



F O R A G E N VISIONS

Radiant Technologies Inc. *Processing Natural Products More Efficiently*

INDUSTRY PROFILE

Radiant Technologies Inc. is a young Canadian company actively commercialising a broadly patented microwave-based natural product extraction technology known as MAP™ (for “Microwave-Assisted Processes”.) This technology, licensed from the Government of Canada, has applications ranging from the processing of commodity food oils, such as canola, soybean and palm oil, to the production of very valuable specialty natural extracts, including essential oils, flavours, fragrances, colourings, and natural medicinal and pharmaceutical compounds.

MAP is an innovative, ecologically efficient platform technology that promotes sustainable development in the bio-based economy. Compared to conventional product extraction methods, Radiant’s MAP technology offers lower production costs, better product yields, higher purity, and new, more specialized products. At the same time, the technology promotes environmental preservation and



Radiant Technologies Pilot Plant

quality of life by reducing energy usage and greenhouse gas emissions, as well as by reducing or even eliminating toxic solvent emissions.

Extracts of natural products have been used as food and medicine since the beginning of civilization. Today, most natural products are extracted from their original sources using a process called solvent extraction. Edible oils are extracted from soybeans, palm kernels, cocoa nibs, and canola, sunflower and cotton seed. Specialty products such as flavours, fragrances, colourings, essential oils, and pharmaceuticals and other bioactive

compounds are isolated from plant leaves, roots and stems, and from other natural biomass materials, including algae, bacteria and even insects.

In the traditional extraction process, a heated solvent (often alcohol or a petroleum-based hydrocarbon) is mixed with biomass material until the desired product compounds are dissolved. These compounds are then separated from the solvent and concentrated for use. While effective, this conventional method can take hours or even days to complete, can require large volumes of solvent, and typically consumes very large quantities of energy leading to significant greenhouse gas emissions.

The MAP Technology

The core of Radiant’s MAP technology is the efficient use of microwave energy to extract valuable products from

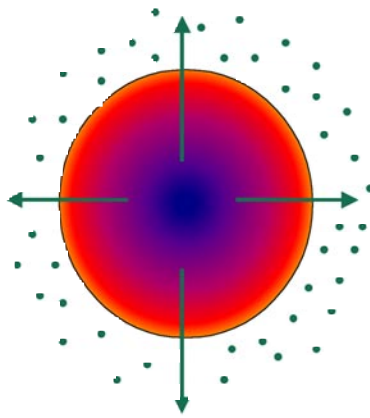
foragen

renewable biomass. The basis of the technology is the ability to selectively target microwave energy into different parts of a heterogeneous chemical system. If solvents relatively transparent to microwaves (i.e. that do not absorb microwave energy and become heated) are chosen, almost all of the energy is selectively deposited into the “target” material (e.g. plant, microbial or animal tissue containing the components to be concentrated or isolated.) The result is a new extraction-driving force with many advantages.

Conventional solid-liquid extraction is a diffusion-driven process, which involves soaking, washing or otherwise contacting the solid material with (usually hot) solvent to extract the target compounds. In these cases, mass transfer takes place in four steps:

1. Diffusion of solvent into the biomass particle through the particle’s natural pore structure,
2. Dissolution of the target compounds into the solvent,
3. Diffusion of the soluble compounds back out to the surface, again through the restricted pores and channels,
4. Washing of the solute-rich solvent (or miscella) from the surface into the bulk of the solvent.

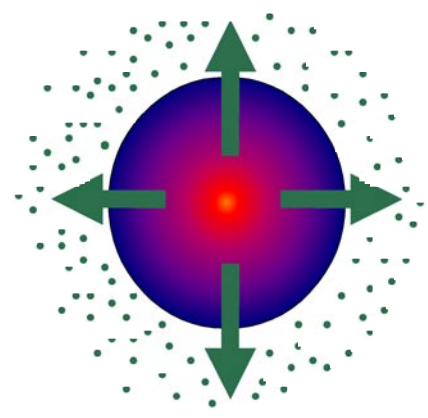
The slowest or rate-controlling step is most often the third one, diffusion of the solute back to the surface. For this reason, conventional extraction systems are designed to maximize this diffusion rate - for example,



Conventional Solvent Extraction
Diffusion-driven process
Driving force is concentration gradients

countercurrent flows are used to maximize concentration gradients, high temperatures are used to maximize diffusivities and sometimes very high pressures are used to make fluids supercritical to overcome diffusivity limitations. The result is that, while it is possible to obtain reasonable yields of product, often the choice of solvents is limited and long extraction times and high temperatures are required. In addition, the target phytochemicals tend to be unstable, and can be thermally degraded by spending prolonged periods soaking in hot solvent.

In the MAP process, microwave energy passes relatively untouched through the solvent and is selectively deposited in the solid biomass material. The result is a very rapid heating of the residual water present in the material (water is the most effective absorber of microwave energy.) This rapid “in-core” heating of the biomass results in an equally rapid pressure increase within the cells of the material. This in turn creates an inverted thermal profile and a pressure-driven enhanced mass transfer of the soluble materials out of the biomass, as shown schematically below. In many cases,



MAP Solvent Extraction
Inverted thermal profile leads to
“pressure-driven mass transfer”

the internal pressure rise is sufficiently high to result in cell wall explosion, directly releasing the contents to be dissolved in the surrounding (cold) solvent.

Greater Flexibility

The key to MAP’s success, therefore, is that the driving force for extraction is not controlled by diffusion. With microwaves, components can be directly expelled from the matrix, which leads to much greater solvent flexibility. In addition, many more variables can be tuned to deliver desired product attributes-including microwave power density, microwave energy, post-microwave mixing, dielectric properties of mixed solvents, and raw material pre-treatments. The result is increased flexibility and the ability to tailor extraction sequences for particular product outcomes. Finally, the very fast extraction rates and high yields from single-stage extraction open the door to efficient downstream isolation and purification steps that are not economical with conventional methods.

Market Opportunities

Radiant's microwave extraction technology is targeted for penetration into the emerging multi-billion dollar naturally-derived specialty chemicals market. Flavours, fragrances, colourings, spice oleoresins, botanical extracts, and natural phytochemicals and pharmaceuticals all tend to be produced in relatively small volumes, but have high values. Demand is high for new and improved products and improved recovery of active ingredients from the raw materials, and companies are driven mainly by the need to gain competitive advantage through the development of better, more unique products. Radiant's MAP technology offers the potential to respond to all of these needs. MAP is capable of producing higher purity products at excellent yields, while at the same time leading to improved process economics and a cleaner environment.

Federal Government Support / Strong IP Position

The federal government has led the development of the MAP

technology for over 15 years. Environment Canada's Dr. Jocelyn Paré is the lead scientist, and has developed several patents around the technology. Radiant has the sole rights to use, market and sub-license the technology for the field of industrial-scale extraction processing.

Radiant also accesses office space and state-of-the-art laboratories and pilot plant facilities at a Burlington, Ontario federal facility. Dr. Steven Splinter, Radiant's founding President, notes that, "As an early-stage company, we have a very significant advantage in that we do not have to focus on developing facilities. This of course means we are able to direct all our resources to the critical product development activities required to drive the company forward and deliver on our strategy."

The MAP Intellectual Property portfolio itself is extensive, consisting of 12 patents in Canada, the USA, Europe, Asia and South America, and a trademark in four countries. In fact, the US patents were granted the status "free of prior art", a qualifier granted to less than 5% of all patents issued. The strength of the patents and Radiant's exclusive license to commercialize them represent a significant opportunity for creating a strong Canadian company.

Strong Partners

Radiant's strategy is commercialisation of MAP via a variety of partnership mechanisms, including licensing agreements, joint venture development and toll processing arrangements. Being a platform technology with very wide-ranging areas of application serves as both strength and a challenge. According to Dr. Splinter, "Our challenge is to carefully prioritize the many opportunities that present themselves and so decide where best to spend our time and resources."

Foragen has been instrumental in helping Radiant meet this challenge. Since deciding to invest in Radiant in April 2003, Foragen has worked closely with Radiant to provide management expertise and help develop and implement strategy. Dr. Splinter notes, "One of Foragen's first actions was to assemble a strong advisory team and organize a strategic planning session for the company. This session was instrumental in refining Radiant's strategy and providing management with clear focus".

President's Message

Agri-Science: Creating a Better World



Dr. Murray McLaughlin PhD, P.Ag.

At Foragen we are constantly looking for the best agri-science projects. Foragen invests not only in biotechnology projects, but also in areas such as natural pesticides, bioprocessing technology, bioproducts, animal health, and methods for tracing food animal and crop sources. I truly believe that for the world to be a better place with less disease, better health and greatly reduced malnutrition, we need to use the best science, including biotechnology.

It amazes me that, even when the safety and the benefits have been so clearly demonstrated, some still hesitate to support biotechnology. Before they reach a farmer's field or a family's kitchen table, biotechnology-based crops, crop management products and livestock treatments and therapies undergo years of rigorous testing to ensure they are safe for people, animals and the environment.

A recent two-year study by the Canadian Biotechnology Advisory

Committee (CBAC) confirmed that biotech foods currently on the market are safe. The report concludes, "GM (genetically modified) foods currently in the marketplace have arguably undergone greater regulatory scrutiny than their conventional counterparts. We conclude that no scientific evidence exists to suggest that GM plants and foods currently in the marketplace pose any greater health or environmental risks than other foods."

Being involved in the broad aspects of technology development allows us at Foragen to interact with regulatory systems nationally and globally. Based on our experience, I can definitely attest that Canada has one of the best regulatory systems in the world for ensuring consumer safety, and is constantly working to make this system even better. CFIA, Health Canada and our other regulatory bodies are exceptional in their diligence and ability to protect the safety of our food system and environment. They have sound policies and procedures in place to take products through registration. The federal government also has the ability to trace, track, recall, and bring under control issues such as BSE, avian flu, and contamination in feed and food such as pesticide residues in fish feed or *E. coli* in organic products. There is no justification for criticism, regardless of the information we may receive through the media.

It also distresses me that organizations claiming to support social justice and

environmental protection prefer to support starvation, ill health and the extensive use of chemical products on the land. The drawn-out registration effort for golden rice is an example of the high price paid for reticence among regulators. In developing countries, blindness resulting from malnutrition strikes 500,000 people a year. Golden rice was developed specifically to prevent this. Sadly, it is now projected that there will be 5-year delay in growing the crop due to lobbying for extreme regulations. This delay will cost 2.5 million people their sight.

Patrick Moore, Chair of GreenSpirit Strategies and a co-founder of Greenpeace, recently stated, "The campaign of fear now waged against genetic modification is based largely on fantasy and a complete lack of respect for science and logic. In the balance, it is clear that the real benefits of genetic modification far outweigh the hypothetical and sometimes contrived risks claimed by its detractors."

As the CEO of Foragen, a Canadian, and a consumer of Canadian food products, I am confident in our food quality and safety. Science has supported the development of improved food over the last century, providing us with abundance and quality.



As we move through this century we will see science continue to improve quality, production, and safety. However, we will also see this science provide increased benefit to the developing countries of the world. The scientific community has taken upon itself a mandate to counter nutritional deficiencies, develop environmental improvements, address the world's food needs through increased production, create technologies for more efficient drug and vaccine delivery

systems, and deliver therapeutic, preventative and rehabilitative products to humans.

At Foragen we continue to search out new technologies that will improve quality of life at home and abroad. Being based in Canada, with its innovative sciences and strong regulatory system, we have a significant advantage in increasing the value of our investments. We also have the necessary skills and resources to deliver a commercial product based on high quality science.

We are proud of our role in helping make the world a better place by supporting the best in agri-science innovation.

Murray McLaughlin
President & CEO

"There are going to be times when we can't wait for somebody. Now, you are either on the bus or off."

Ken Kesey, in *The Electric Kool-Aid Acid Test*
by Tom Wolfe

Investment Saskatchewan and Foragen: *a good fit for many reasons*

Over the last several years, Canada's biotechnology industry has undergone tremendous growth. First identified as an industrial sector in the 1997 Speech from the Throne, the sector became increasingly recognized as one of this nation's most important building blocks towards the 21st Century's new, knowledge-based economy.

Given its natural assets and resident academic resources, Saskatchewan has taken great strides in the development of its biotechnology business strategy. The "Saskatchewan Advantage" in this area is considerable, including the life science cluster at Innovation Place and the University of Saskatchewan, a formidable innovative research and development community, an attractive tax climate for innovation and research, a supportive net



work of private and public stakeholders, and the ongoing development of world-class facilities such as the Canadian Light Source (Synchrotron), to name but a few.

From the Saskatchewan perspective, the emerging bioeconomy represents the province's greatest opportunity for growth, development and prosperity. Recognizing the merits of investment in this sector, in the year 2000 Investment Saskatchewan Inc. (formerly CIC III) joined RBC Technology Ventures Inc. and Quebec's SGF Soquia Inc. to fund Foragen Technology Ventures Inc. to establish an early-stage seed capital fund that invested in and helped establish pre-commercial agricultural technology companies.

The Foragen Fund was seen as a first and fundamental "fit" for Investment Saskatchewan, and the Government of Saskatchewan, in growing the province's biotech and venture capital industry.

By concentrating on increasing the viability of selected companies so they can attract traditional sources of financing, Foragen's focus is a match with the Investment Saskatchewan mandate. Governed by an independent board of private businesspeople, Investment Saskatchewan is committed to the growth of healthy and vibrant capital markets in Saskatchewan, incremental in-bound investment, and a reduced investment role for government.



Investment Saskatchewan maintains that if properly nurtured, the biotech sector could have a beneficial domino effect on the economy, particularly in the province's agricultural sector. Investment Saskatchewan is confident that with Foragen as a partner in deploying funds to a growing number of Saskatchewan bio-ventures, the appropriate placement of capital in the biotechnology industry will help to create jobs, expand leading edge innovation, and create a platform for sustainable development in the sector.

Investment Saskatchewan has found an astute biotechnology venture capital fund manager in

Foragen. Foragen is led by Dr. Murray McLaughlin, a past President of Saskatchewan's Ag-West Biotech Inc, a former Deputy Minister of Saskatchewan Agriculture and Food, and President of Ontario Agri-Food Technologies. McLaughlin's company has proven it possesses the resources and expertise to strategically place capital into a number of promising Canadian and Saskatchewan companies. One of its investments, in Saskatchewan-based MCN BioProducts, has already shown tremendous potential and a healthy forecast.

The partnership of Investment Saskatchewan and Foragen continues to be a good fit. According to Shelley Legin, VP of Business Development

and Investment Funds for Investment Saskatchewan and a Foragen Board member, "Investment Saskatchewan takes pride in being part of the Foragen Fund and its vast network within the agbiotech sector. Saskatchewan has world class biotechnology infrastructure totalling \$1 billion - our investment and trusted association with Foragen is critical to the province's continued public-private partnerships in this emerging and potentially high-growth sector."

A primary source for this article is The Crown Investments Corporation of Saskatchewan: <http://www.cicorp.sk.ca>

The First Agri-Food National Centre of Excellence

The federally sponsored Networks of Centers of Excellence (NCE) Program fosters powerful partnerships among universities, governments, not-for-profit organizations and industry members. The Program is designed to develop Canada's economy and improve the quality of life for Canadians

The recently established Advanced Foods and Materials Network (AFMNet) is the newest organization to join the Networks. AFMNet brings together natural scientists, engineers, health researchers, social scientists, and lawyers to work on various aspects of food and bio material advances. Through collaboration, it is anticipated that the combined expertise will support accelerated research activity.

The venture has been awarded 22.2 million dollars allocated over 5 years.

As a new component in the Networks of Centers of Excellence, AFMNet addresses three broad themes:

- the structure, dynamics, and function of foods and bio-materials
- functional foods and nutraceuticals
- economics, environment, and social issues

Dr. McLaughlin, Chair of the Advanced Foods and Materials Network and President of Foragen Technologies Inc. says. "Wellness is a critical concern to society. AFMNet will be key to ensuring agriculture is brought into the wellness scenario."

Projects underway through the agriculture-based Network include

research on the production of non-latex rubber from sunflowers. According to the Web site, sunflowers produce a small amount of rubber naturally. With genetic modification, creating commercial-scale amounts may be possible. Over 400 medical devices are made from rubber. This is a matter of concern since approximately 7% of the population has latex allergies. If the option to use sunflower based rubber comes to fruition, Canada could see both health and economic benefits.

The administration centre is based at the University of Guelph. The management team,

The logo for Foragen features the word "foragen" in a lowercase, sans-serif font. A green curved line arches over the letters "o" and "r", extending from the top of the "o" to the top of the "n".

also based in Guelph, includes Dr. Rickey Yada, Scientific Director; and Dr. Larry Milligan, Network Manager.

The Network incorporates 29 Universities, 32 industries and 29 government departments and agencies.

The Networks of Centres of Excellence (NCE) program has been operating successfully for fifteen years. In February 1997, the government established the NCE

as a permanent program. Two years later, it increased the program's budget by \$30 million bringing it to \$77.4 million per year.

Three Canadian federal granting agencies - the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council of Canada (SSHRC) - and Industry Canada combine their efforts to support and oversee the NCE initiative.

For more information on AFMNet go to http://www.nce.gc.ca/nces-rces/afmnet_e.htm

"Food is more than fuel for the body. It is the source of some of our greatest pleasures and, not surprisingly, greatest fears."

Carol Tucker Foreman,
Director,
The Food Policy Institute
at the Consumer Federation
of America.

About Foragen:

Foragen Technology Management Inc. and its team manage investments in advanced agricultural technologies and provide a complete development package to move technology from concept to successful commercialization.

The company seeks out innovative ideas in such areas as human and animal wellness, food and fibre quality and trait enhancement, food safety, and alternative bio-based products, materials and processes.

Foragen is committed to building long-term productive partnerships with technology innovators. Future issues of *Visions* will feature Foragen clients and members of the Foragen Management Team.

For more information, visit our Web site at www.foragen.com, or e-mail Dr. Murray McLaughlin at murray.mclaughlin@foragen.com.

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