TORONTO REGION ACCELERATE INNOVATION.

Advanced Manufacturing & Materials

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Innovation Snapshot

Polymers and plastics for advanced manufacturing applications

"One of the things about plastic is that [it] has always been a democratizing material. It has made it possible to manufacture more cheaply things that otherwise would be too expensive for millions of people to have."[1]

Jeffrey Meikle, Professor, Art History and American Studies, University of Texas

Introduction

Although the plastics industry is over 100 years old, it is considered relatively modern compared to other materials. The birth of plastics started with chemically modified natural materials such as rubber, nitrocellulose, and collagen. Mass production of synthetic plastics began in the 1930s with the full automation of injection moulding processes.

The industry's growth in the 1990s was driven by the increasing use of polymers as replacement for traditional materials. Polymer parts and products are typically cheaper to produce because of high-throughput processes, manufacturability and the cost-to-performance ratio. Resins and polymers, that are essential to the manufacture of plastics, are derived from crude oil and natural gas and are therefore a by-product of the oil industry.[2]

Canadian Industry at a Glance

The Canadian industry is made of nearly 3,000 companies with over 100,000 workers and $33 billion in revenue (in 2008). Top destinations for Canadian products include the US, China and UK. However, the US is Canada's largest trading partner and accounted for 90% of exports and 72% of imports in 2008. Canada is also the top export and import market for the US. Canadian companies are known for superior products in machinery, moulds and synthetic resins (Figure 1). It is estimated that Canada consumes enough resins to produce 2% of the world's plastic products.

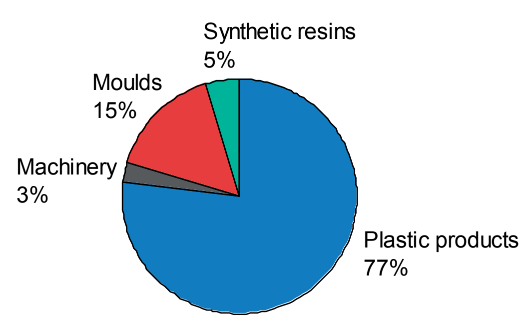
The Canadian industry grew during and after the first oil crisis in the 1970s because Canada was considered a secure supply of synthetic resins for the US. Plastics have traditionally outpaced the total economy and other manufacturing sectors in Canada in terms of compound annual average growth in output.

The Canadian industry is a sophisticated network of resin suppliers, compounders, processors, recyclers, equipment, machinery manufacturers, and mould and die makers. Canada's major end-use markets are packaging, automotive, and construction.[3,4]

Did you know…

- The first semi-synthetic plastic "Celluloid" was made in 1869 as a substitute for billiard balls.
- Plastic products consume 4% of all crude oil and natural gas (Canadian Plastics Industry Association).

Figure 1: Breakdown by Type of Establishment in Canada



Source: TRRA analysis based on Industry Canada, 2008

Industry Distribution

The Canadian industry is concentrated in four provinces: Ontario, Québec, Alberta and British Columbia. Alberta is the largest Canadian producer of petrochemicals, while Ontario is home to the highest concentration (48%) of all plastics businesses (Figure 2). Ontario is home to more than 77% of Canada's plastics machinery establishments and 71% of its mould makers.[3]

Plastics Industry in the Toronto Region

Ontario is the top Canadian exporter of plastic products, with the states of Michigan, Ohio, New York, Illinois and Indiana as the top export destinations (Figure 3). Ontario has gained an international reputation for high-quality machinery and mould manufacturing. Southern Ontario companies are amongst the top in North America in sales in many plastics-related categories, including mould making, pipe, profile and tubing extruders (Table 1).[5,6]

23% (694) of all Canadian companies are located in the Region. These companies employ one-third of Canada's plastics labour force (Figure 4). 71% of Toronto Region companies are plastics processors. Plastics machinery and equipment is the next largest segment with 15% of all companies involved in related activities.[3,7]

Toronto Region companies benefit from synergies that have developed between mould makers, equipment manufacturers, and plastics processors. The plastics industry is closely connected to other sectors in 'Canada's manufacturing heartland' and is an important part of the automotive, construction and medical supply chain.

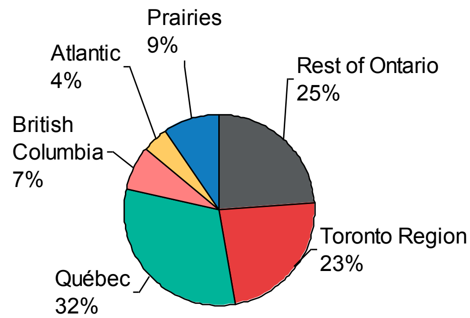
The Toronto Region is a hub of industrial activity and is home to headquarters of industry-leading companies including Husky Injection Molding, Royal Group Inc., Mold Masters, ABC Group Inc., Magna International, and the Woodbridge Group. The following are examples of Toronto Region's internationally recognized companies.

Husky Injection Molding (Bolton, Ontario) was created in 1953 by Robert Schad and started as a small machine shop operation in a Toronto garage. Husky began mass production of high-speed injection moulding machines in 1961 and has evolved into the largest brand name supplier of injection moulding equipment and services to the plastics industry. The company posted an estimated $1 billion in revenue in 2009 and targets consumer electronics, medical, and packaging industries.

Husky is a technology-oriented company with over 900 patents under its name and substantial know-how kept as trade secret. It has pioneered many innovations in polyethylene terephthalate (PET) packaging and has 50% of the market share. Much of its R&D work is conducted in the Advanced Manufacturing Centre in Bolton.[8]

Figure 2: Regional Distribution of Plastics Businesses

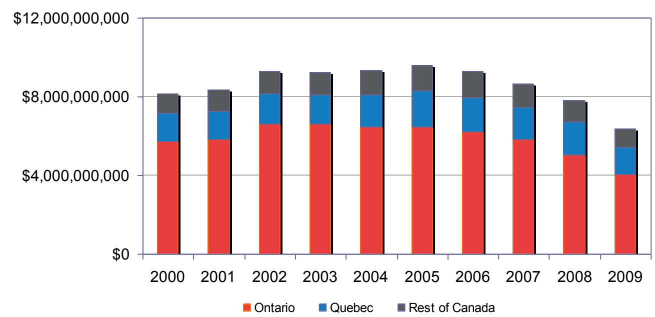
2975 businesses in Canada



Source: TRRA analysis based on Industry Canada and Canadian Plastics Sector Council data

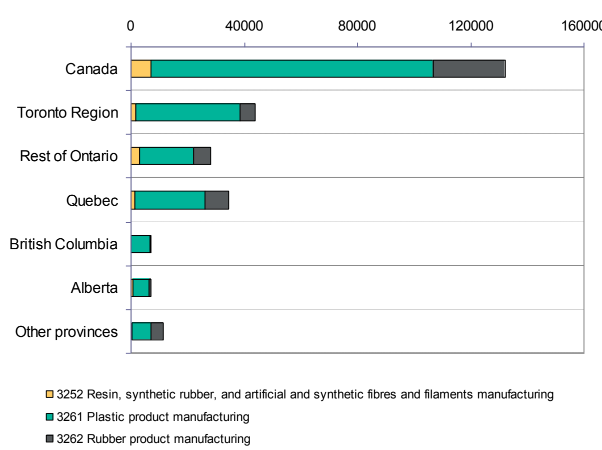
Figure 3: Total Exports in Plastic Product Mfg.

(NAICS 3261) – Distribution by Province



Source: TRRA analysis based on Industry Canada, Trade Date Online

Figure 4: Labour Force (by NAICS code)



Source: TRRA analysis based on Statistics Canada, 2006 census

Mold-Masters Ltd. (Georgetown, Ontario) is a multinational and leading supplier of advanced hot runner technology, temperature controllers and systems. The company was founded by husband and wife Jobst and Waltraud Gellert in Toronto in 1963.

As the first company to exclusively focus on the manufacture of hot-runner technology, Mold-Masters has led technological innovation in the field since the early 1960s. It introduced the first copper-alloy system in 1965 and now has more 1,600 patents pending or granted. In fact, the strength of Mold-Master's IP makes it one of the top ten technology companies in the heavy industrial equipment sector.[9,10]

Magna International (Aurora, Ontario) is the largest North American automotive parts supplier with $23.7 billion in sales in 2008. The company began as one person tool-and-die shop in 1957 and established itself in the 1960s through contracts with Ford and GM. Magna entered the auto plastics sector in 1979 with the development of the single belt pulley system. Magna is now involved in the engineering and manufacture of various automotive systems such as interior/exterior, metal body and chassis, as well as electronic and powertrain modules.

In the summer 2010, Magna created the $7.2 million Magna-NRC (Natural Research Council Canada) Composite Center of Excellence in Concord, Ontario for the development of lightweight thermoplastic automotive parts. Magna has posted a number of innovations in plastics processing including multi-shot technology, print mold design, and reinforced reaction injection molding (RRIM) urethane technology.[11,12]

Table 1: Top North American Pipe, Profile & Tubing Extruders

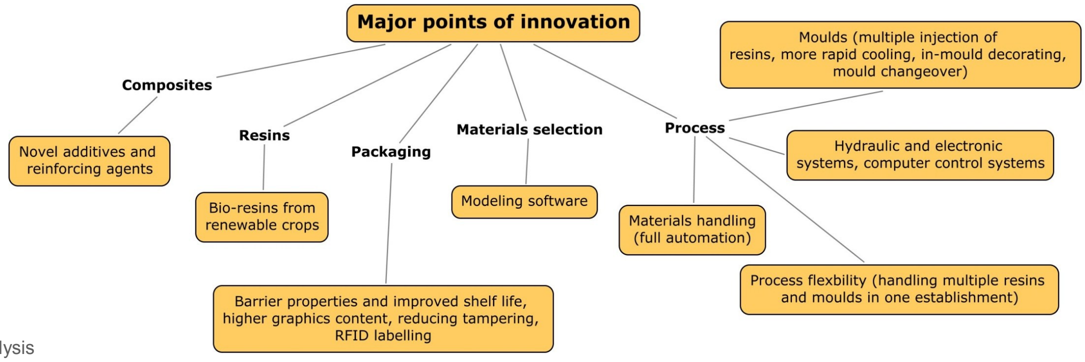
Rank	Company	Location	2008 Sales, US$ millions
1	JM Eagle	Los Angeles, CA	1,600.00
2	Royal Group Inc.	Woodbridge, ON	915.00

Top North American Mould Makers

Rank	Company	Location	2008 Sales, US$ millions
1	Husky Injection Molding	Bolton, ON	121.00
2	Wentworth	Burlington, ON	67.00
3	Proper Mold & Engineering Inc.	Warren, MI	55.00
4	H.S, Die & Engineering Inc.	Grand Rapids, MI	54.00
5	Hi-Tech Mold & Engineering Inc.	Rochester Hills, MI	54.00
6	Concours Mold Inc.	Lakeshore, ON	51.00
7	Active Burgess Mould & Design	Windsor, ON	50.00
8	Triangle, Tool Corp.	Milwaukee, WI	48.50
9	Reko International Group Inc.	Oldcastle, ON	46.50
10	Omega Tool Corp.	Oldcastle, ON	45.00

Source: www.plasticsnews.com

Figure 5: Points of Innovation in the Plastics Industry



Source: TRRA analysis

"The characteristics of the new polymer materials industry are well adapted to Canada's industrial strengths. Our past success leaves Canada with globally competitive mould makers, machinery manufacturers and engineering and design capabilities. Competitive threats from large, emerging industrial economies are largely based on the old mass production model."

Plastics Technology Roadmap, Canadian Plastics Sector Council (2007)

Innovation in the Plastics Industry

There are opportunities for innovation along the entire plastics value chain, from basic materials, resins and additives to packaging, materials handling and mould production (Figure 5).

The drivers for innovation in the Canadian industry include: globalization and foreign competition, weakened domestic construction and auto industries, a high Canadian dollar, concerns over recycling and sustainability, and search for petroleum substitutes.

The Canadian Plastics Sector Council proposed a Technology Roadmap to 2016. It envisions four key components in Canada's future plastics industry:[13]

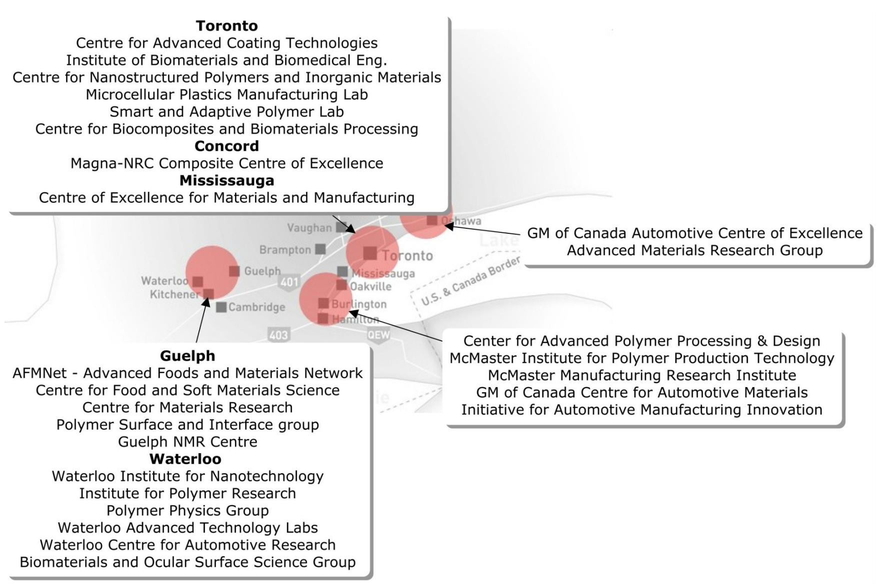
1) A shift from the concept of mass production to mass customization, which combines the benefits of manufacturing processes with the ability to produce customized goods for customers.

2) Hybrid polymer-based materials. Polymers, the building blocks of plastics, have enormous flexibility in terms of design and processing. The combination of polymers and novel additives or reinforcing agents, can give rise to plastics with novel properties: self-healing, heat resistance, electrical conductivity, temperature indicators, traceability.

3) Bioplastics. Low-cost and low-impact renewable materials derived from renewable crops.

4) An industry in which plastics function as high-value products and not commodities.

Figure 6: Related Research Institutes in the Toronto Region



Source: TRRA analysis

Overview of R&D Expertise in the Toronto Region

In addition to the strong industrial base, the Toronto Region is an active hub of polymer and plastics-related research activities. There are 100 researchers engaged in related research at approximately 30 institutes and centers in the Region (Figure 6).

Funding

Nearly $219 million was invested in polymer-related R&D in the physical sciences and advanced manufacturing across Canada (1999-2009). The Toronto Region received 29% of NSERC (Natural Sciences and Engineering Research Council of Canada) and 46% of the CFI (Canada Foundation for Innovation) funds (Figure 7a and 7b).

CFI funding is used for research infrastructure related to plastics and polymer projects. Examples of funded centers include University of Toronto's Center for Nanostructured Polymeric and Inorganic Materials and the Center for Characterization of Polymers and Cellular Polymeric Composites at the University of Ontario Institute of Technology in Oshawa. Three Toronto Region universities, Waterloo University, McMaster and University of Toronto, accounted for 26% (or $31.7 million) of all NSERC funds.[14,15]

Publications

The Toronto Region is one of the top North American regions in the number of scientific publications related to the field of polymers and plastics. It was ranked fifth in North America in plastics resins, which involves research on both conventional (petrochemicals) and renewable sources (plants) between 1999 and 2009. It was also ranked number six in polymer composites and hybrids, which includes the study of traditional polymer composites (e.g. fiber-reinforced) as well as systems with novel additives (e.g. nanoparticles).

The Toronto Region is exceptionally strong in R&D related to plastics processing – research related to the manufacture of plastics and plastic products including extrusion, injection moulding and in-mould decorating (Figure 8). The Region placed second worldwide in the number of scientific publications and the research is of highest impact (second overall in citation impact or citations per publication).[16]

Figure 7a: Polymer-related R&D

Total NSERC Funding in Canada 1999-2009: $121.4 million for 2615 projects

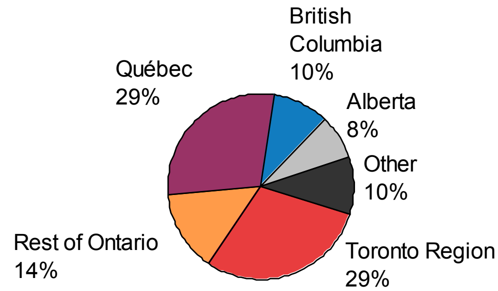
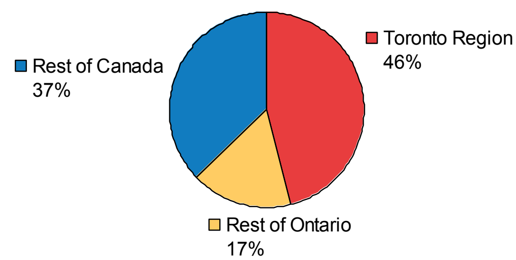


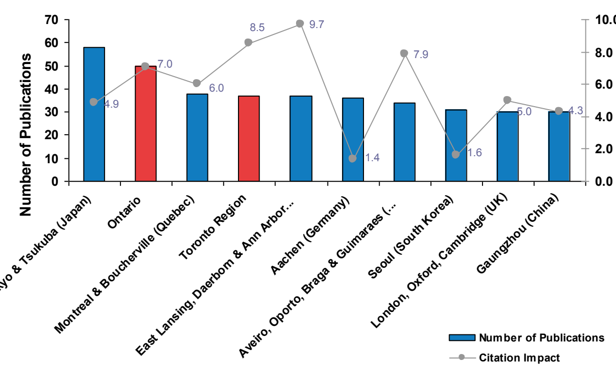
Figure 7b: Distribution of CFI Funding for Plastics and Polymers Projects by Region (1999-2009)

Total CFI Funding in Canada: $97,469,339



Source: TRRA analysis based on NSERC and CFI data, 2010

Figure 8: Top Publishing Global Regions on Plastic Processing and their Citation Impact (1999-2009)



Source: TRRA Analysis based on ISI Web of Knowledge, 2010

Experts

The Toronto Region is home to thirteen Canada Research Chairs (CRC) and two NSERC Industrial Chairs in the area of polymers and plastics, including CRC in Advanced Polymer Materials, CRC in Smart and Functional Polymers, CRC in Polymer Science and Engineering, and CRC in Soft Matter Physics. [14,17]

The following are select experts who are international leaders in their respective fields with extensive history of industry collaboration:

Mitch Winnik, Professor of Chemistry at the University of Toronto and Director of the **Centre for Nanostructured Polymer and Inorganic Materials**, has produced polymer research of the highest industrial impact. His work has been recognized as making top technical contributions to the coating and paint industries and he is, in fact, one of the most highly-cited researchers over the last 20 years.

Dr, Winnik is the author of over 400 technical papers and holder of 12 patents. His expertise is in the formation of films from latex dispersion, the basis for coating technologies. He is also a pioneer in the application of fluorescence spectroscopy to polymer systems. Much of his research is conducted in collaboration with industrial partners (e.g. Dow Chemicals, DuPont, 3M, Eastman Kodak).[18,19]

Global leadership in the area of foamed plastics is provided by **Dr. Chul Park**, a Professor of Mechanical and Industrial Engineering Department at the University of Toronto. He is the holder of the Canada Research Chair (Tier 1) in Advanced Polymer Processing Technologies and the Director of Toronto's **Microcellular Plastics Manufacturing Lab**.

Dr. Park's research revolves around novel microcellular processing technologies, computational modeling and measurement of thermophysical and rheological properties. He has an extensive portfolio of projects carried out with the private sector in the area of microcellular processing, inert gas-injection processing, rotational foam molding, and wood-fiber composites. He is also leading the **Consortium for Cellular and Microcellular Plastics (CCMCP)**, a network supported by over 20 industry members.[21]

Robert Pelton, Professor of Chemical Engineering at McMaster University and Canada Research Chair in Interfacial Technologies (Tier 1), leads one of the world's most prolific academic research groups in the area of polymer-paper making. He conducts industrially-relevant research and frequently collaborates with private partners including BASF Canada, Vale Inco, and Domtar.

His expertise lies in microgels, colloids, adhesion science, interfacial engineering of paper-based materials, and paper surface chemistry and bioactivity. He has authored over 200 publications and patents in polymers and papermaking processes. Dr. Pelton is the director of the **SENTINEL Network**, a Canadian Network for the development and use of bioactive paper.[20]

Amar Mohanty, Professor and Ontario Premier's Research Chair in Biomaterials and Transportation at the University of Guelph, is a passionate advocate of a provincial bioeconomy – an economy in which plant materials, not petroleum, form the basis for resins, polymers and fibers for plastics.

With 13 US patents and more than 350 publications, he has established himself as a leading expert in the field of biobased materials, biofuels and biorefinery. He serves on a number of editorial boards of leading publications, including the International Journal of Plastics Technology and is the Editor-in-Chief of the Journal of Biobased Materials and Bioenergy. His research interests are biobased materials including green natural fiber composites, bioplastics, and renewable biodegradable polymers and sustainable packaging.[22]

Projects

The Toronto Region is home to large-scale multidisciplinary projects that push the innovation frontier in the plastics industry thus providing the private sector with the opportunity to tap into the expertise and advanced equipment of Toronto Region universities (Figure 9).

Ontario BioAuto Council (Guelph, Ontario)

Within the Council the emphasis is on biomaterials, including flexible foams for automotive interiors and wood fiber composites for automotive and construction sectors. With an estimated $6 million in funding since 2006, the Council connects Ontario's industries that would be considered major stakeholders in a bio-based economy: agriculture and forestry sectors, chemical and plastics producers, and advanced manufacturing.

The Council oversees applications from Ontario for-profit ventures for biomaterials commercialization or market-ready products and processes. It partners with companies on projects of up to $2 million. The Council received $2.5 million from the Ontario government to fund three Toronto Region companies involved in the manufacture of green auto parts from crops: Canadian General-Tower Ltd., the Woodbridge Group, and GreenCore Composites.[23,24]

Ontario BioCar Initiative (Guelph, Ontario)

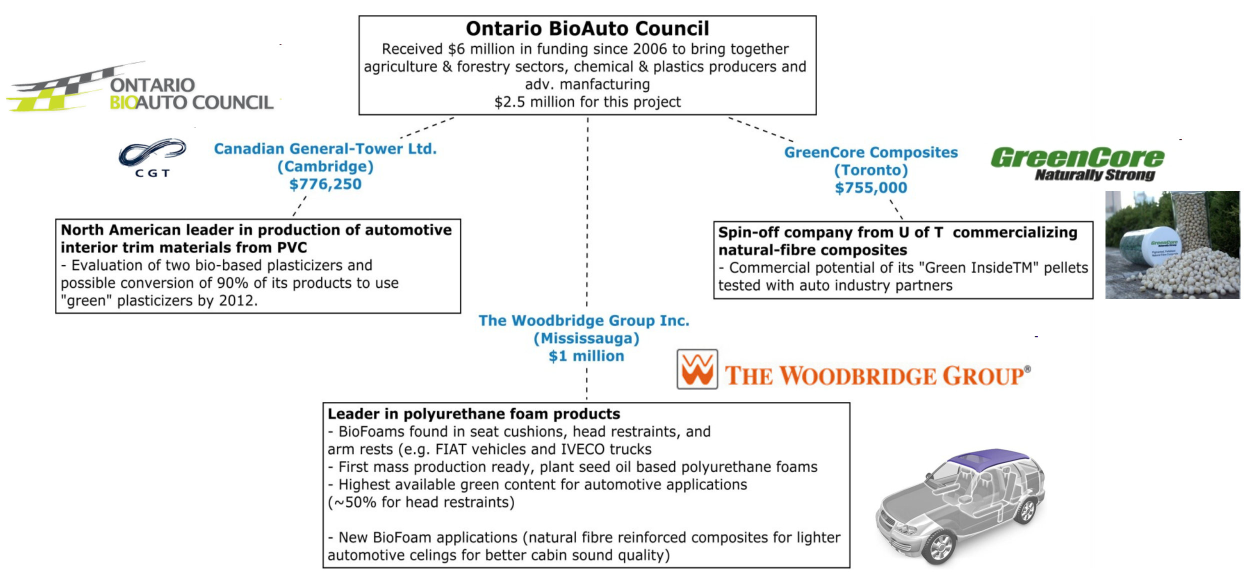
This initiative represents a multi-university project led by the University of Guelph with the involvement of the automotive and agricultural industries. Equipped with $5.9 million from the Ontario Ministry of Research and Innovation, $5.9 million from universities and $5.9 million from 12 private partners, the objective is to have every car in Ontario with a green interior, made entirely from composites of agricultural crops such as corn and wheat.

The project brings together 16 researchers whose expertise spans across the entire value chain: raw plant materials and crop genetics at the University of Guelph, processing and separation of biological feedstock at the University of Toronto, engineering composite resins and polymers at the University of Waterloo and integration of bio-based components into cars at the University of Windsor. Industrial partners include Ford, Chrysler, DuPont, Magna, Arkema, and the Ontario Wheat Board.[25]

Intelligent Food Packaging (Guelph, Ontario)

The goal of Professor Loong-Tak Lim's research is to fabricate "intelligent" food packaging by using electrospun nanofibers from biodegradable sources as the basis for packaging materials to extend the shelf life of liquids. He is working with DuPont's Kingston R&D center. As an Assistant Professor in the Department of Food Science at the University of Guelph, his expertise is in active packaging, encapsulation, electrospinning, biodegradable polymers, and edible films.[26]

Figure 9: Examples of Ontario BioAuto Council-funded Projects



Source: TRRA analysis

NSERC Network for Innovative Plastic Materials and Manufacturing Processes (NIPMMP) (Toronto, Ontario)

With $5 million over five years (2010-2014) from NSERC, the Network for Innovative Plastic Materials and Manufacturing Processes (NIPMMP) brings together 23 professors from 11 Canadian universities, as well as 20 Canadian industrial partners and the NRC-Industrial Materials Institute.

Under the leadership of Toronto professor Park Chul, the vision for the Network is to develop innovative manufacturing technologies for value-added plastics across four themes: biomaterials, lightweight hybrid composites, micro- and nano-structured polymeric materials and microcellular foams.

The objective of the Network is to position Canada as a leader in innovative polymer materials and technologies and at the same time produce plastics that combine superior properties (high strength, lightweight, low density) with the functionality of traditional plastics for a range of end-markets: automotive, aerospace, biomedical, construction, packaging and electronics industries.[27]

Conclusion

The Toronto Region has gained an international reputation for high-quality plastics machinery and mould manufacturing. It is home to corporate headquarters of industry-leading companies that benefit from linkages with other sectors in the region (automotive, construction). The emphasis on green energy in Ontario and the passage of the Green Energy Act, which sets local content requirements, will provide the plastics industry with opportunities to diversify and to supply the growing clean technology industry with plastic parts and components.

An estimated 100 experts in the Toronto Region conduct highly-regarded plastics R&D at nearly 30 related research institutes. The research in plastics processing is internationally recognized and is of the highest impact. The universities in the region are increasingly connecting with private partners to work on high value-added plastics for advanced applications. The government is supporting large-scale projects in innovative plastics.

Did you know…

- Production of well-known plastics (polyethylene, polystyrene) grew in the 1940s to fuel the war effort.
- World's first: Ford introduced wheat straw-reinforced plastic interior storage bins in the 2010 Ford Flex based on a part produced through the Ontario BioCar Initiative.
- Intelligent packaging will be one of the fastest-growing segments in the plastics industry with an estimated market of US$590 million by 2013. (Source: www.canplastics.com)

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