modification (GM) is also a challenge for the bioplastics industry. None of the currently available bioplastics - which can be considered first generation products - require the use of GM crops.
Source: http://en.wikipedia.org/wiki/Bioplastics#cite_note-3

2. Global Demand For Bioplastics

According to a recent report from Pike Research (www.pikeresearch.com), worldwide packaging-industry revenues will increase from $429 billion in 2009 to $530 billion by 2014, representing a growth rate greater than that of the global economy itself.

But growing even faster than packaging overall is the new field of sustainable packaging. Pike Research anticipates that environmentally-friendly packaging will nearly double in revenues between 2009 and 2014, from $88 billion to $170 billion.

Plastics will be the fastest-growing segment of the sustainable packaging sector through 2014, Pike predicts. "More eco-friendly plastic packaging will have a huge impact," says Pike managing director Clint Wheelock, "because it represents more than a third of the total global packaging industry, second only to paper packaging."

It is expected that the global demand for bioplastics will increase to more than 900,000 metrics tons by 2013. Biodegradable plastics totalled nearly 90 percent of the overall market. The following Table 2 – World Package Demand for Bioplastics by Region outlines the global packaging demand for bioplastics by region.

TABLE 2: WORLD PACKAGING DEMAND FOR BIOPLASTICS BY REGION (thousand metric tons) 1998 - 2018

Item	1998	2003	2008	2013	2018
World Packaging Bioplastics Demand	42	50	90	389	790
North America:	11	13	27	85	169
United States	9	11	22	72	140
Canada & Mexico	2	2	5	13	29
Western Europe	15	21	32	125	227
Asia/Pacific:	12	12	26	133	274
China	2	2	7	30	86
Japan	6	6	12	75	124
Other Asia/Pacific	4	4	7	28	64
Other Regions	4	4	5	46	120

Source: Freedonia Group Inc.

3. North American Market

The North American market is comprised of Canada, the United States and Mexico. Biopolymer demand has traditionally been strong in Canada and the United States with Mexico increasingly becoming more developed and increasing the amount of trade in the region. Demand for biopolymer-based products in the North American markets has dampened with the recent economic downturn but is projected for substantial growth.

Demand for biopolymer in North America is projected to be 193,000 tonnes in 2013 and growing to over 400,000 tonnes by 2018. As the economy strengthens past 2010 the demand for the more expensive biopolymer based products will increase along with disposable income and more sensitive awareness of the environment.

One of the major drivers is expected to be plastic bags as municipal jurisdictions move towards banning them and consumers demand a biodegradable alternative. In 2005, 9.5 million tonnes of plastic bags were produced in Canada and the U.S. As well, the cost to produce biopolymer should reduce as new technology and processes are developed to increase efficiency.

The US is the largest producer of biopolymers and exports throughout the world with the leading biopolymers being PLA and PHA resins. PLA is produced by NatureWorks in Blair, Nebraska and PHA is now produced in volume from the new Telles' plant. Strong advances are also expected for petroleum-based biodegradables in blends with other bioplastics.

Canada does not have any biopolymer production of note but is expected to continue strong demand for biopolymer-based products and that will drive imports, primarily from the US for PLA based products. Increased efforts to provide industrial composting and biopolymer recycling will further increase demand for biopolymer-based products.

Mexico also does not have any biopolymer production and imports from the US. As Mexico continues to develop, the demand for bio-based products is anticipated to gradually increase but not near the pace of US or Canada. One exception is the demand for biodegradable bags as Mexico City banned traditional plastic bags in August 2009.

TABLE 3: NORTH AMERICA -- BIOPLASTICS DEMAND BY TYPE & MARKET (thousand metric tons) 1998 - 2018					
Item	**1998**	**2003**	**2008**	**2013**	**2018**
Plastic Resin Demand	44020	51780	54900	62950	70900
kg bioplastic/m ton plastic	0.39	0.54	1.06	3.07	5.78
Bioplastics Demand	17	28	58	193	410
By Type:					
Biodegradable	14	24	53	83	175
Non-Biodegradable	3	4	5	110	235
By Market:					
Packaging	11	13	27	85	169
Nonpackaging	6	15	31	108	241
% North America	27.9	28.6	29.0	21.4	21.0
World Bioplastics Demand	61	98	200	900	1950

Source: The Freedonia Group, Inc.

4. Industry Comments

As part of the process of completing the Bio-Based Packaging Opportunity Assessment, Keating Business Strategies (KBS) was asked to interview bio-based industry in North America to identify any opportunities or barriers in the bio-based packaging industry as well as any comments about the industry in Alberta. Several companies were interviewed and results identified common trends and needs among all industry members. The following section provides a summary of the discussions.

KBS has collected surveys from suppliers of raw materials, manufacturers of bio-based chemicals used in packaging, manufacturers of bio-based packaging, and end users of packaging. Respondents primarily represent the cosmetics/personal care and food products industries. Many of the businesses are involved in multiple industries and some have multiple functions. The following gives a brief summary of the information collected in the assessment.

Respondent demographics

Industry	No. of respondents*
Cosmetics and Personal Care	6
Food Products	3
Biomedical	1
Other	7

- Industrial, Multi-industry (2), Biopolymer production, Industry Association, Chemicals/Materials, Consulting

Company's role in the bio-based manufacturing and packaging industry	No. of respondents*
Provide the raw materials to bio-based manufacturers	2
Manufacture bio-packaging ingredients or bio-based packaging/films	6
Purchase packaging for products (cosmetics, food, biomedical)	4
Other	2

- Industry Association, Consulting

Business details:

There were few companies willing to give company information such as prices and volumes of materials they purchase or ship. Here is a summary of the information that was collected:

- One international, U.S based company that manufactures polylactic acid sources their corn from a plant close to Nebraska, Iowa. They generally purchase 15 million bushels per year at a price of $4/bushel.

- Another large international, U.S based company manufactures bio resin and sources all raw materials from various plants in the United States.
- A company in Canada that extracts chemicals from crops using a novel solvent-based technology sells their products to U.S. companies. They sell typically around 5-10 kg/month; however their production is expected to increase by 5-10 times. The best price they've received for their product is $40,000/kg.
- A large international packaging company adds a degradable additive from Epiglobal in Vancouver, B.C to their film.
- A high end cosmetics company listed the prices they pay for packaging as $.30 for generic/less specialized to $1.50-$2.50 for expensive airless bottles. These prices include printing.

Purchasing of Alberta bio-based packaging:

All six that were asked the question, "Would you purchase Alberta *bio-based ingredients or packaging* if available?" answered "yes". However, two indicated they would not pay a premium. The main comments were as follows:

- Market would bear a certain premium.
- Would pay 10-15% premium.
- If the product was price sensitive, they wouldn't pay a premium.

Incentives/Investment drivers needed to entice investment in Alberta:

- Access to source material.
- Direct financial assistance to defray costs of relocation.
- Easy distribution channels (roads, trains etc).
- Cheap and abundant labor – difficult if the oil and gas industry is booming.
- Government grants or help, such as matching dollars.
- Break on municipal/income taxes.
- Universities offering the right programs, getting technical institutes more involved in the business side.
- Free flow of information and goods across the Canada/U.S. border.

Information required to get started:

- Need information on unique technologies – i.e. What is University of Alberta doing in the packaging area that companies could leverage?
- Description of R&D/demonstration facilities.
- Cost of doing business in Alberta.
- Sense of potential accessible technology.
- Characteristics of the customer/demand/market requirements.
- Optimal location for a facility.
- Government support.

- Scan of other companies in the same sector/what industries are in Alberta - want to be present where there is a cluster of other companies.
- Identify competition as well as those who would compliment business.

Potential opportunities for the development of the bio-based industry in Alberta:

- Ways to reposition those already in the industry.
- Opportunities in the packaging market as a whole.
- The consumer is becoming more "green", which is driving the supplier/manufacturer to change their ways. Having a bio based packaging facility in Alberta will not only help suppliers present these options to consumers in hopefully a more affordable way than sourcing from the US/Europe/Asia, but also reduce our carbon footprint as well. Also introducing such a facility will help enhance people's awareness of the environment and alternative processes and products to use.
- As regulations become predominately detailed by government, bio based packaging would be more viable.
- Cup manufacturers (inc. lids) in Alberta.
- Lot of opportunities within bioproducts - new oils and polymers, biofuel applications.
- Industrial side has a lot of potential but not a lot of companies in the sector, need early stage company creation.
- Development of a resin that you could process well and be as clear as PET.
- Companies are always looking for unique technologies.

Ryan Radke, President of BioAlberta had this to say about the industry in Alberta, *“The bio-based industry offers real promise for the future of Alberta’s economy. Our existing strength in agriculture and energy, provides a natural pathway for new bioproduct and biofuel applications that can spur Alberta’s diversification”.*

Alberta’s competitiveness:

Of the thirteen respondents, eleven indicated they consider Alberta to be a competitive place to do business and suggested the following:

- Geographic location makes it convenient (except for locations in eastern Canada). However, it is noted that geography is low on the list for competitiveness.
- Many businesses are closer to Alberta than the east coast.
- Close proximity to Vancouver and the Pacific Ocean and proximity to California, Oregon, and Washington which are all considered to be quite "green" states.
- Good corridor to California.
- Can service western Canada.
- Government support/funding - specifically Alberta food processors.

- Alberta has a vast amount of food processors.
- Overall low cost/tax rate.
- Strong R&D infrastructure – beyond to pilot and prototypes.
- Opportunities for companies looking to locate, especially in agriculture - access to raw materials and product for food products and cosmetics.
- People in Alberta have a "can-do" attitude.
- Minimal politics and bureaucracy.

Barriers:

Most of those who indicated there were barriers to investment in Alberta, suggested availability of capital in Alberta as the main reason:

- Not a solid foundation of angel investors.
- Archaic laws making it difficult for US investors to invest in Canadian companies.
- Immature financial ecosystem (limiting opportunities to syndicate investors).
- Lack of local capital.
- Most investment in Alberta is in the oil and gas industry, getting people to invest in something that is bio-based may be difficult.
- Geography was a factor for those research/manufacturing facilities located in northeastern U.S. Most manufacturing facilities are located in mid or eastern U.S.
    - Product supply chain value (logistics of shipping material from Alberta - not cost competitive as to where the end users are located).
- Un-coordinated bureaucracy, over regulated environment.
- Inexperienced support industries (engineering, design, legal etc).
- Limited experienced manpower.
- Alberta doesn't have an advantage in terms of raw material costs.
- Competitiveness – people are not willing to pay more just because it is a green product.

Some of the respondents suggested the following company specific barriers within the bio-based packaging industry:

- Lack of regulations on flow of recycle stream - what can and can't be recycled - still up for debate in the industry.
- Cost of bio based products makes it difficult to purchase.
- Test on resin indicated it didn't run smoothly in existing equipment.

5. Alberta's Competitive Advantages

Alberta has an abundance of natural resources, a skilled work force, and a growing knowledge-based economy.

Economic Results

- From 2003 to 2008, Alberta had the highest average rate of economic growth in Canada at 3.8% per year. Because of the global economic downturn, Alberta's economy contracted by 0.2% in 2008 and 2% in 2009. However, experts believe that Alberta will fully recover and continue to lead the country in economic growth over the long term.
- Alberta's exports of goods and services more than tripled between 1998 and 2008 to $118.7 billion. A growing number of those exports are manufactured products and services. Exports of manufactured goods more than doubled over the same period.
- Alberta has had a rapidly growing manufacturing base. Between 1998 and 2008, manufacturing shipments more than doubled to $70.1 billion.
- Average annual employment in Alberta in 2008 increased by 53,900 over 2007. More than 500,000 new jobs were created between 1998 and 2008.
- Alberta's average unemployment rate in 2008 was the lowest in Canada at 3.6%.

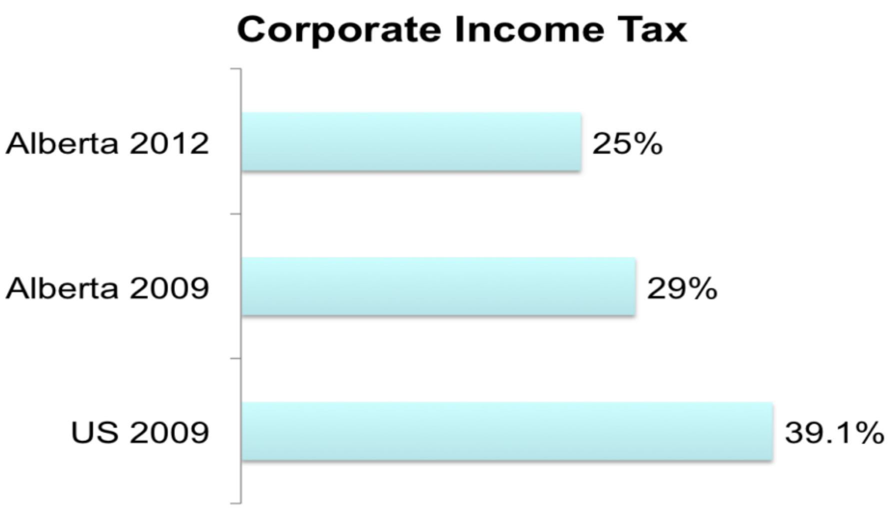
Source: www.alberta-canada.com

5.1. Investment

The Alberta government encourages investment with important tax incentives and exhibits the following:

- The lowest tax regime in Canada. Alberta businesses do not pay general sales taxes, capital taxes or payroll taxes. The general corporate tax rate is 10 per cent, and the small business tax rate is three per cent, the third lowest among the provinces.
- A 10 per cent refundable provincial tax credit for scientific research and experimental development, which encourages research and development in Alberta. It is worth up to $400,000 annually per company.

Chart 1: Corporate Income Tax



Source: Alberta Finance and Enterprise

5.2. Access to Markets/Infrastructure

Alberta is strategically located with its central position in the growing western Canadian market of nine million people. It has emerged as the western North American warehouse and distribution hub for Canada and the Pacific Northwest region of the United States.

Figure 1: Alberta Location

Alberta is the only western province that offers overnight, less than 24-hour delivery service to all of western Canada and the U.S. Pacific Northwest with direct connections to two of North America's largest highway trade corridors. This is a market of more than 50 million consumers.

Along the same access routes are connections to the enormous markets of the Pacific Rim, California and central Canada. The Pacific Rim is easily accessible with the intermodal system linking Alberta to the Port of Vancouver, logistics to California from the Pacific Northwest are easily managed and the Trans-Canada highway links Alberta to central Canada. There is increasing potential for expanded transportation of goods along these routes as infrastructure is continued to be built and improved upon.

Alberta has an extensive network of road, rail and air transport facilities. This includes; 8,400 kilometres of rail tracks, 13,000 kilometres of paved highways with favourable backhaul rates on refrigerated vans heading for California, and equipment flatdecks bound for Texas and the Mid-West. Alberta has two of Canada's busiest and most efficient international airports, both with plans for expansion over the next two years. Also, with easy access to the Port of Vancouver there are favourable rates on containers returning to the Pacific Rim.

5.3. Identification of Biomass

Alberta has a geographic advantage of a large landmass with an expanse of forested areas and productive agricultural lands.

Agricultural biomass includes a wide range of plant material along with the main product of the crop. Alberta’s farm land embraces a total area of 52 million acres. The agriculture land base comprises about 32 million acres in production (65%) on an annual basis and the balance (35%) is in permanent cover (tame pasture, forages, rangeland).

Table 4: Available Biomass

Residue Type	Available Quantity mt/year
Wheat Straw	5,980,000
Barley Straw	2,860,000
Flax Straw	48,000
Hemp Straw	3,000
Wheat Bran	600,000

Source: Alberta Agriculture and Rural Development

Alberta's land base covers 106 million acres (43m ha) area of forest, which allows the annual harvest of 23.3 million cubic meters of wood. Of the wood harvested, approximately 50% is generated in the form of valuable products from saw, pulp and paper mills. The remaining 50% in the form of chips, sawdust, bark, planer shavings and yard waste is left unused. According to a survey which was commissioned by the Alberta Forest Products Association in 1998, there was 1.4 million bone dry tonnes (bdt) of surplus wood waste including 445 thousand bdt of whitewood waste. The association also surveyed the pulp and paper industry who indicated they obtained 58 thousand bdt of excess sludge.

Table 5: Wood Waste Surplus

Residue Type	Production	Utilization	Available	Surplus %
Bark	714,332	270,771	443,561	31.8
Sawdust/Pins	399,966	179,527	220,439	15.8
Shavings	414,178	189,121	225,057	16.1
Trim Blocks	37,117	29,784	7,333	0.5
Log Yard Debris	416,003	115,404	300,599	21.5
Other	1,321,316	1,230,109	91,207	6.5
Dry Waste	186,234	180,289	5,945	0.4
Wet Waste	178,847	135,100	43,747	3.1
Sludge	158,922	101,529	57,393	4.1
Total	**3,826,915**	**2,431,634**	**1,395,282**	**100**

Source: Alberta Agriculture and Rural Development

5.4. KPMG Competitive Alternatives– Chemical Manufacturing Plant

Competitive Alternatives is KPMG's guide to comparing business locations in North America, Europe and Asia Pacific.

The Competitive Alternatives study is the most thorough comparison of international business locations ever undertaken by KPMG. This study contains valuable information for any company considering their international business location options.

Competitive Alternatives 2008 compares business competitiveness for more than 100 cities in ten countries: Australia, Canada, France, Italy, Japan, Germany, Mexico, the Netherlands, the United Kingdom, and the United States. For the first time, the 2008 study includes all three NAFTA countries and all 50 US states, in addition to its traditional G7 coverage.

The primary focus of Competitive Alternatives 2008 is international business costs. The study measures the combined impact of 27 significant cost components that are most likely to vary by location, as applied to 17 different business operations. The basis for the cost comparison is the after-tax cost of startup and operation, over a 10-year planning horizon. Results are based on the combined results for a group of comparable cities in each country, and are expressed in comparison to the baseline results of the United States.

For the comparison conducted in the report, 10 cities were identified. In Alberta, three major cities along the Highway 2 corridor were selected including Red Deer, Calgary and Edmonton. Across Canada three additional cities were selected - Toronto, Montreal and Vancouver. Adding international representation is Paris and Frankfurt in Europe, Hamamatsu in Japan and one city in Australia, Sydney.

The industry most closely related to the production of biopolymers included in the KPMG Competitive Alternatives is the chemical industry. This is the basis for comparison between the cities. A summary of the operating parameters for the facility is shown here.

Table 6: Summary of Operating Parameters

SUMMARY OF OPERATING PARAMETERS
Industry: Chemicals
Operation: Specialty chemicals manufacturing

Facilities requirements

Industrial site purchased	5acres (2 hectares)
Size of factory built	50,000 sq.ft. (4,645 sq.m.)

Other initial investment requirements

Machinery and equipment - US $'000	$14,000
Office equipment - US $'000	$500
R&D equipment - US $'000	$500
Inventory - US $'000	$5,000
Equity financing - % of project costs	40%

Workforce

Management	5
Sales and administration	16
Production/non-dedicated product development	
- Professional, technical	71
- Operators	2
- Unskilled laborers	4
- Other	2
Total employees	100

Energy requirements
Electricity: monthly consumption/peak demand
500,000 kWh and 1,800 kW
Gas: monthly consumption
41,300 CCF (117,000 m3)

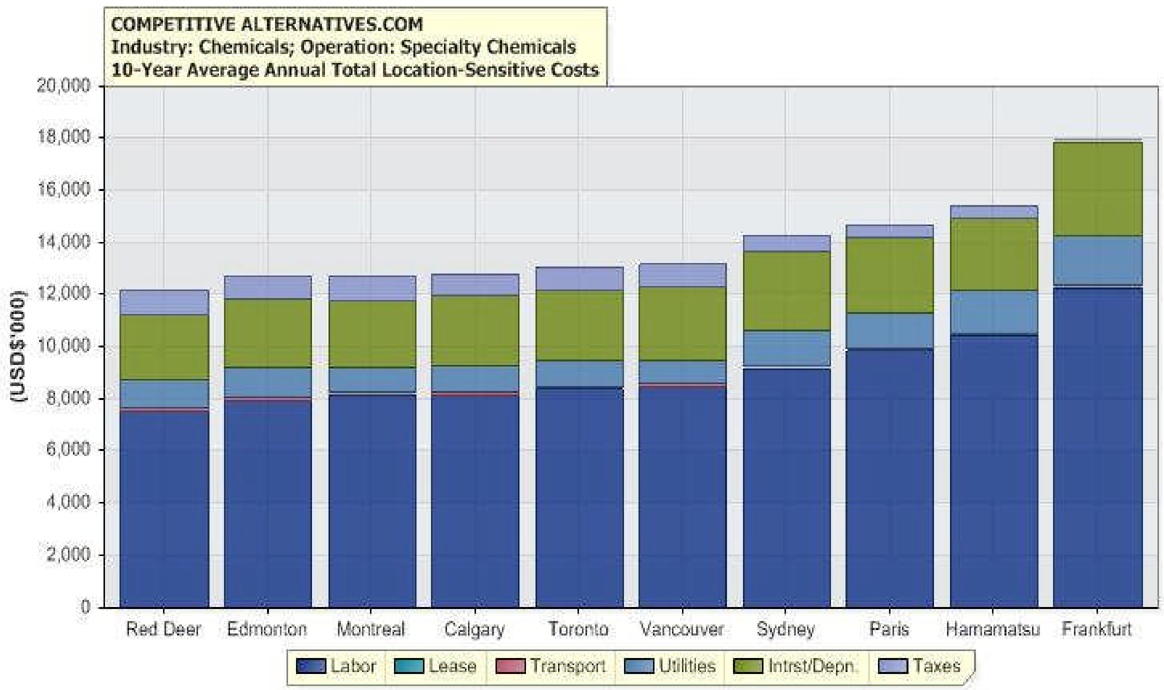
Other annual operating characteristics

Sales at full production – US	$30,000
Materials and other direct costs - % of sales	43%
Other operating costs - % of sales	4%
Investment in tax-eligible R&D - % of sales	2.1%

Source: KMPG Competitive Alternatives

The analysis shows that Canada has a cost advantage over all of the other countries examined in the cost comparison. Alberta has two cities, Red Deer and Edmonton, having the best results comparatively to all other cities examined. Labour and utilities have the largest cost impact and most variability between cities, especially on facilities located outside of Canada.

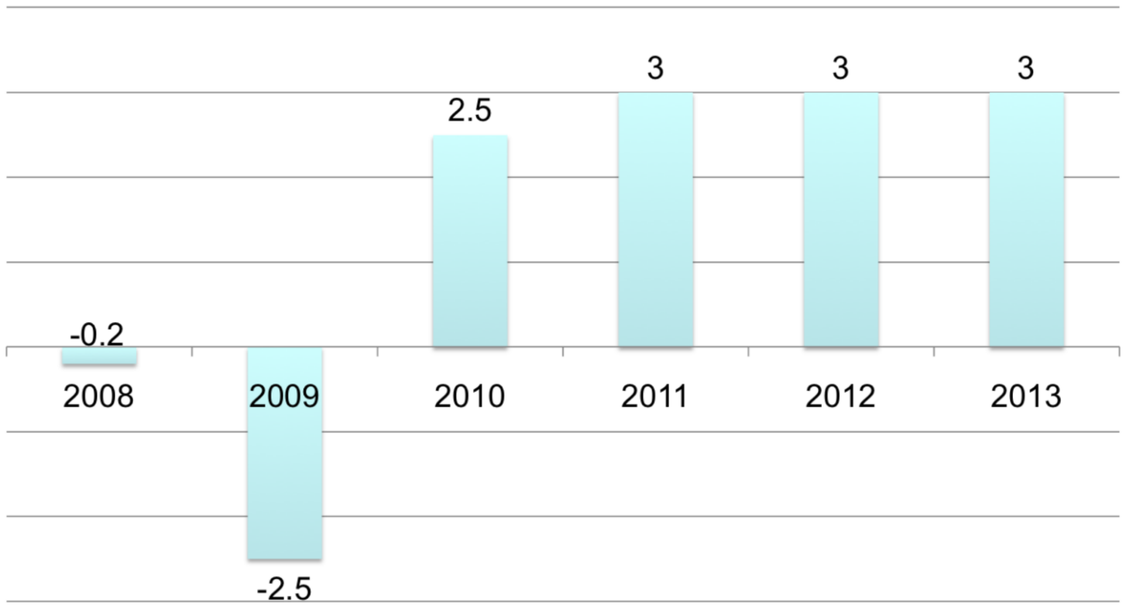
Chart 2: Competitive Alternatives



5.5. Alberta's Competitive Advantages for Bio-Based Packaging

The province of Alberta has an abundance of biomass, infrastructure and skilled labour to grow the bio-based economy. Attracting large global companies to invest in the production of biopolymers will not only add direct revenue to the producers of biomass, but will also generate revenue and jobs in rural areas.

Chart 3: Alberta's Economic Outlook



Source: Alberta Budget 2010: 2010-13 Economic Outlook

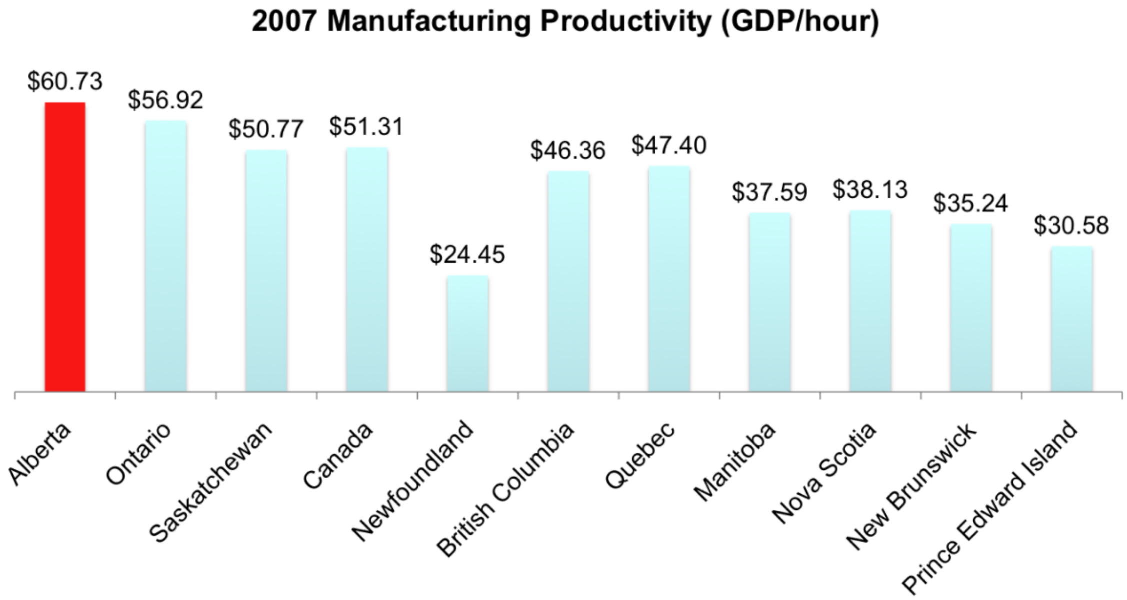
Labour

The recession has led to a drop of 25,200 in average employment in Alberta between 2008 and 2009, increasing the unemployment rate from 3.6% to 6.6%. Alberta still had the third lowest unemployment rate among the provinces in 2009.

With forecasted stronger domestic demand and higher corporate profits a modest rise of 15,000 (0.8%) in average employment is expected in 2010. The unemployment rate is expected to average 6.6% for 2010 as a whole, similar to the rate prevailing at the end of 2009 because offsetting growth in the labour force. The unemployment rate is expected to gradually decline to 4.9% by 2013.

Worker productivity has traditionally been strong in Alberta. In 2007 Alberta had the highest GDP per hour of any other province at $60.73. The chart shows the comparison of the provinces.

Chart 4: 2007 Manufacturing Productivity



Polyethylene in Alberta

Polyethylene describes a huge family of resins obtained by polymerizing ethylene gas and it is by far the largest volume commercial polymer. This thermoplastic is available in a range of flexibilities and other properties depending on the production process, with high-density materials being the most rigid. Polyethylene can be formed by a wide variety of thermoplastic processing methods and is particularly useful where moisture resistance and low cost are required.

Polyethylene resins, both high and linear low-density, are produced at the Nova Chemicals Inc. facility in Joffre and at the Dow Chemical Canada facility in Prentiss. Most of the polyethylene resins produced at these facilities are exported to the United States and some volume does go to Asia. Total polyethylene produced at the two locations is estimated to be 1.1 million tonnes per year, which is equivalent to 2.5 billion pounds.

There may be opportunities for Nova Chemicals to expand its markets for its polyethylene resins for the manufacture of large-shape plastic product in Alberta. As transportation costs are high relative to the value of product shipped, a regional manufacturer may have a competitive advantage to be located in Alberta versus manufacturers from outside of Alberta. In addition to the two major polyethylene producers there are plastic product users and plastic recyclers in Alberta.

Nova Chemicals makes ethylene, polyethylene, and performance styrenics used in the manufacture of plastic and foam products. Applications include rigid and flexible packaging, plastic bags, appliances, electronics, housewares, and plastic pipe. The US and Canada account for 80% of Nova Chemicals' sales. In 2008 worldwide sales were estimated at $7.4 billion with 2,850 employees. Abu Dhabi's International Petroleum Investment Co. (IPIC) owns Nova Chemicals Inc. IPIC purchased the company in 2009 for $2.3 billion.

Blending Polyethylene with Biopolymers

There have been some attempts to blend polyethylene from the petrochemical industry with biopolymers to achieve a lower cost polymer and/or to improve the properties of the polymer (ie. impact resistance). Much research is still required in this area but there is promise. In 2008 a summary of research for blending polylactide and polyethylene was published in Polymer Reviews titled 'Toughening Polylactide".

6. Industry Structure

6.1. Purchasers of Bio-Based Packaging Products

Coke – PlantBottle™

The Coca-Cola Company announced that beverages in its new PlantBottle™ packaging are arriving on store shelves in select markets throughout the world. This is the start of Coke's goal toward producing 2 billion of the special PET plastic bottles by the end of 2010.

PlantBottle PET plastic bottles are made partially from plants, which reduce the dependence on petroleum - a non-renewable resource. Other benefits are that it is 100 percent recyclable, and preliminary research indicates that from the growing of the plant materials through to the production of the resin, the carbon footprint for the PlantBottle packaging is smaller than for bottles made with traditional PET.

PlantBottle packaging is currently made through a process that turns sugar cane and molasses, a by-product of sugar production, into a key component for PET plastic. The sugar cane being used comes from predominantly rain-fed crops that were processed into ethanol, not refined sugar. Ultimately, the Company's goal is to use non-food, plant-based waste, such as wood chips or wheat stalks, to produce recyclable PET plastic bottles.

While the bio-based component can account for up to 30 percent of the resulting PET plastic in PlantBottle packaging, the percentage varies for bottles that also contain recycled PET. For example, Denmark uses recycled content in its PlantBottle packaging. The combined plant-based and recycled content makes up 65 percent of the material, with 50 percent coming from recycled material and 15 percent from plant-based material. For the PlantBottle packaging in the United States and Canada, up to 30 percent of the content in the PET plastic comes from plants.

Figure 2: Coke PlantBottle™

Excerpt from: www.thecoca-colacompany.com/presscenter/presskit_plantbottle

SunChips® Compostable Bag

Snack food packaging has three layers that with specific functions. Frito-Lay R&D were able to develop an exterior layer from PLA that could be printed on and provide a quality graphics medium. The challenge was for the company to develop an inner layer of PLA capable of ensuring the snack product integrity and a middle layer that joins the two together.

The company successfully developed all three layers using PLA and now offers SunChips® in a 100% compostable bag. The new bags will fully biodegrade in about 14 weeks when placed in a hot, active compost pile. The company cautions that actual results may vary, depending on the conditions of the compost pile or bin.

The SunChips® 100% compostable bag is considered to be more environmentally friendly because it's made from more than 90% renewable, plant-based materials. The primary environmental benefit of this compostable bag will be that it completely breaks down into compost in a hot, active compost pile or bin.

Municipal Programs

This bag will break down in several municipal green bin programs, but it depends on the municipality and its program as to whether or not they will accept the bag. Frito Lay Canada has partnered with the Composting Council of Canada to educate Canadian municipalities about the compostability of this bag and how it can fit into municipal green bin programs.

Certification

The SunChips® compostable bag has been certified through the Biodegradable Products Institute (BPI), the only internationally recognized labeling program. This certification means that the chip bags can be composted in many waste management programs (provided the local infrastructure is both available and capable of including this packaging material).

Figure 3: SunChips® Compostable Bag

6.2. Manufacturers of Biopolymers

Profiles of the most active companies in the production of biopolymers are presented. Each profile is an extract of information from the respective company websites, with a more detailed description followed.

Company	Location(s)	Website
Cereplast	Cereplast, Inc. 3421-3433 West El Segundo Boulevard Hawthorne, CA 90250 Phone: (310) 676-5000 Fax: (310) 676-5003 William E. Kelly Sr. VP Technology 310.219.4075 wkelly@cereplast.com	www.cereplast.com
BIOP	Biopolymer Technologies AG Gostritzer Str. 61- 6301217, Dresden Phone: +49 (0)351 871 81 46 Fax:+49 (0)351 871 84 47	www.biop.eu
Plantic	Plantic Technologies Limited 51 Burns Road Altona, 3018, Victoria Australia Phone: +61 3 9353 7900 Fax: +61 3 9353 7901 Email: info@plantic.com.au Plantic Technologies Limited 800 Turnpike St, Suite 300 AndoverMA 01845USA Phone: +1 978 794 5541 Email: info@plantic.us	www.plantic.com.au www.plantc.us
Rodenburg Biopolymers B.V.	Denariusstraat 194903 RC Oosterhout (Ind. Terrein Vijf Eiken)The Netherlands Phone: +31162497030 Fax: +31162497031 Email: info@biopolymers.nl	www.biopolymers.nl/en
MGP Ingredients	Cray Business Plaza 100 Commercial Street P.O. Box 130 Atchison, Kansas 66002-0130 Phone: 913.367.1480 Fax: 913.367.0192	www.mgpingredients.com

Company	Location(s)	Website
FKuR	FKuR Kunststoff GmbH Siemensring 79 47877 Willich, Germany Phone: +49 2154 9251-0 Fax: +49 2154 9251-51 E-Mail: Main Office info@fkur.com Sales & Marketing sales@fkur.com FKuR Plastics Corp. 921 W New Hope Drive, Suite 605 Cedar Park, TX 78613 USA	www.fkur.com
NatureWorks	**Corporate Headquarters** NatureWorks LLC 15305 Minnetonka Boulevard Minnetonka, MN 55345 USA **Manufacturing Facility** NatureWorks LLC, Manufacturing 650 Industrial Road, PO Box 564 Blair, NE 68008 USA	www.natureworks.com
Telles	Telles a Metabolix/ADM Joint Venture 650 Suffolk St. Suite 100 Lowell, MA 01854 Metabolix 21 Erie St. Cambridge, MA 02139 USA	www.mirelplastics.com www.metabolix.com
Novamont	Novamont Via G. Fauser 8, 28100 Novara, Italy Phone:+39.0321.6996.11 Fax: +39.0321.6996.00/01	www.materbi.com
DuPont	E. I. du Pont Canada Company P.O. Box 2200, Streetsville Mississauga, Ontario, Canada L5M 2H3	www.dupont.com
BASF	BASF Corporation 2080 Whittaker Road PMB 229 Ypsilanti, MI 48197	www.ecovio.com

Cereplast, Inc.
www.cereplast.com

Cereplast Inc. designs and manufactures proprietary starch-based, renewable plastics created from breakthrough technology.

Cereplast

The Renewable Plastic

These resin families replace a significant portion of petroleum-based additives with bio-based material such as starches from tapioca, corn, wheat and potatoes, meeting the demand from consumers and manufacturers for sustainable plastics.

Cost Benefits

Since Cereplast resins replace a significant amount of petroleum-based content with starches, the cost is not as influenced by the volatile price of fossil fuels. The manufacturing process for Cereplast resins takes place at a lower heat than that required for manufacturing with traditional plastics, further bringing down manufacturing costs.

Cereplast Products

On the cutting-edge of bio-based plastic material development, Cereplast now offers resins to meet a variety of customer demands:

- Cereplast Compostables® resins are ideally suited for single-use applications where high bio-based content and compostability are advantageous such as the food service and packaging industries.
- The newly launched Cereplast Hybrid Resins® products combine high bio-based content with the durability and endurance of traditional plastic. Cereplast Hybrid Resins® products meet the needs of customers in industries such as automotive, consumer goods, electronics and packaging.

A Better Bio-Based Plastic

Cereplast resin can be used in all major converting processes such as injection molding, thermoforming, blow molding and extrusions.

Revenue

Gross sales for 2007 reached $2.3 million and for 2008 reached a record $4.6 million. 2009 has seen a slight decrease in revenue up to the third quarter and final revenue numbers have not been reported.

Locations

Cereplast corporate office and R&D facility is located at:
3421-3433 West El Segundo Boulevard
Hawthorne, CA 90250
Tel: (310) 676-5000
Fax: (310) 676-5003

Key contact at Cereplast:
William E. Kelly, Sr. VP Technology
Phone: 310.219.4075 Email: wkelly@cereplast.com

Production Facilities

Cereplast operates out of two main locations in Hawthorne, California and Seymour, Indiana.

California Facilities — The Hawthorne facility consists of one building covering an aggregate of 25,000 square feet that serve as the main corporate office, research and development lab, production facility and logistic center.

Indiana Facility — The 105,000 square foot Seymour facility is currently used as a distribution facility for products; construction and installation of the first production line is mechanically completed.

Product Families

Cereplast primarily conducts its operations through three product families:
The lead time for customer testing (which, for compostable products, includes the full product lifecycle necessary to receive compostable certifications) of our resins generally ranges from one to three years or more depending upon the industry, the customer and the specific application. As of September 30, 2009, over 230 companies have requested and been provided with samples of our bioplastic resin and 150 customers have purchased resin for trials and testing. Of these, 80 customers have advanced to prototype testing and qualification of more than 135 different product applications. Thirty customers, including Dorel Industries, WNA, Alcoa, Genpak, Innoware, Penley, Solo, Cadaco, Jatco, Dentek, CSI-

Cosmolab, Warner Tools, Handgards and Pace Industries, have commercialized and introduced 95 different bioplastic products using our resin. As a result of successful testing and commercial product launches, some of our customers have signed multi-year supply contracts with increasing volume.

- Cereplast Compostables Resins® are renewable, ecologically-sound substitutes for petroleum-based plastics targeting primarily single-use disposables and packaging applications. We offer 17 commercial grades of Compostables Resins in this product line. These resins are compatible with existing manufacturing processes and equipment making them a ready substitute for traditional petroleum-based resins. Cerelplast commercially introduced its Compostables line in November 2006.

- Cereplast Hybrid Resins® replace up to 50% of the petroleum content in conventional plastics with bio-based materials such as industrial starches sourced from plants. The Hybrid Resin line is designed to offer similar properties to traditional polyolefins such as impact strength and heat deflection temperature, and is compatible with existing converter processes and equipment. Hybrid Resins provide a viable alternative for brand owners and converters looking to partially replace petroleum-based resins in durable goods applications. Hybrid Resins address this need in a wide range of markets, including automotive, consumer goods, consumer electronics, medical, packaging, and construction. Cereplast commercially introduced its first grade of Hybrid Resin, Hybrid 150, at the end of 2007 and currently offers two commercial grades in this product line.

- Cereplast Algae Plastics™. In October 2009 Cereplast announced it had been developing a new technology to transform algae into bioplastics and intend to launch a new family of algae-based resins that will complement the company's existing line of Compostables & Hybrid resins. Although it does not expect this new technology to become commercial before the end of 2010 or early 2011, it remains an important development as the potential of algae is quite substantial. Cereplast algae-based resins could replace in a first step 50% or more of the petroleum content used in traditional plastic resins. Currently, Cereplast is using renewable material such as starches from corn, tapioca, wheat and potatoes and Ingeo® PLA. Recently the algae production business has attracted a lot of attention when Exxon announced a $600 million investment in Synthetic Genomics and BP's $10 million investment in Martek Biosciences. The Company retains that algae is a very attractive feedstock as it does offer a low carbon footprint alternative and at the same time could be accessible in very large quantity. Cereplast has future plans to create algae plastic made of 100% algae component abandoning any reliance on fossils fuels.

Appendix A includes additional information about Cereplast, Inc.

Biopolymer Technologies
www.biop.eu

Corporate Office

Biopolymer Technologies AG
Gostritzer Str. 61- 63 01217, Dresden
Phone: +49 (0)351 871 81 46 Fax: +49 (0)351 871 84 47 Email: info@biop.eu

BIOPAR® is a potato starch based biopolymer with the capability to 100% biodegrade – DIN 13432 - into water and carbon. BIOPAR® readily biodegrades in the environment with the help of the microorganism present in this environment. There is no need to compost BIOPAR® in an industrial composting facility but it is possible. The shelf-life of the converted BIOPAR® is at least 5 years without the loss of properties and no biodegradation.

BIOPAR® does not use starch predestined for the food chain, human nor animal. The starch used comes from a potato especially grown to produce starch. This is usually a non-edible potato. This particular starch has been used already for decades in the paper, textile, lubricants for oil drilling, glues, wall paints etc.

BIOPAR® can be used for producing products typically made out of Polyethylene – PE, LLDPE, LDPE, HDPE or Polypropylene – PP or PVC. It can be processed on the same production lines and requires two thirds less energy than the conventional plastics on temperatures up to 140C° instead of 240C°.

Plastics preserve the quality of foods, keeps away dirt and prevents contaminations etc. of many non-food products. The negative side effects – the consequential damage - of the use of plastics occur during the second life of the plastics which is the irresponsible disposal of the plastics and are the main focus of BIOPAR®

BIOPAR® solves a few negative issues that occur out of this. BIOPAR® cannot prevent littering by the users nor can BIOPAR® prevent people from being irresponsible. BIOPAR® however helps to eliminate all consequential damage caused by this irresponsible behaviour.

BIOPAR® is better in the first life usage and performs best in the second-life option.

Plantic
www.plantic.com.au

Plantic Technologies Limited is a world leading innovator in bioplastics, with a track record of science and industry awards, an international network of corporate customers and distributors, and a growing list of premium quality multinational research and development partners.

Plantic Technologies is based in Australia, where its head office, principal manufacturing and R& D facility is located. The company also has sales offices in Germany and the United Kingdom, and employs approximately 50 people internationally.

A New Approach to Plastic

Plantic has achieved a unique place in the world market for bioplastics through proprietary technology that delivers a completely biodegradable and organic alternative to conventional plastics based on corn; which is not genetically modified. The entire process integrates the science of organic innovation with commercial and industrial productivity in a new way. The result is both a broad range of immediate performance and cost advantages, and long-term environmental and sustainability benefits.

Plantic's single-minded commitment is to provide bioresponsible materials solutions for the world market that deliver all the functionality of conventional petrochemically derived plastics in an economical and ecosensitive way.

Plantic technology is based on high amylose corn-starch, whose unique chemical properties allow for a diverse range of applications, from the production of resin for sale to materials manufacturers to the extrusion of sheets for use in food, cosmetic and pharmaceutical packaging.

Plantic Technologies also owns the technology which allows this bioplastic to be modified to suit an even broader range of needs across the complete spectrum of conventional plastics conversion and end user applications, including thermoforming, injection moulding, film extrusion and blow moulding, as well as rigid and flexible packaging.

Plantic's unique technology ensures a diverse range of bioplastics that can be produced cost-effectively, without complicated manufacturing processes or unnecessary wastage. 40% less real energy is required to produce Plantic bioplastic material than conventional petrochemically derived plastics, which don't biodegrade and create still further costs in waste management.

Plantic-based products also offer a range of immediate performance benefits. Given that they can also be customized to work with conventional plastics, the potential for the technology is effectively unlimited, with cost savings and improved environmental impact increasing exponentially with each new application.

Contact Information

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USA
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Web: www.plantic.us

Rodenburg Biopolymers B.V.
www.biopolymers.nl/en

Netherlands

Rodenburg Biopolymers headquarters are located in Oosterhout, Netherlands, which was established in 2001 with its main production facilities located at this site.

Brazil

Rodenburg Biopolymers has a wholly owned subsidiary in Brazil. Rodenburg Biopolymers South America has been located at São Paulo since 2002.

Canada

Rodenburg Biopolymers has a joint venture called 'Solanyl Biopolymers Inc' in Canada, located at Carberry, Manitoba. The joint venture was established in 2004.

Products

Solanyl® BP is a patented and commercially available bioplastic, a unique material which is biobased and biodegradable. The word Solanyl originates from Solanum Tuberosum, which means potato.

Solanyl® BP is based on a side stream potato starch of the potato processing industry. Production of Solanyl® BP granules is highly efficient. Production of Solanyl® for example requires 65% less energy compared to polyethylene production.

The Solanyl® BP granules can be used to combine with natural fibres as well as being blended with other biopolymers. Solanyl® is fully colourable using a biodegredable masterbatch.

Rodenburg is able to adapt the mechanical properties of the end product to meet specific end-product requirements by blending our material with other bio-materials.

Rodenburg Biopolymers is ISO 9001:2000 certified since 2004. Rodenburg considers offering goods and services of high quality is needed in its industry. The ISO 9001:2000 certificate demonstrates that the way it works is consistent with its goals to achieve optimal quality of goods and customer satisfaction.

Production Facilities

The production facilities are located in the Netherlands. Two separate lines are operating at this site for the production of Solanyl®. This provides Rodenburg with optimal flexibility to serve its customers at highest level and fulfilling their demanding requirements.

Main plant

The main plant has an annual production capacity of 40,000 metric tons of Solanyl®. These amounts will provide enough volume to achieve a broad number of different applications and ability to satisfy customer volume and quality needs. Large requirements are handled through the main plant.

Specialty plant

Rodenburg's specialty plant is set up to provide the ability to produce Solanyl® grades with different ingredients and additives. This can be for example grades with special functions like controlled release. The specialty plant is also used for small scale applications and further developments. The specialty plant has a capacity of 7.000 metric tons per year.

Injection molding

Injection molding provides prospects and customers a *"proof-of-concept",* or to jointly work on injection moulding projects, with two injection molding machines installed at its location in Oosterhout.

Contact Information

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Email: info@biopolymers.nl

MGP Ingredients, Inc.
www.mgpingredients.com

Company Overview

MGP Ingredients, Inc. is a fully integrated producer of ingredients and distillery products. Ingredients primarily consist of specialty wheat proteins and starches for food and non-food applications.

MGP Ingredients, Inc. processes protein, starch and alcohol products at its headquarters in Atchison, Kansas. In 2005, the company acquired a facility in Onaga, Kansas, for manufacturing plant-based biopolymers and wood composites.

Interest in eco-friendly, biobased goods is growing. MGPI's Terratek® line of starch- and protein-based polymers has been developed to address this need. The molding of Terratek® is similar to thermo plastics. Because these unique polymers can be formed into a variety of shapes and sizes, they have virtually unlimited applications in the production of both pliable and hard plastic products, including tableware, golf tees, credits cards, etc. Containing natural components derived from renewable resources, MGPI's Terratek® provides an excellent alternative to petroleum-based polymers.

Contact Information

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913.367.1480
913.367.0192 (fax)

<u>Onaga Facility</u>
210 South Leonard
P.O. Box 356
Onaga, Kansas 66521
785.889.4600
785.889.4700 (fax)

FKuR Plastics Corp.
www.fkur.com

Company Overview

Using the slogan "Plastics – made by nature!“ FKuR Kunststoff GmbH was incorporated in 2003.

In cooperation with the Fraunhofer Institute UMSICHT, Oberhausen, FKuR Kunststoff GmbH has developed a wide range of biodegradable plastics primarily made from natural resources. All FKuR bioplastics are processable on conventional plastics processing machinery.

Generally, raw bioplastics (starch, PLA, PHA, PBS and others) are not easy to use and are therefore blended and compounded into more functional materials. This processing of raw bioplastics requires special knowledge in the field of additives and a smooth compounding process.

The growth of the FKuR product range is mainly based on bioplastics for the packaging of short life products (food packaging, waste bags, diaper back sheets and others). Here the biodegradability and the alternative disposal route for the consumer are particularly of benefit.

The need for bioplastics for durable goods is constantly growing and will in the medium term exceed the need for shorter life products. Since the relevance of biodegradability takes a back seat in this context and sometimes is even not desired, the research and development of FKuR increasingly focuses on the increased use of natural resources.

Products

BIO-FLEX® - Biodegradable plastics for extrusion
BIOGRADE® - Biodegradable plastics for injection moulding
FIBROLON® - Natural fibre reinforced plastics

Contact Information

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FKuR Kunststoff GmbH
Siemensring 79 47877 Willich Germany
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Appendix B describes their USA expansion plans.

NatureWorks LLC
www.natureworksllc.com

Company Overview

NatureWorks LLC is an independent company wholly owned by Cargill. Dedicated to meeting the world's needs today without compromising the earth's ability to meet the needs of tomorrow, NatureWorks LLC is the first company to offer a family of commercially available low carbon footprint polymers derived from 100-percent annually renewable resources with cost and performance that compete with oil-based plastics and fibers. The production of these biopolymers uses less fossil fuel and emits fewer greenhouse gases than conventional polymers. The company applies its proprietary technology to process natural plant sugars to make Ingeo™ biopolymer, which is then used uniquely to make and market finished products under the Ingeo™ brand name.

Product and Applications

Ingeo™ biopolymers are already proving themselves in success commercial applications in the areas of fiber and nonwovens, films, extruded and thermoformed containers, and extrusion and emulsion coatings. Ingeo™ biopolymer is a natural fit for many applications currently using polyester, polyolefins, polystyrene and cellulosics. With performance properties that span these materials, as well as its ease of processability, Ingeo™ biopolymer can offer cost and productivity advantages that constitute a competitive advantage for customers.

Branded as Ingeo™ biopolymer, the resin is ideal for packaging manufacturing. Applications using Ingeo™ biopolymer can be clear, opaque, flexible or rigid. Ingeo™ biopolymer provides gloss and clarity similar to polystyrene, and exhibits tensile strength and modulus comparable to hydrocarbon-based thermoplastics. Like polyester, Ingeo™ biopolymer resists grease and oil, and offers an excellent flavor and odor barrier. And Ingeo™ biopolymer provides heat sealability at temperatures equivalent to polyolefin sealant resins.

High-Performance Synthetic Fiber

When extruded into a high-performance synthetic fiber, the resin is branded as Ingeo™ fiber – an innovative performance fiber ideally suited for apparel, furnishings and nonwovens applications. The natural versatility of Ingeo™ fibers gives NatureWorks the opportunity to design new yarns, fabrics and garments for a contemporary wardrobe. Ingeo™ fiber works in both pure qualities and innovative blends for everything form dress shirts to draperies. A comprehensive range of Ingeo™ fiber types fit with all standard nonwoven technologies including: spun lacing, thermo, chemical or resin bonding, calendaring, needle punch, wet laid and spun bond processes.

Manufacturing Facilities

The manufacturing facility, located in Blair, Nebraska, USA, has an annual capacity of 300 million pounds (140,000 metric tons) of polymer. The plant came online in 2002.

In 2003, NatureWorks LLC built the world's largest lactic acid manufacturing facility to feed the polymer plant.

In 2005, NatureWorks LLC purchased Renewable Energy Certificates (green energy) to offset all non-renewable energy used the entire 2006 production, making Ingeo™ biopolymer the first commercially available polymer, with significantly reduced greenhouse gas emissions.

Sales

Today NatureWorks LLC does business in North America, Europe and Asia Pacific, and works with converters, brandowners and retailers around the world to help introduce Ingeo™ biopolymer and fiber products into the ever-evolving marketplace for plastics and synthetic performance fibers.

Contact Information

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USA

<u>Manufacturing Facility</u>
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USA

Appendix C includes a list of all of the Canadian customers for Ingeo™ .

Telles
(a Metabolix/ADM Joint Venture)
www.mirelplastics.com

Company Overview

Telles is a joint venture between Metabolix and Archer Daniels Midland Company (ADM) that uses proprietary technology for large-scale microbial fermentation to produce a versatile family of polymers known as polyhydroxyalkanoates, which Telles has branded under the name Mirel.

The first commercial-scale Mirel production plant is being constructed adjacent to ADM's wet corn mill in Clinton, Iowa. The plant is expected to come online in December and will have commercial product available for customers in the first quarter of calendar year 2010.

Product

Mirel™ is a family of bioplastic materials made from a renewable resource, plant derived sugar. Mirel resins are durable but will biodegrade at the end of their useful life. Mirel resin is unique in that it shares many of the physical properties of petroleum based resins but is both biobased and biodegradable. Mirel resins are certified to biodegrade in soil and water environments, as well as home composting and industrial composting facilities (in areas where such facilities are available). However, like nearly all bioplastics and organic matter, Mirel will not biodegrade in conventional landfills.

Mirel is a distinctive solution as a high-performance bioplastic alternative in consumer goods, compost bags, business equipment, packaging, agriculture/ horticulture, and marine/aquatic applications.

Mirel™

- fermentation pathway → initially sugar-fed
- Bio-based, biodegradable plastic with unique properties
- High degree of IP protection
- Processed with existing plastics converting equipment

The Production Facility

Constructed by ADM, the plant is a proprietary, large-scale microbial fermentation system for producing bioplastics. The microbial fermentation system combines proprietary engineered microbes with sugar and other materials in a fermenter. The microbes digest the sugar and produce the bioplastics within their cells. Then the bioplastics are separated from the microbes and formulated into Mirel resins for commercial sale.

The Telles site is designed for 110 million lbs / year on a 30 acre facility adjacent to the ADM corn wet mill in Clinton, Iowa. Building adjacently allows for integrated economics and the footprint is designed for 4x expansion ($1+ billion revenue potential).

Metabolix Overview

Founded in 1992, Metabolix, Inc. (NASDAQ: MBLX), is an innovation driven bioscience company focused on providing sustainable solutions for the world's needs for plastics, chemicals and energy. The company is taking a systems approach, from gene to end product, integrating sophisticated biotechnology with advanced industrial practice. Metabolix is now developing and commercializing Mirel™ bioplastics, a sustainable and biodegradable alternative to petroleum based plastics. Mirel is suitable for injection molding, cast and blown film, sheet, extrusion coating, and thermoforming. Metabolix is also developing a proprietary platform technology for co-producing plastics, chemicals and energy from crops such as switchgrass, oilseeds and sugarcane.

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Telles a Metabolix/ADM Joint Venture
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Novamont
www.materbi.com

Company Overview

Since 1989, Novamont a pioneer in the bioplastics sector, has invested over 82 million € in research and development. They are an international leader in the bioplastics sector and has made transparency, collaboration with institutions and integration with its partners, an essential part of its development.

Novamont's products, which are sold under the brand name Mater-Bi® are bioplastics based on vegetable starches which allow simulating the behaviour of traditional plastics. Mater-Bi® is the first plastic to obtain the ok biodegradable soil and ok compost home certifications from AIB –VINCOTTE. It is also DIN CERTCO, Biodegradable PLASTIC SOCIETY (Japan), AIAB (Member of IFOAM) certified.

WHAT IS MATER-BI®?

Biodegradable and Compostable by nature

Mater-Bi® is the first family of biopolymers that uses substances obtained from vegetables, like maize starch, whilst preserving the chemical structure generated by photosynthesis. A variety of molecular superstructures with a wide range of properties are created by "complexing" the starch with variable amounts of biodegradable complexing agents, which are derived from renewable, synthetic or mixed sources.

Mater-Bi® is a family of materials engineered to adapt to the various levels of performance that the market demands. Manufactured in the factory in Terni, Mater-Bi® comes in granular form and can be processed using the most common transformation techniques to make products whose characteristics are similar, or even better than those of traditional plastics, but which are perfectly biodegradable and compostable. After use, products made of Mater-Bi® biodegrade in a single composting cycle.

As versatile as plastic

Mater-Bi® can be used in an infinite number of ways and in variety of applications. The extreme flexibility of the production facility in Terni means that the Mater-Bi® output can be customized to respond to the most varied demands: from agriculture to manufacturing, from packaging to disposable articles, to toys, various accessories and biofillers.

From the most innovative research

In nature, starch comes in crystalline form with linear (amylose) and branched (amylopectin) molecules. By breaking the original structure of the starch Novamont researchers were able to create a new supermolecular order by forming complexes between the amylose and natural or synthetic molecules. These complexes create a new crystalline order which increases the water-resistance and changes the mechanical properties of the original starch but without modifying its chemical structure.

Products from bioplastics

Film, packaging, agricultural applications, waste and shopping bags, injection moulding, catering, foams, thermoforming and extrusion.

Contact Information

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DuPont
www.dupont.com

Renewably Sourced Materials Overview

DuPont and Tate & Lyle (London, England) recently began manufacturing corn-based PDO (1,3-propanediol) from fermentation of sugars from corn in Loudon, Tennessee.

DuPont Tate & Lyle reports that production of Bio-PDO consumes about 40% less energy and reduces greenhouse gas emissions by about 20% versus petrochemical-based feedstock. Bio-PDO has a higher purity level and causes less irritation than ingredients it can replace in personal-care and cosmetic products. Bio-PDO is also replacing DuPont's PDO process based on petrochemicals and is a key element in DuPont's Sorona polymer (polytrimethylene terephthalate) platform, which has wide application in automotive, engineering polymers, fibers, and coatings.

DuPont™ Sorona® contains 37% renewably sourced material (by weight) derived from corn. A breakthrough in polymer science, the key ingredient in Sorona® is DuPont Tate & Lyle Susterra™ renewably sourced™ propanediol, which replaces petroleum-based 1,3-propanediol. Sorona® is an advanced material that offers a unique combination of attributes that are beneficial in a wide variety of applications. Whether it is textile fibers and fabrics for home interiors and apparel, carpeting, or a variety of packaging applications such as films, sealants, foams, and rigid containers, Sorona® imparts distinctive, value-added characteristics. Sorona® is commercially available.

Contact Information

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BASF
www.ecovio.com

BASF has added a new product to its range of plastics. Like the well-known Ecoflex®, this material is a completely biodegradable plastic called Ecovio®. Ecovio® is made of Ecoflex® – which is based on petrochemicals – together with renewable raw materials. The first member of this new product class is Ecovio® LBX 8145 and, in addition to Ecoflex®, it contains 45% by weight of PLA (polylactic acid).

PLA is made of corn, a renewable raw material. The first application will be for flexible films that can be used to produce plastic shopping bags.

"With Ecovio®, we are offering a functional and versatile compound. This product will allow us to keep pace with the demand for biodegradable products made of renewable raw materials," explains Dietmar Heufel, Business Manager for Ecoflex® and Ecovio®.

In the next five years BASF expects the world market for biodegradable plastics to grow by more than 20 percent per year. The renewable component PLA is being purchased from NatureWorks LLC. Samples of Ecovio® will be available in Europe starting in December of 2005, while commercial quantities are expected to hit the market in March of 2006. Ecovio® is scheduled to reach Asia and the NAFTA region in the second half of 2006.

Product development and concept

This special compound is manufactured using a process specially devised for biodegradable products, where Ecoflex® and PLA are chemically bound. "We had to pay close attention to the viscosity of the product during the development so as to achieve the most favourable processing properties for our customers. This is where BASF's comprehensive know-how in plastic production and processing came to the fore," elaborates Gabriel Skupin, who developed Ecovio®. The name Ecovio® is not going to be used for just a single product, but rather for an entire family of products, all made with Ecoflex® and renewable raw materials.

Either as a ready-made or for other compounds

The vital benefit for the customer is that he can process Ecovio® as a ready-made: It can be directly used without further addition, modification or preparation to extrude biodegradable films. On the other hand, Ecovio® can also go into customers' own tailor-made blends. They can mix the basic component Ecovio® L with Ecoflex® or PLA so as to obtain softer or harder formulations. Processors can even modify the material so that it is suitable for injection-moulding or deep-drawing applications.

Source:
http://www.plasticsportal.net/wa/plasticsEU~en_GB/portal/show/common/plasticsportal_news/2005/05_538

Contact Information

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6.3. Biopackaging End Users

6.3.1. BioMedical

Biopolymers are a new and exciting area of research for the medical field. They can be employed in three main applications: medical devices, tissue engineering and the drug delivery market. The use of biopolymers in the medical field is a relatively new and emerging area of research. For medical applications, apart from the fact that biopolymers are biodegradable, research is ongoing into the various other favourable aspects of biopolymer properties. Such properties would be:

- biocompatibility
- higher retention duration within the body
- degradation by natural mechanisms that occur within the body
- non-cytotoxic
- exhibiting immuno-tolerance

Biopolymer Medical Devices

Biopolymer medical devices can be found in fields such as orthopaedics, cardiology, ophthalmology and general surgery. Some examples of biopolymer medical devices that have been and could be developed includes dental implants, corneal implants and artificial cornea, artificial tendons and ligaments, hip and knee joint replacements, vascular grafts, heart valves, pacemakers, artificial heart and ventricular assist device components, stents, balloons, and blood substitutes.

Biopolymer Tissue Engineering

These biopolymers are employed for tissue regeneration, restoration and repair and to improve tissue function. They can be used to develop scaffolds for tissue engineering, which would supply nutrients and other growth factors and aid the growth of tissues. Some of the tissue engineering applications of biopolymers include: tissue screws and tacks, burn and wound dressings, artificial skin and tissue adhesives and sealants. There are many uses currently filled by medical grade plastics that could be substituted by similar biopolymers, which would generally cause fewer adverse reactions in patients. Skin rejuvenation and cosmetic tissue repair using tissue compatible biopolymers would be of commercial interest.

Biopolymer Drug Delivery

Demand for natural polymers in pharmaceuticals and related drug delivery systems are forecast to grow 5.1 percent yearly to $492 million in 2012. The main component used to develop biopolymer delivery systems is cellulose. Cellulose is a polysaccharide polymer derived from glucose found in green plants, cotton and wood. Cellulose is processed into several derivatives that serve the pharmaceutical market, including: microcrystalline cellulose (MCC), ethyl cellulose and hydroxypropyl methylcellulose (HPMC). These derivatives can be used in a wide range of applications to make capsules, tablets, tablet coatings and controlled-release drug delivery.

Table 7

Medical Demand for Natural Polymers (million dollars)

Item	1997	2002	2007	2012	2017
Pharmaceutical Shpts (bil2000$) Lb polymer/000$ pharm shpts	116 0.72	177 0.62	210 0.67	244 0.76	285 0.81
Natural Polymer Demand (mil lb) $/lb	83 4.04	109 4.54	141 5.07	185 5.49	231 6.17
Natural Polymer Medical Market	335	495	715	1015	1425
By Application:					
Pharmaceuticals	207	290	384	492	626
Orthopedic Injections	25	44	78	150	265
Wound Care	22	34	50	69	89
Other	81	127	203	304	445

Source: The Freedonia Group, Inc.

6.3.2 Cosmetics

As cosmetic companies continue to develop new products in efforts to differentiate their product lines in the marketplace, they look for unique ingredients to put into their products and a variety of natural polymers are utilized. These natural polymers make up many formulations in a variety of products including skin and hair care products, especially lotions, creams, dyes, shampoos and conditioners. Advances in the development of natural polymers can boost innovative cosmetic products into the marketplace with higher performing and more specialized products. For example, organic and natural products are the current trend and there is a high expectation of growth. Particularly with the larger, more established cosmetic companies looking to introduce new product lines.

Natural polymers used in the cosmetics market include collagen, hyaluronic acid-based products, chitosan, alginates, carrageenan and cellulose ethers. Research efforts are focused on the performance properties of natural polymers and the development of hypoallergenic properties to ensure quick, easy and safe use of the personal care product.

Table 8

Cosmetic & Toiletry Demand for Natural Polymer (million dollars)

Item	1997	2002	2007	2012	2017
Natural Polymer Demand (mil lb) $/lb	58 1.69	73 1.74	89 2.21	115 2.39	141 2.62
Natural Polymer Demand	98	127	197	275	370
Protein-Based	20	33	56	82	121
Cellulose Ethers	34	43	54	75	94
Starch & Fermentation	6	10	24	42	63
Other	38	41	63	76	92

Source: The Freedonia Group, Inc.

In addition to consumers' growing earth-friendly attitudes, corporate boards have caught wind of the effects of sustainable practices on profitability, and have propelled efforts into high gear. Add to this the increasingly powerful role of retail giant Walmart, as well as legislation from countries such as China and Germany-and sustainable packaging protocols for the beauty industry are pushing brands and suppliers to new levels of creativity and compliance.

Source: *Sustainable Packaging: The Beauty Industry's Perfect Storm?,* beauty packaging, April/May 2010

The industry standards for cosmetics packaging, in particular natural and organic cosmetics, include a requirement for packaging that goes beyond just an "*interest*". This is perhaps more so for the cosmetics industry than for other areas.

6.3.3 Food and Beverages

The demand for bioplastics for disposable foodservice in projected to increase 48,000 metric tons by 2013. Cutlery is the leading use for bioplastics in foodservice disposables with increased opportunities to be found in dishes, plates, trays, bowls and cups. The majority of bioplastics are primarily produced from PLA with cellulose and starch based plastics used as well. BIOGRADE cellulose resins from FKuRKunststoff offers a replacement in food service products such as cups, straws, mugs and cutlery. Food and beverages accounts for the second largest market demand for natural based polymers which accounted for 21 percent of the 2007 total value.

Table 9

Food & Beverage Demand for Natural Polymers
By Application and Products
(million dollars)

Item	1997	2002	2007	2012	2017
Food & Beverage Shpts (bil 2000$) lb polymer /000$ food & bev shpts	461 0.37	482 0.41	516 0.46	541 0.50	568 0.55
Natural Polymer Demand (mil lb) $/lb	170 2.04	196 2.18	237 2.54	273 2.75	312 3.00
Natural Polymers Demand	346	428	603	752	937
By Application:					
Confections & Baked Goods	175	195	280	355	450
Dairy & Desserts	65	89	123	145	170
Others	106	144	200	252	317
By Product:					
Cellulose Ethers	137	182	248	302	365
Marine Polymers	55	81	140	185	244
Exudate & Vegetables Gums	54	49	101	130	167
Starch & Fermentation	81	91	80	94	113
Other	19	25	34	41	48

Source: The Freedonia Group, Inc.

Table 10

Natural Polymer Demand by Market (million dollars)

Item	1997	2002	2007	2012	2017
Nondurable Goods Shpts (bil 2000$) Lb polymer/000$ nondurables	1732 0.40	1710 0.49	1734 0.69	1770 0.99	1820 1.34
Natural Polymer Demand (mil lbs) $/lb	689 2.21	830 2.32	1192 2.39	1750 2.30	2440 2.27
Natural Polymer Demand	1525	1928	2850	4020	5530
Medical	335	495	715	1015	1425
Food & Beverage	346	428	603	752	937
Oilfield	121	117	264	330	390
Construction	145	172	199	223	265
Cosmetics & Toiletries	98	127	197	275	370
Adhesives	146	167	195	225	258
Packaging	28	68	193	543	986
Paints & Inks	98	110	152	183	220
Textiles & Leather Tanning	61	75	109	172	266
Other	147	169	223	302	413

Source: The Freedonia Group, Inc.

6.4. Competition

This section identifies competition from other natural or organic packaging.

Glass

Glass is thought to be safe for you and the environment. What more could you want out of a package? Glass is pure; it is made from all-natural, sustainable raw materials and is the preferred packaging for consumer health and the environment.

According to a 2006 survey conducted by Newton Marketing & Research of Norman, Oklahoma, consumers prefer glass packaging for maintaining the purity of food and beverages (78 percent), for preserving a product's taste or flavor (75 percent), and for maintaining the integrity or healthiness of foods and beverages (82 percent).

Glass is the only packaging material rated "GRAS" or "generally regarded as safe" by the U.S. Food & Drug Administration.

Glass has a premium image as no other packaging material matches the shelf impact of glass. The clarity, shape, and feel of glass containers contribute to the premium image of products ranging from fine perfumes to liquor to gourmet foods and beverages.

Glass is 100% recyclable and can be recycled endlessly with no loss in quality or purity. Glass recycling is a closed loop system, creating no additional waste or by-products and glass is a mono-material, meaning it is not made up of several different materials. Recycling glass reduces consumption of raw materials, extends the life of plant equipment (such as furnaces) and saves energy. Energy costs drop about 2-3% for every 10% recycled glass used in the glass making process.

The pitfalls associated with glass packaging include:

- Glass is very heavy and therefore very energy intensive to ship around the planet.
- Glass is brittle and can break during shipping.
- Lower resistance than other materials to fractures, scratches and thermal shock.
- More variable dimensions than metal or plastic containers.
- Potentially serious hazards from glass splinters or fragments in foods.
- Glass packaging does not always allow you to dispense the entire product resulting in wasted product and frustrated customers.

Plastic has more flexibility for size of packaging, shape and ease of handling. Plastic is lighter, safer and more durable for distribution and is also easier for the consumer to transport. Plastic packaging is of consistent size and there is more opportunity to do product branding with the shape of the packaging.

Paper

The paperboard carton has been the best solution for higher graphics, recyclability and low costs.

Paperboard cartons have an advantage of extremely high graphics capabilities in a package format that has a more favorable cost when compared to other types of packaging. Paperboard allows for great shelf presence and a billboard effect for graphics, giving the producer the ability to market products at a very competitive cost structure.

Paper has an excellent image as a packaging material (renewable and biodegradable) but has missing performance characteristics. Due to these missing performance characteristics and barrier properties (e.g. fat resistance) paper has been largely replaced by polymers (e.g. PE). Using biopolymers, the missing performance and barrier properties of paper can be compensated, while still providing the same positive image paper has enjoyed.

6.5. Biopolymer Distribution

The primary distribution method of biopolymer companies is direct sales to the individual manufacturing user. Biopolymers have specific characteristics that users are looking for and there are only a few developed companies operating in this niche.

The secondary distribution channel is through traditional plastic distributors. The biggest distributor of thermoplastic materials is Ashland Distribution. They distribute throughout North America, Europe and China. They signed an agreement with NatureWorks in March 2009 to distribute NatureWorks' products in North America.

The agreement enables plastics processors of any size to benefit from the many advantages that Ashland offers, including local inventory and stocking programs, credit programs, technical service, broad product lines, and professional sales staff.

Michael Gilbert, VP of Plastics for Ashland Distribution, noted, "We are confident about the future success of the NatureWorks relationship and the enhanced possibilities in the plastic markets by incorporating Ingeo™ into our distribution mix. With this agreement we are able to provide Ingeo™ to a wide range of plastics processors to create the innovations today's brands and retailers are looking for to meet their sustainability objectives."

Source: http://www.natureworksllc.com/news-and-events/press-releases/2009/03-19-09-ashlandna.aspx

7. Existing Support from Government and Industry

- Alberta Biomaterials Development Centre
  – created to test methods and technologies for producing new or enhanced materials, chemicals and energy from fibre feedstock.

- Alberta Innovation Voucher Pilot Program
  –vouchers in the pilot program worth up to $10,000 or $50,000 to use at Alberta's public and not-for-profit service providers for business and technology development services in the emerging growth sectors such as clean technology, health, bio-tech and ICT.
  –www.advancededucation.gov.ab.ca/technology/support/vouchers

- Alberta Ingenuity Fund
  –a suite of industry-focused programs helping companies across the province increase their capacity to use technology to compete globally. The Ingenuity Industry programs are also targeted at these companies' need for highly qualified personnel.
  –www.albertaingenuity.ca/industry/programs

- NRC Industrial Research Assistance
  –NRC-IRAP offers direct technical assistance, access to the latest technological advances, expertise, facilities, and resources, as well as cost-shared financing of innovative technical projects.
  –www.nrc-cnrc.gc.ca/eng/ibp/irap/about/prairies

- Alberta International Business Partnering Program
  –helps businesses target new opportunities in China, California and India.
  –www.advancededucation.gov.ab.ca/technology/support/partnering

- The Canada-Alberta Western Economic Partnership Agreement
  –a 4 year, $50 million joint federal/provincial program that supports economic development in Alberta announced in March 2009.
  –www.advancededucation.gov.ab.ca/technology/wepa

8. Current and Future Trends/Drivers of Bio-Based Packaging

The potential benefits seen with biopolymers from renewable resources are environmentally friendlier, more efficient products and processes, with less dependence on high-cost crude oil.

Major factors influencing future markets and demand for biopolymers includes:

- Limited availability and increased cost of non-renewable resources;
- Policy development in countries around the globe with emphasis on climate change mitigation, sustainable production practices and industrial policy;
- Changing consumer demand based on the awareness of the environment and the need to ensure sustainable production and consumption patterns.

In the European report, "Taking Bio-Based from Promise to Market", published on November 3, 2009. The list of positive benefits of bio-based packaging included:

- Use of renewable and expandable resources
- Less dependency on limited and increasingly expensive fossil resources
- The potential to reduce greenhouse gas emissions (carbon neutral / low carbon impact)
- The potential for sustainable industrial production
- Potentially better recovery and recycling options
- Often low toxicity
- Often high bio-degradability or compostability
- Less resource-intensive production (water, energy, waste)
- Potentially improved population health
- Support to rural development
- Increased industrial competitiveness through innovative eco-efficient bio-based products

Source:
http://ec.europa.eu/enterprise/sectors/biotechnology/files/docs/bio_based_from_promise_to_market_en.pdf

9. Standards and Certifications

Biobased - ASTM D6866

The ASTM D6866 method has been developed to certify the biologically derived content of bioplastics. Cosmic rays colliding with the atmosphere mean that some of the carbon is the radioactive isotope carbon-14. CO_2 from the atmosphere is used by plants in photosynthesis, and therefore new plant material will contain both carbon-14 and carbon-12. Under the right conditions, and over geological timescales, the remains of living organisms can be transformed into fossil fuels. After ~100,000 years, all the carbon-14 present in the original organic material will have undergone radioactive decay leaving only carbon-12.

A product made from biomass will have a relatively high level of carbon-14, while a product made from petrochemicals will have no carbon-14.The percentage of renewable carbon in a material (solid or liquid) can be measured with an accelerator mass spectrometer.

There is an important difference between biodegradability and biobased content. A bioplastic such as high density polyethylene (HDPE) can be 100% biobased (i.e. contain 100% renewable carbon), yet be non-biodegradable. These bioplastics such as HDPE play nonetheless an important role in greenhouse gas abatement, particularly when they are combusted for energy production. The biobased component of these bioplastics is considered carbon-neutral since their origin is from biomass.

Biodegradability - EN 13432, ASTM D6400

The EN 13432 industrial standard is arguably the most international in scope and compliance with this standard is required to claim that a product is compostable in the European marketplace. In summary, it requires biodegradation of 90% of the materials in a commercial composting unit within 180 days. The ASTM 6400 standard is the regulatory framework for the United States and sets a less stringent threshold of 60% biodegradation within 180 days, again within commercial composting conditions.

The "compostable" marking found on many items of packaging indicates that the package complies with either of the two standards mentioned above. However, the marking is not owned by either regulatory body but by third party trade associations representing companies making or selling biodegradable plastics. In Europe, this is European Bioplastics, in the U.S. it is the Biodegradable Products Institute.

Many starch based plastics, PLA based plastics and certain aliphatic-aromatic co-polyester compounds such as succinates and adipates, have obtained these certificates. Additivated plastics sold as fotodegradable or Oxo Biodegradable do not comply with these standards in their current form.
Source: http://en.wikipedia.org/wiki/Bioplastics

3rd Party Certification

Worldwide Vinçotte (http://www.vincotte.com) provides more than 130 specialized inspection, monitoring and certification services, analyses and tests for the most wide-ranging applications in the field of electricity, hoisting apparatus, pressure equipment, civil engineering, safety in the work place, environmental protection and radiant protection.

At the end of September 2009, Vinçotte announced the launch of its new certification program OK biobased. The methodology for OK biobased is fully based on the American standard ASTM D6866. The certification program was developed in cooperation with national and international experts from the academic sector, the industry and retail.

Vinçotte at first only offered certification to the manufacturers of the raw material but as of January 2010, the manufacturers and distributors of intermediate and finished products can apply at Vinçotte for the certification of their products being made of renewable resources. This is an opportunity to make a clean and easily verifiable claim about the renewable origin of their products. Vinçotte announced the first OK biobased certificates on a whole range of raw materials and the first three licensee holders are each located in a different continent: Asia, America and Europe.

Waste treatment is a continuously growing problem. Using compostable materials is one way to help solve this major problem and Vinçotte has already offered a solution in this respect. Vinçotte has introduced four conformity marks: OK Compost, OK Compost HOME, OK biodegradable SOIL and OK biodegradable WATER.

Figure 4: Logos used by Vinçotte for their 3rd party certification services.

Source: http://www.okcompost.be

Biodegradable Products Institute

The Biodegradable Products Institute (BPI) is a professional association of individuals and groups from government, industry and academia. They promote composting of biodegradable materials if products can be demonstrated to completely biodegrade in approved composting facilities.

BPI operates under three key components as outlined in their website:

1. Educating consumers, producers and municipal and industrial composters of the benefits and availability of biodegradable and compostable materials.

2. Promoting the responsible use of the BPI Compostable Logo for any product which meets the requirements in ASTM D6400 or D6868, specifications. The specifications are based on more than 8 years of research by suppliers, composters and academia.

Figure 5: BPI Compostable Logo

3. Working with other organizations around the world to further the use and recovery of biodegradable materials, including the harmonization of standards around the world.

A complete overview on approved testing labs, information about composting, BPI news and a list of BPI approved products can be found at www.bpiworld.org.

Regulation Considerations

Natural polymer producers must meet federal, provincial and municipal regulations just as any other manufacturing company. In addition to the regulations faced for the production, storage and distribution of their products, biopolymer companies must also consider end-use and end of life requirements for their products. Of special interest are biodegradability standards; waste management of the products once their useful life ends (composting and recycling) and the standardization of regulations between countries. As well, biopolymers spark debate about the use of food for industrial use while millions of people go hungry every day.

10. Bio-Packaging in Alberta SWOT Analysis

Strengths

- Abundant and high quality raw materials
- Excellent research and development resources
- Highly trained and skilled workforce with skills and knowledge transferability from the oil and gas industry
- Funding programs available for R & D
- Strong provincial research and innovation focus in Alberta
- Excellent market location and market access
- Excellent distribution network through road, rail and air

Weaknesses

- Limited commercialization expertise and funding in province in proportion to research and development expertise and funding
- Limited commercial management and operations expertise in biopackaging industry
- Funding programs and assistance are targeted towards pre-commercial activities and not commercialization
- Lack of commercialization capital for biobased ventures
- Limited understanding of industry potential in Alberta
- Market growth is somewhat restricted by higher production costs of biopolymers

Opportunities

- Potential for the production or blending of biopolymers with Alberta produced polyethylene
- The consumer is becoming more *"green",* which is driving the supplier/manufacturer to change their ways. An Alberta based biopackaging facility would help suppliers present these options to consumers in hopefully a more affordable and environmentally friendly way than sourcing from the US, Europe or Asia.
- As regulations become predominately detailed by government, bio based packaging would be more viable.
- Cup manufacturers including lids in Alberta.
- Development of a resin that could be processed well and be as clear as PET.
- Development of bio-based fibres for packaging.

Threats

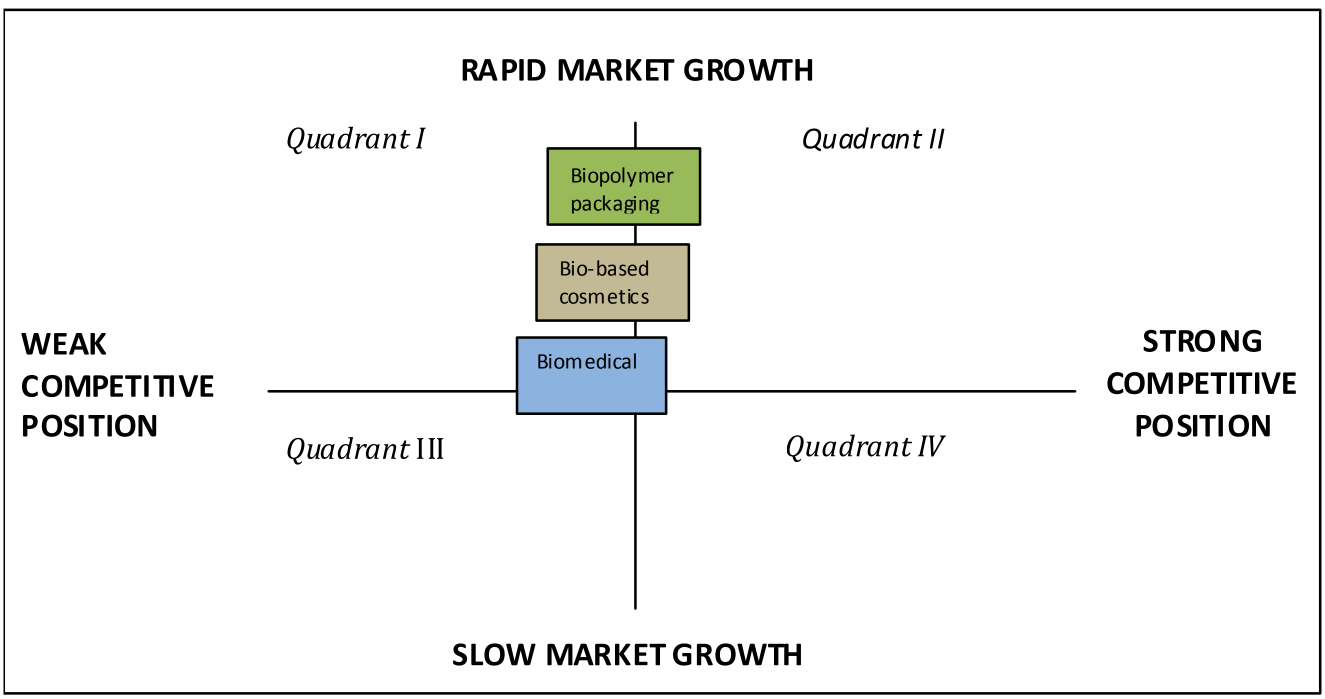
- Competition from the large multinationals that have already gained a strong and ever increasing foothold on the bioplastics and biopackaging market
- Increasing international regulations and standards
- Consumer backlash from utilization of food based ingredients (starches and oils) in production of biopolymers

11. Grand Strategy Matrix

The Grand Strategy Matrix is a tool that is used to formulate alternative strategies. It is based on two evaluative dimensions: market growth and competitive position. The Grand Strategy Matrix is divided into four strategy quadrants where organizations or opportunities can be positioned.

Firms or opportunities located in Quadrant 1 have a strong strategic position and should develop strategies to concentrate on market and product development. Firms or opportunities located in Quadrant 2 are in a rapid-market-growth industry and are unable to compete effectively in the marketplace. These firms should develop an intensive strategy to increase their competitiveness. Firms or opportunities located in Quadrant 3 have weak competitive positions and compete in slow-growth industries. These firms need to develop strategies to reduce costs and may need shift resources away from the current business to generate profits. Firms positioned in Quadrant 4 have a strong competitive position but compete in a slow-market-growth industry. Firms in Quadrant 4 typically have high cash flows and limited internal growth and can pursue horizontal, concentric or conglomerate diversification with success. Development of joint ventures is another strategy available to firms in this quadrant. **Figure 6 below**:

Grand Strategy Matrix for Alberta Bio-based Products



As outlined in the above matrix it is clear that the identified opportunities have strong potential for development. Biopolymer packaging has strong market growth and a competitive position due to the public interest in "green" packaging and the robust demand for packaged products. The current cost of producing biopolymers is a competitive barrier as petrochemical-based products have the cost advantage.

Bio-based cosmetics and biomedical products are both in Quadrant 1 as well with lower anticipated market growth and the same biopolymer cost issue faced by biopolymer packaging. Regulatory barriers may also be higher for bio-based cosmetics and biomedical products depending upon the types of product being developed and/or enhanced. If the cost of producing biopolymers decreases the opportunities identified would all become more competitive in the marketplace and would move towards Quadrant 2. Research into producing biopolymers more effectively and/or from a less expensive raw material source is a strategy for all firms engaged in the bio-based economy.

12. Recommendations for Industry Development

It is evident there is opportunity for the development of the bio-packaging industry in Alberta. Alberta has a number of key competitive advantages with an abundance of raw materials, access to research and development infrastructure and expertise, synergies with the oil and gas industry, skilled labour force, a competitive tax regime and direct access to a market of more than 50 million people. The biopackaging industry is in a relatively early stage of development and opportunities exist for Alberta to enter this industry. In particular, research indicates there may be an opportunity for the commercial production or blending of biopolymers with Alberta produced polyethylene. It is also clear that opportunities exist for the commercial development of natural fibre based packaging products or manufacturing utilizing Alberta based agriculture and forestry feed stocks.

The following outlines key recommendations which include:

- Renew focus on producing biopolymers from biomass based in western Canada such as canola and forestry
- Approach petrochemical companies to blend biopolymers and develop new market offerings similar to DuPont and BASF product offerings
- Monitor research efforts into developing biopolymers from lower-cost cellulosic raw materials, residual biomass such as wheat straw and non-food plants.
- Develop a targeted investment attraction program of bio-industrial companies to identify potential partnerships, corporate interest and potential commercial investment
- Meet with the three main biopolymer companies in the US to determine potential partnerships and expansion opportunities in Alberta: *NatureWorks, Cereplast and Telles*

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BIOP	www.biop.eu
Plantic	www.plantic.com.au www.plantic.us
Rodenburg Biopolymers B.V.	www.biopolymers.nl/en
MGP Ingredients	www.mgpingredients.com
FKuR	www.fkur.com
NatureWorks	www.natureworks.com
Tellus	www.mirelplastics.com www.metabolix.com
Novamont	www.materbi.com
DuPont	www.dupont.com
BASF	www.ecovio.com

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Cereplast™

www.cereplast.com

Cereplast Bio-Sheet

CereplastTM resins are made from renewable resources, primarily starches, and meet the ASTM and EN standards for biocompatibility and compostability as well as the USDA standards under the Federal Biobased Products Preferred Procurement Program (FB4P).

Independent analysis for biodegradability, compostability and toxicity

All CereplastTM resins are certified biodegradable and compostable in the United States and Europe:

- **Meet Biodegradable Products Institute (BPI) standards for compostability (ASTM 6400 D99 and ASTM 6868)**
- **Meet European Bioplastics standards (EN 13432)**
- **Fully biodegrade within 60-180 days in a compost facility**
- **Analyses confirm that CereplastTm resins return safely to nature and leave no harmful chemical residue in the soil.**
- **Independent third party analysis conducted on Cereplast resins demonstrates that the resins do not have any DNA of Genetically Modified Organisms (GMO). Cereplast resins are GMO free.**

Independent analysis of Cereplast resins for bio-based content concluded (ASTM 6866) that all Cereplast resins are biobased. The level of biobased content varies with the applications that the resin is designed for.

- **Thermoforming** — **Bio-based content 90+ percent**
- **Injection Molding** — **Biobased content 90+ percent**
- **Extrusion** — **Biobased content 75+ percent**
- **All plastic resins from CereplastTM meet the bio-based threshold set by USDA standards**

Life Cycle Assessment of Cereplast Resin (LCA)

LCA is an analytical tool used to assess the impact of extended systems on the environment. In the case of a product LCA, the system encompasses the entire "life cycle" of the product, including everything from raw material extraction to end of life disposition: manufacturing, distribution, and waste collection and processing.

A BEES analysis was performed under the supervision of the US Department of Agriculture on Cereplast resin and concluded that the resins are a better choice for the environment and human health. A BEES analysis is considered a streamlined Life Cycle Assessment.

Appendix A

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FKuR expands to North America

Leading bioplastics manufacturer FKuR expands business to North America.

At the beginning of 2010, FKuR Kunststoff GmbH (Willlich, Germany) began operations of its newly founded subsidiary, FKuR Plastics Corporation, in Cedar Park, Texas, USA with a team of 4 people. Mr. Patrick Zimmermann was appointed the President of FKuR Plastics Corp. and will also continue to assume his role as Sales Manager for FKuR Kunststoff GmbH. He will continue his efforts in Germany while assisting his staff in capturing the American market with the bioplastics' compounds Bio-Flex®, Biograde® and Fibrolon®.

North American customers will be able to receive the resins directly from a local warehouse in the USA and manufacturing of the compounds will begin once the sales volume has reached a stable dimension. "With my team in Texas and the comprehensive technologic and personal resources in Europe we want to convince the North American market of the high quality of our compounds", says Mr. Zimmermann. "Our extrusion and injection molding specialists, as well as the entire material development competence are prepared for this challenge."

FKuR, which has sold biocompounds mostly in Europe since 2003, considers itself a leader in technology and precursor in the development of technologically sophisticated and tailor-made compounds. FKuR's enormous yearly growth in sales is based on the factors of success, such as smooth processing on conventional extrusion equipment and unique technical customer service with man's tailor-made biocompounds made to customers' specifications. Compounds made by FKuR offer technical performance characteristics comparable to the level of established plastics and are used in many applications for superior packaging.

Bioplastics are a class of material which is based on renewable resources or enables the biodegradability of products made from these polymers.

FKuR Kunststoff GmbH produces and markets tailor-made biopolymer specialties on the basis of Polylactic acid/Copolyester (Bio-Flex®), cellulose ester (Biograde®) and WPC / wood-plastic-compound (Fibrolon®). The cooperation with the Fraunhofer Institute UMSICHT guarantees for innovation, know-how and quality.

Characters (incl. blanks): 2,225

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Photo: Patrick Zimmermann

Appendix B

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Allcard	Canada	765 Boxwood Drive Cambridge, Ontario Canada N3E 1A4	Mark Brown	info@allcard.ca	519-650-9515
BI-AX International, Inc.	Canada	596 Cedar Ave. Wingham, Ontario N0G 2W0	Brad Harrow	bharrow@biaxinc.com	(519) 357-1818
Broody Chick Natural Products	Canada	964 Newport Avenue, ,Victoria,BC,V8S 5C9	Stephanie Wilmott	Steph@broodychick.com	+1 250 595 1151
Cascades Inopak, a Division of Cascades Canada Inc.	Canada	772 Sherbrooke Street West, Suite 400 Montreal, Quebec, Canada, H3A 1G1	Sandra Hudon	sandra hudon@cascades.com	(514) 284-9859
Colourfast Printing	Canada	1285 Britannia Road East Mississauga Ontario L4W 1C7 Canada	Andrew Mimnagh	andrew@colourfast.com	905-696-8691
Dyne-A-Pak Inc.	Canada	3375 Francis-Hughes Laval Canada H7L 5A5	Paul Boudrias	pboudria@dyneapak.com	450-667-3626 ext 107
Encore Custom Preforms Ltd.	Canada	6605 Kestrel Road Mississauga, Ontario L5T 1 P4	Shanta Oudit	s.oudit@encorecustompreforms.com	416 728 9013
G.N. Plastics Company Limited	Canada	P.O. Box 710 345 Commons Road Chester, Nova Scotia CANADA B0J 1J0		gn@gnplastics.com	(+1) 902-275-3571
Husky Injection Molding Systems Ltd.	Canada	500 Queen St. South Bolton, Ontario Canada L7E 5S5	Enrico Gribaudo		(905) 951 5000
K L Jane Ltd.	Canada	2386 Haines Road,Unit # 23,Mississauga,ON,L4Y 1 Y6	Zivka Damjanovska	zivka@kljane.com	905 275 8628 Cell: 416 857 5541
S.O.X. Marketing Inc.	Canada	3701 Rue Jarry E,,Montreal,QC,H1Z 2G1	Louise Mayrand	lmayrand@doris.net	514-376-3000
Sears Canada Inc	Canada	222 Jarvis Street, ,Toronto, ,M5B 2B8	John Robertson	johndr@sears.ca	
SOLE Custom Footbeds	Canada	4C, 416 Meridian Rd SE Calgary AB T2A1X2 Canada	Jonathon Koops	jkoops@yoursole.com	866-235-7653
Stafford Textiles	Canada	2200 Lakeshore Blvd,Suite 308,Toronto,ON,M8V 1A4	Stan Stanczuk Stanczuk	stan@staftex.com	416 252-3133 3133
The Waste Reduction Store	Canada	51 Alloway Avenue Winnipeg, MB R3G 0Z7	K.M. Boylan	orders@wastereductionstore.com	204-226-4628
Tilton Plastic	Canada	175 rue des Grands Lacs Saint Augustin de Desmaures Quebec G3A 2K8 Canada	Frédéric Noël	f.noel@tiltonplastic.com	(418) 878-6100

Appendix C

Glossary

In bioplastics MAGAZINE again and again the same expressions appear that some of our readers might (not yet) be familiar with. This glossary shall help with these terms and shall help avoid repeated explanations such as 'PLA (Polylactide)' in various articles.

Bioplastics (as defined by European Bioplastics e.V.) is a term used to define two different kinds of plastics:

a. Plastics based on renewable resources (the focus is the origin of the raw material used)

b. → Biodegradable and compostable plastics according to EN13432 or similar standards (the focus is the compostability of the final product; biodegradable and compostable plastics can be based on renewable (biobased) and/or non-renewable (fossil) resources).

Bioplastics may be
- based on renewable resources and biodegradable;
- based on renewable resources but not be biodegradable; and
- based on fossil resources and biodegradable.

Amylopectin | Polymeric branched starch molecule with very high molecular weight (biopolymer, monomer is → Glucose).

Amyloseacetat | Linear polymeric glucose-chains are called → amylose. If this compound is treated with ethan acid one product is amylacetat. The hydroxyl group is connected with the organic acid fragment.

Amylose | Polymeric non-branched starch molecule with high molecular weight (biopolymer, monomer is → Glucose).

Biodegradable Plastics | Biodegradable Plastics are plastics that are completely assimilated by the → microorganisms present a defined environment as food for their energy. The carbon of the plastic must completely be converted into CO_2 during the microbial process. For an official definition, please refer to the standards e.g. ISO or in Europe: EN 14995 Plastics- Evaluation of compostability - Test scheme and specifications. [bM 02/2006 p. 34f, bM 01/2007 p38].

Blend | Mixture of plastics, polymer alloy of at least two microscopically dispersed and molecularly distributed base polymers.

Carbon neutral | Carbon neutral describes a process that has a negligible impact on total atmospheric CO_2 levels. For example, carbon neutrality means that any CO_2 released when a plant decomposes or is burnt is offset by an equal amount of CO_2 absorbed by the plant through photosynthesis when it is growing.

Cellophane | Clear film on the basis of → cellulose.

Cellulose | Polymeric molecule with very high molecular weight (biopolymer, monomer is → Glucose), industrial production from wood or cotton, to manufacture paper, plastics and fibres.

Compost | A soil conditioning material of decomposing organic matter which provides nutrients and enhances soil structure.

Compostable Plastics | Plastics that are biodegradable under 'composting' conditions: specified humidity, temperature, → microorganisms and timefame. Several national and international standards exist for clearer definitions, for example EN 14995 Plastics - Evaluation of compostability - Test scheme and specifications [bM 02/2006 p. 34f, bM 01/2007 p38].

Composting | A solid waste management technique that uses natural process to convert organic materials to CO_2, water and humus through the action of → microorganisms [bM 03/2007].

Copolymer | Plastic composed of different monomers.

Fermentation | Biochemical reactions controlled by → microorganisms or enyzmes (e.g. the transformation of sugar into lactic acid).

Gelatine | Translucent brittle solid substance, colorless or slightly yellow, nearly tasteless and odorless, extracted from the collagen inside animals' connective tissue.

Glucose | Monosaccharide (or simple sugar). G. is the most important carbohydrate (sugar) in biology. G. is formed by photosynthesis or hydrolyse of many carbohydrates e. g. starch.

Humus | In agriculture, 'humus' is often used simply to mean mature → compost, or natural compost extracted from a forest or other spontaneous source for use to amend soil.

Hydrophilic | Property: 'water-friendly', soluble in water or other polar solvents (e.g. used in conjunction with a plastic which is not waterresistant and weatherproof or that absorbs water such as Polyamide (PA).

Hydrophobic | Property: 'water-resistant', not soluble in water (e.g. a plastic which is waterresistant and weatherproof, or that does not absorb any water such as Polethylene (PE) or Polypropylene (PP).

Microorganism | Living organisms of microscopic size, such as bacteria, funghi or yeast.

PCL | Polycaprolactone, a synthetic (fossil based), biodegradable bioplastic, e.g. used as a blend component.

PHA | Polyhydroxyalkanoates are linear polyesters produced in nature by bacterial fermentation of sugar or lipids. The most common type of PHA is → PHB.

Readers who know better explanations or who would like to suggest other explanations to be added to the list, please contact the editor.
[*: bM ... refers to more comprehensive article previously published in bioplastics MAGAZINE]

PHB | Polyhydroxyl buteric acid (better poly-3-hydroxybutyrate), is a polyhydroxyalkanoate (PHA), a polymer belonging to the polyesters class. PHB is produced by micro-organisms apparently in response to conditions of physiological stress. The polymer is primarily a product of carbon assimilation (from glucose or starch) and is employed by micro-organisms as a form of energy storage molecule to be metabolized when other common energy sources are not available. PHB has properties similar to those of PP, however it is stiffer and more brittle.

PLA | Polylactide or Polylactic Acid (PLA) is a biodegradable, thermoplastic, aliphatic polyester from lactic acid. Lactic acid is made from dextrose by fermentation. Bacterial fermentation is used to produce lactic acid from corn starch, cane sugar or other sources. However, lactic acid cannot be directly polymerized to a useful product, because each polymerization reaction generates one molecule of water, the presence of which degrades the forming polymer chain to the point that only very low molecular weights are observed. Instead, lactic acid is oligomerized and then catalytically dimerized to make the cyclic lactide monomer. Although dimerization also generates water, it can be separated prior to polymerization. PLA of high molecular weight is produced from the lactide monomer by ring-opening polymerization using a catalyst. This mechanism does not generate additional water, and hence, a wide range of molecular weights are accessible (bM 01/2009).

Saccharins or carbohydrates | Saccharins or carbohydrates are name for the sugar-family. Saccharins are monomer or polymer sugar units. For example, there are known mono-, di- and polysaccharose. → glucose is a monosaccarin. They are important for the diet and produced biology in plants.

Sorbitol | Sugar alcohol, obtained by reduction of glucose changing the aldehyde group to an additional hydroxyl group. S. is used as a plasticiser for bioplastics based on starch.

Starch | Natural polymer (carbohydrate) consisting of → amylose and → amylopectin, gained from maize, potatoes, wheat, tapioca etc. When glucose is connected to polymer-chains in definite way the result (product) is called starch. Each molecule is based on 300 -12000-glucose units. Depending on the connection, there are two types → amylose and → amylopectin known.

Starch (-derivate) | Starch (-derivates) are based on the chemical structure of → starch. The chemical structure can be changed by introducing new functional groups without changing the → starch polymer. The product has different chemical qualities. Mostly the hydrophilic character is not the same.

Starch-ester | One characteristic of every starch-chain is a free hydroxyl group. When every hydroxyl group is connect with ethan acid one product is starch-ester with different chemical properties.

Starch propionate and starch butyrate | Starch propionate and starch butyrate can be synthesised by treating the → starch with propane or butanic acid. The product structure is still based on → starch. Every based → glucose fragment is connected with a propionate or butyrate ester group. The product is more hydrophobic than → starch.

Sustainable | An attempt to provide the best outcomes for the human and natural environments both now and into the indefinite future. One of the most often cited definitions of sustainability is the one created by the Brundtland Commission, led by the former Norwegian Prime Minister Gro Harlem Brundtland. The Brundtland Commission defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainability relates to the continuity of economic, social, institutional and environmental aspects of human society, as well as the non-human environment).

Sustainability | (as defined by European Bioplastics e.V.) has three dimensions: economic, social and environmental. This has been known as "the triple bottom line of sustainability". This means that sustainable development involves the simultaneous pursuit of economic prosperity, environmental protection and social equity. In other words, businesses have to expand their responsibility to include these environmental and social dimensions. Sustainability is about making products useful to markets and, at the same time, having societal benefits and lower environmental impact than the alternatives currently available. It also implies a commitment to continuous improvement that should result in a further reduction of the environmental footprint of today's products, processes and raw materials used.

Thermoplastics | Plastics which soften or melt when heated and solidify when cooled (solid at room temperature).

Yard Waste | Grass clippings, leaves, trimmings, garden residue.