Kingdom of Thailand

Bridging the Gap from the Laboratory to the Market

Where one might see waste, an innovator might see opportunity. This was the case for researchers at the National Metal and Materials Technology Center in Thailand, who developed an environmentally friendly process to extract solid rubber from the waste that results from traditional rubber manufacturing. With protection of this innovation in the form of patents and trade secret – and guided by strong IP management policies – the research center is undergoing efforts to transfer the technology from the laboratory to the commercial sector, thus turning waste into profit.

Background

Natural latex is most commonly cultivated from the para tree (Photo: Garik Asplund)

In many emerging economies, researchers, inventors and entrepreneurs face a number of barriers to successfully commercializing innovations. Limited exposure to the commercial sector, less developed technological capability, and a general focus on academic publishing instead of intellectual property (IP) means that it can be easier and less risky for companies to purchase technology from abroad instead of developing it locally. Many of these economies are also based on agricultural commodities, and slim profit margins make it difficult for players in the agricultural industry to take a risk on a locally developed technology that has yet to be proven.

Although a number of developing countries have successfully allowed market forces to drive domestic innovation, in many of them technology transfer organizations have taken a leading role. The Kingdom of Thailand (Thailand) is no exception, and a number of agencies and programs in the country are encouraging the development and commercial dissemination of technology domestically. One such leading organization is the National Science and Technology Development Agency (NSTDA), under which four major national centers of research operate in the fields of electronics and computers, genetic engineering and biotechnology, nanotechnology, and metal and materials technology.

The Industrial Technology Assistance Program (ITAP), a division of NSTDA, works with each of these organizations to encourage and realize the commercialization of developed technologies. Given the abundance of natural resources in Thailand and the significant factor they play in the country's economic development, the fourth entity – the National Metal and Materials Technology Center (MTEC) – serves to meet vital needs in the country. In 2006, and with the assistance of ITAP, researchers at the Polymer Research Unit (PRU) at MTEC's Rubber Research Program (RRP) developed a new process to reclaim useful rubber from the waste of rubber factories, which has the potential to drastically improve the industry in Thailand.

An Expanding Resource for a Growing Economy

Representing over 10% of Thailand's gross domestic product (GDP), the agricultural industry is an integral part of the country's economy. Natural rubber in particular is one of the country's most important agricultural products. Raw natural rubber and derived products represent 5% of Thailand's exports, and as of 2012 the country was the world's leading natural rubber producer and exporter (Food and Agricultural Organization, 2012). Because of the importance of rubber to the country's economy, the government of Thailand invests heavily in the research and development (R&D) of all aspects of rubber production, from the cultivation of latex trees – the source of natural rubber – to final processing.


Rubber, one of Thailand's most important exports, is used to create a variety of products (Photo: Glenn Brown)

Demand and cost for natural rubber has continually increased, and by 2010 doubled over what it was in 2005. By 2013, natural rubber production from the world's top rubber-producing countries came to 11.15 million metric tons, which represented a 4.7% increase over the previous year. Processing all of this natural rubber requires the use of highly toxic and volatile chemicals such as acids, ammonia and formaldehyde, which can negatively impact the environment and pose a safety risk for those working in the natural rubber industry. Because of these considerations, R&D in the rubber industry in Thailand has focused on increasing the yield of rubber and reducing, or more efficiently managing, the use of volatile chemicals during processing. The RRP focuses on these and a number of other challenges facing the rubber industry in Thailand.

Natural rubber is an elastic hydrocarbon polymer that comes from latex, a milky substance that is the sap in some plants, the most common of which is the *para* rubber tree. Latex is collected from *para* rubber trees through making a precisely angled incision into the bark of the tree. This triggers the flow of latex to the incision as a defense mechanism, which is then collected in a vessel attached to the tree. Raw latex coagulates naturally when exposed to air, so it must be treated or processed in a way that controls coagulation and maximizes the desired elastic properties. After collection, raw latex is processed into one of three semi-finished states before being supplied to rubber manufacturers: concentrated latex maintained in a liquid form; smoked solid latex sheets; and solid latex blocks. Concentrated latex is more widely used and is essential in the production of a wide variety of rubber and chemical products.

When rubber latex is tapped from the *para* tree, it comes out with a solid rubber concentration of 25 – 40%. Blending with latex from a variety of other sources brings the concentration to the industry standard of 35%. Water is then removed from this blend by centrifuge to increase the concentration to 60%, and the various aforementioned chemicals are added to control coagulation and prevent bacteria degradation. The final concentrated rubber latex is sold to rubber products manufacturers to make dipped rubber products (those products made with molds).

Untapped Potential

Each of these processing stages results in waste, and in that waste are untapped residual rubber solids. The rubber solids in the waste can be defined into three categories. The first is "skim" rubber, which is the water removed from the centrifuge process. This water still contains approximately 3 – 8% rubber solids. The second is "sludge," which clumps together inside the centrifuge and other machinery and also pools at the bottom of latex reservoirs. Sludge is removed at regular intervals during processing. Lastly is "washing water," which is the water that is used to wash out centrifuges and other machinery and contains a small amount of dissolved rubber solids.

Raw latex is collected by tapping a para tree (Photo: Blake Lennon)

Of the three categories, skim rubber contains the most rubber solids and has the most potential to be commercially viable. In 2006, representatives at a major Thai rubber company read an article about recovering rubber solids from skim rubber. Intrigued by the commercialization possibilities, the company contacted ITAP to see if such a technical process could be developed. After consulting with PRU at MTEC, ITAP discovered that the research unit had in fact already launched a program that same year to develop a process for recovering rubber solids from skim rubber.

While it was not yet commercialized, the process was a success in the laboratory. The new process adds concentrated sulfuric acid to the skim rubber, which forces coagulation of the solids into floating lumps of rubber that could be separated from the surface of the liquid. However, the extracted rubber solid is generally of low quality and can only be used in the production of items such as rubber bands.

Even so, Thai rubber companies expressed interest, and five of them agreed to host visits by MTEC researchers with the aim to develop a pilot program to test the process on a large scale at a factory. As the project matured, the rubber companies realized that the new process required expensive additional equipment and it was thus never commercialized. However, an even more exciting development was born from this research.

During the pilot program, one of the participating companies had an informal discussion with MTEC researchers and mentioned the benefits of being able to recover rubber from sludge. Researchers tended to ignore the sludge because it contains a very small percentage of rubber, the latex in it is already solidified (thus making it less valuable), and it contains high amounts of inorganic substances that were added during processing. Although sludge could be used as low-grade fertilizer, the high rubber content lowers its effectiveness. Because of these factors, rubber processers generally consider sludge neither a valuable source of rubber nor a viable fertilizer, and usually pay to have it removed.

Seizing an Opportunity

The company that approached MTEC researchers saw an overlooked opportunity: if the rubber solids could be separated from the inorganic material, it would result in two important economic opportunities. First, rubber output could be increased from the same inputs, and second, the removal of the inorganic material would allow the production of a high-grade fertilizer, which could be sold to offset the cost of chemicals used in processing. Intrigued with the potential of such a process, MTEC's research program shifted focus from skim rubber to recovering rubber solids from sludge. Although it would have a lower yield, researchers determined that commercialization would be much easier.

At the outset, MTEC focused on removing chemicals from the rubber to purify it. However, this proved to be an exceedingly difficult task because even though the sludge was primarily rubber with a small percentage of residual chemicals, there was no easy way to viably remove the chemicals to make usable rubber. In addition, such an approach proved that it was nearly impossible to yield any significant volume of marketable fertilizer. Faced with this dilemma, an RRP researcher wondered if there was a way to get the rubber out of the chemicals instead of the chemicals out of the rubber. The research program was already very familiar with technologies surrounding separating rubber from many other compounds, including during the development of the aforementioned skim rubber process. This experience combined with an innovative approach – getting the rubber out of the chemicals – led to RRP's successful development of a new way to extract rubber solids from sludge waste.

A Breakthrough Process

The newly developed process involves immersing the sludge in a liquid medium, such as water, and then adding acid to lower the pH (the measure of the acidity of a solution) to a range from 0 to 3.5. The acid causes the solid rubber to clump together, which can then be easily collected and separated from the liquid medium. The recovered rubber is washed and dried, after which it is suitable for sale. The remaining liquid is then adjusted to a pH level between 6 and 14, which causes the inorganic substances to precipitate out. One of these substances is magnesium ammonium phosphate, which is extremely valuable as a fertilizer as well as for use in ceramics manufacturing.

The invention uses a liquid medium, such as water, to clump solid rubber together (Photo: Sergiu Bacioiu)

After inventing this initial process, RRP researchers and personnel from the company that approached MTEC went to work on refining it to yield even greater results. After optimizing the required chemical formulations to achieve the highest level of rubber recovery, the team realized that the chemicals used in the process are also used in other steps of rubber manufacturing, many of which are discarded with wastewater after use. Reuse of this waste would enable further savings, making the process even more efficient.

Instead of using water as the liquid medium, the team reasoned that the residual solution from the centrifuge process, cleansing water, or discarded water from other parts of rubber processing could be used. Similarly, instead of adding selected acids to separate the rubber, excess acidic solution from the natural course of rubber processing can be used with no additional material cost. The recycled use of these waste streams can be used as many times as necessary to achieve the desired rubber recovery level.

From Sludge to Increased Benefits

The improvements on the original invention led to even greater potential commercial value. Using wastewater instead of fresh water and residual chemicals instead of new chemicals increases a rubber factory's output without increasing cost. Results indicate that by using existing water and chemical waste, approximately 15% of the sludge can be recovered as marketable rubber solids. A high-grade fertilizer can also be developed, which can be sold to offset any cost a rubber processor incurs by using the new process. In addition, impurities in wastewater are reduced, which translates into savings for wastewater treatment. A safer working environment is also provided, as employees have to manage fewer volatile chemicals.

Although many of these factors and techniques can also apply to a process for skim rubber, there are subtle but important differences. Applying a similar technology to skim rubber will only recover about 5% of the solid rubber, whereas up to 15% can be recovered from sludge. In addition, using the process with skim rubber will bring with it none of the additional benefits brought from reusing wastewater and chemicals. At the same time, such a process requires additional costly equipment, which further lessens the economic benefit. Therefore, the process as applied to sludge rubber is truly innovative and brings many positive benefits.

IP in Action

NSTDA strives to protect all of its developed technologies through strategic use of the IP system, and the new process related to sludge rubber is no exception. Securing IP rights (IPRs) and other protection, such as trade secrets and non-disclosure agreements, of NSTDA-funded research is undertaken by the Agency's Technology Licensing Office (TLO), specifically through the IP Management Group (IPM) and the IP Policy Group (IPP). With over 150 applications submitted on average every year, they are some of Thailand's most experienced IP management and policy groups.

Multiple Protection Tools

Because of the perceived value of this technology in the rubber industry, NSTDA drafted a patent application for the process to recover residual rubber solids from sludge waste. A national patent application (#0801005432) was filed with the Thailand Department of Intellectual Property in 2008 and in neighboring major rubber producing countries such as Malaysia (#PI20094408; 2009), the Republic of Indonesia (Indonesia), and the Republic of India (India).


Resulting sludge containing rubber solids collected from processing equipment (Photo: MTEC)

Although patents are the primary means with which NSTDA protects its innovations, at times a combination of other types of protection, such as trade secrets, is necessary. This can be illustrated in the sludge rubber recovery technology, which brought several IP challenges. First, the process is straightforward and easy to replicate. Second, there is no way to detect whether recovered rubber was derived from this process, or from any other source, so enforcement is difficult. Finally, since a major benefit of the technology involves using existing chemicals and manufacturing process flows, potential competitors and customers already possess a great deal of relevant knowledge.

Taking this into consideration, IPM (the patent management group at NSTDA) determined that protecting the know-how of the process via a trade secret was essential. To that end, certain details regarding specific acidic compounds used in the process to recover rubber solids from sludge waste are protected by NSTDA as a trade secret. Moreover, because an important benefit of the technology is to save costs by utilizing existing waste streams, the formulation must be adjusted to the unique requirements of each factory. This reaffirms that the know-how of NSTDA researchers – protected as a trade secret – is vital to the successful commercialization of the technology.

Technology for All

With a new natural rubber production process in hand, NSTDA had to determine the best way in which this innovation could reach the market. In order for the technology to have broad reach, the Agency determined that a technology transfer scheme in the form of licensing would be the most effective approach. Just a year prior, in 2005, NSTDA established the Technology Management Center (TMC), which manages scientific R&D and commercial linkages, and the TLO, which is the main vehicle for technology transfer. These entities were the perfect means with which the new rubber production process could be transferred to industry.

Comprised of employees with a wide range of expertise in IP and technology marketing in a myriad of industries, the TLO consists of three groups: the IP Management Group (IPM), the IP Business Group (IPB), and the IP Policy Group (IPP). Through these groups, the TLO handles all IP related issues (such as patent applications), identifies NSTDA technologies with commercial potential, finds qualified licensing partners, and develops and manages NSTDA policies for the creation, protection and exploitation of IP.


Examples of semi-finished rubber in smoke sheets and rubber blocks (Photo: MTEC)

Benefit sharing is also important to NSTDA, and as such researchers at NSTDA organizations (such as MTEC) involved in new technologies brought to the market receive 70% of all income up to a threshold of 1 million Thai Baht (approximately US$30,000). After this threshold is reached, researchers receive 30% of any additional income. In the case that the research was funded by NSTDA but R&D was conducted at another organization, NSTDA receives 21% while the researcher's organization receives 64%.

Regardless of where the R&D takes place, in order to offset operating costs the TLO receives 15% of total revenue, calculated from both up-front and royalty payments. This creates opportunities beyond the TLOs activities of securing and commercializing NSTDA research. In the long term, it allows the TLO to provide commercial services to any outside organization or company on a fee basis. As it develops its capabilities, the TLO envisions that it will be able to create technology portfolios and commercialization strategies for R&D performed by a number of centers domestically and internationally.

Reaching the Market

The first licensing agreement for the natural rubber sludge process was entered into with the company that suggested the idea for recovering rubber from sludge instead of skim. Because of its involvement early on, the company was granted a lower initial licensing fee. Furthermore, because of the difficulty involved in monitoring the usage and sales of products resulting from this technology, the company was not required to pay any royalties. In addition, a provision in the licensing agreement stated that the TLO would only license the technology to a maximum of five rubber producers during the first three years.

By 2014, the technology was commercialized through licensing agreements with four companies, with more on the horizon. Because of the competitive nature of the worldwide rubber industry, the TLO has only entered into licensing agreements with Thai companies. Once these agreements expire, the TLO will review this strategy to determine if the process can also be successfully commercialized in neighboring rubber-producing countries such as India, Indonesia and Malaysia.

Going Forward

Because of the nature of the process, it can be difficult to concretely gauge its commercial success. Although there is no clear way to determine how much rubber was sold as a direct result of using the technology, by 2014, through licensing agreements it was commercialized with four of Thailand's largest rubber producers which have over 50% market share. The technology has also clearly improved the financial health of the licensees, as they are able to increase their production output without any additional equipment or costs. Furthermore, in 2012 the research teams that developed the process were recognized for their invention at the Seoul International Invention Fair 2012, in the Republic of Korea. Implementing this technology has given the Thai rubber industry an important boost, and future potential commercialization abroad has the chance to strengthen the international presence of NSTDA while bringing in revenue through licensing, which can be used to develop further innovations.

From Sludge to Profit

In countries such as Thailand, the gap between the laboratory and commercialization can be considerable. However, by leveraging multiple resources including strong IP policies, technology transfer, and trade secrets, NSTDA was able to facilitate the transformation of the sludge rubber recovery technology from the laboratory to the commercial sector. Commercialization of the technology has enabled companies to turn waste into profit while protecting the environment and providing safer working conditions.