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MIT technology insider

FROM THE EDITORS OF TECHNOLOGY REVIEW

SPINOFF SPOTLIGHT

Cracking the Energy Problem

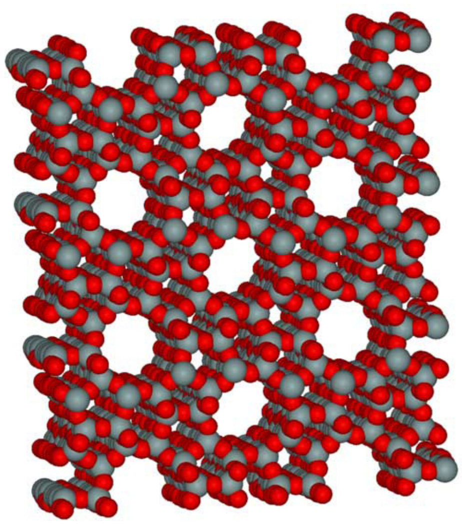
Rive Technology's nano engineered catalysts make the process of refining petroleum more efficient

With all the talk these days of wind and solar power, plug-in hybrids, and cellulosic ethanol, not many people consider petroleum when they think of high-tech approaches to energy. But MIT spinoff Rive Technology says that it has a method to make oil refineries more efficient, getting more high-quality fuel out of crude oil and bridging the gap to alternative fuels.

"[Our technology] enables us to make more gasoline and diesel fuel per barrel of crude," says Rive CEO Larry Evans. "Improved yield of just a few percent per barrel of crude, when you consider the amount of crude that gets processed every day, is significant."

To turn crude oil into gasoline and other fuels—including diesel, jet fuel, and kerosene—refineries must "crack" it, breaking the long chains of the hydrocarbon molecules into shorter molecules with more desirable properties. One common cracking method is to heat the crude to high temperatures and introduce catalysts that promote the breaking of molecular bonds. The catalysts used most often by refineries are zeolites, crystals made up of silicon, oxygen, and aluminum atoms. The zeolites are studded with small pores, and when hydrocarbons enter the pores, they split into smaller molecules.

The problem with the process is that the openings of the pores are small—typically about 0.7 nanometers in diameter. Many of the hydrocarbon molecules in the crude are larger than that and can't enter the pores to be cracked. But Javier García Martinez, who cofounded Rive with Evans, developed a method to make the pores larger.



ZEOLITE IMAGE: WIKIPEDIA

In 2002, García Martinez, who heads the Molecular Nanotechnology Laboratory at the University of Alicante, in Spain, was working as a postdoctoral fellow in MIT's Nanostructured Materials Research Laboratory under Jackie Ying, the Saint Laurent Professor of Chemical Engineering. García Martinez synthesized zeolites by mixing their constituents into an alkaline solution and adding a surfactant, a soap-like material. The surfactant creates bubbles that the zeolites form around. The surfactant is then burned off, leaving behind zeolites with pores that have openings from two to five nanometers in diameter. Tweaking the chemistry of the surfactant lets García Martinez alter the size of the pores.

With openings that large, a much higher proportion of the hydrocarbons can get into the pores. García Martinez can't say what proportion exactly, partly because it depends on the initial quality of the crude oil. Evans says that the company will have a better idea of just what kind of yield it can get once it's done some testing in a new 929-square-meter pilot plant that it's building near Princeton, NJ.

The larger pore openings also let the hydrocarbons escape the zeolites more easily. That's important to avoid "overcracking," in which the hydrocarbons continue to break down into very short chains, producing lighter, less valuable gases. One major by-product of refining petroleum is coke, a solid residue that can be used as fuel but that is less desirable than gasoline. Rive's catalyst reduces the percentage of crude that becomes coke. It also helps cut down on the production of so-called aromatics, such as benzene, that contribute to pollution.

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Rive calls itself a clean-energy company; Evans says that's justified because getting more usable products out of a barrel of crude oil should help lessen the demand for crude. The more efficient process also reduces the amount of energy used by refineries. And as oil supplies are depleted, more of what oil companies exhume is heavier crude that requires more processing, making the increased efficiency of Rive's process even more valuable.

Creating these new zeolites, which the company has named RiveCat, shouldn't cost the catalyst industry much, because adding the surfactant is the only change in the production process of the zeolites. "We do not expect to make the process much more complicated," García Martinez says. "This is just one simple additional step in the production stage."

Rive's plan is to partner with existing catalyst makers, such as BASF or W.R. Grace, and license the zeolite recipe to them; these companies would in turn sell the finished product to refineries. Before that can happen, Rive must optimize the formulation of the catalyst, which is one of the issues that the Princeton facility is working on. The zeolites, which Evans says have a consistency similar to that of confectioners' sugar, must be mixed with clay and other materials to form pellets, much the way that drugs have their active ingredients mixed with other materials to manufacture pills.

Cracking crude is only Rive's first project. Zeolites come in about 120 different crystalline forms, each with its own properties, and García Martinez can select the pore size for any of them. That ability opens up their use for processing other sources of fossil fuel, such as tar sands, which contain extremely dense petroleum. And as researchers perfect new sources of hydrocarbons, such as biodiesel produced by algae, the various forms of catalyst can refine those as well. They also offer a new tool for refining fine petrochemicals, a long list of petroleum-derived products that go into making plastics, lubricants, and other chemicals. "This is really a platform technology," García Martinez says.

The zeolites could even be used to purify air or water, he says. A lot of products, from car engines to paint thinners, generate volatile organic compounds, a component of air pollution. Passing an airstream through zeolites with the right pore sizes would allow the crystals to trap the compounds, cleaning the air. Current zeolites have pore openings too small to capture the compounds.

In 2004, García Martinez teamed up with Andrew Dougherty, who earned his MBA from MIT's Sloan School of Management in 2001, to create a business plan based on the zeolite technology, and they entered the then $50K Entrepreneurship Competition. They didn't win, but Dougherty was working at Aspen Technology, a company that makes software to optimize process manufacturing. Evans, who was a chemical-engineering professor at MIT from 1962 to 1990, had founded Aspen based on his work at MIT, and served as CEO there until 2002.

Evans and García Martinez got together and founded Rive—whose name, pronounced "reeve," is a verb that means to split or break apart—later in 2004; the company now has an exclusive license to the technology from MIT. Based in Cambridge, MA, Rive launched with a $1.2 million seed round of financing. It has since raised two rounds of venture financing, bringing its total funding to over $22 million. Evans says that the company may look for another round in 2010. Given the economy, he's happy to have closed the latest round last August and to have plenty of money on hand for the research and development phase.

Evans says that he expects the first commercial applications of the zeolites will be ready sometime in 2011. Rive employs 18 people and may add a couple to that number by midyear.

Tim Woodward, managing director of venture-capital firm Nth Power, in San Francisco, says that Rive's technology could improve the yield of crude oil by 8 to 10 percent. (Nth Power is one of the primary venture investors in Rive.) Since the oil-refining industry has been around for so long, yield improvements of 0.5 to 1 percent are usually enough to get it to adopt a new technology, Woodward says. That makes an improvement of several percentage points worth getting excited over.

And even with the movement toward electric cars, vehicles—even hybrids—are likely to be using some form of gasoline for the next 20 years or more, so technology that goes into oil refineries will continue to be valuable. "We're going to see transportation fuels in the global economy for many, many years," Woodward predicts.

IN BRIEF

COMPANY
Rive Technology

CEO
Larry Evans

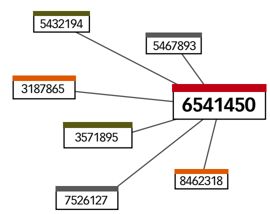
CONTACT
www.rivetechnology.com

MAJOR PRODUCT
Engineered catalysts for oil refining

FUNDING
More than $10 million

PATENT STRENGTH
Core protection

TIME TO MARKET
One to three years



PATENT MAP
For a graphical analysis of Rive Technology's patent position, go to www.ipvisioninc.com/techinsider/02/09

Therapeutic Alchemy

The good news for patients with hard-to-treat diseases is that researchers are discovering more and more about which drugs work together and how important the timing of each dose can be. The bad news is that, as a result, patients are faced with ever more complex pill schedules, and pharmaceutical companies must find ways to create pills that have accurate time-release mechanisms. Kimberly Hamad-Schifferli, an assistant professor of mechanical engineering, may have a novel solution: gold nanotubes of different shapes, each form filled with a different therapeutic, that release their payload when irradiated with lasers.

"Different-size rods release at different wavelengths of light," Hamad-Schifferli says. She and her colleagues are developing a system that takes advantage of this to provide active control over the release of multiple drugs. So far, the system has only been proved in test tubes, and issues such as a delivery system and a way to address gold's potential cellular toxicity must still be worked out. But Hamad-Schifferli and her colleagues believe that it could be used for very precise multidrug treatments. Against cancer, for example, one drug could be used to kill a tumor, and a second one used to prevent drug resistance. "It's a way of delivering drugs and controlling which one is released, how much, and when," she says.

Predicting Stent Success

To help avert a heart attack, or prevent one from recurring, cardiologists often choose to place tiny, man-made tubes called stents into previously clogged arteries to keep them open and blood flowing through. But these stents, some of which also release a steady stream of drugs, can paradoxically cause blood clots and hence heart attacks. Despite a wide variety of stents and years of research, surgeons still have a hard time knowing which particular stent might work best in different situations. Now health-sciences and technology professor Elazar Edelman and his colleagues have created a sophisticated computer model that allows them to predict which kinds of stents will be more or less likely to cause life-threatening side effects.

Edelman's modeling technique is the first to show that the design of the stent is even more important when there's a drug involved, and that much depends on blood flow around the device. "We've provided a tool for device makers and regulatory agencies to test these complex devices and evaluate the importance of specific changes without having to take devices into the clinic," Edelman says.

Metallic Solutions

Glass is not always clear and fragile. Chemically speaking, glass can be any solid with the chaotic, noncrystalline molecular composition of a liquid. In some instances, it can even be made from metals—an exotic class of materials that have both inherent springiness (sports-equipment manufacturers can use it for golf clubs and tennis rackets) and malleable magnetism (energy suppliers must have transformer cores that are magnetically "soft," allowing for magnetic polarity to change easily with alternating current). Unfortunately, not only are metallic-glass alloys notoriously difficult to make, but researchers have known of only a few different types, all of which have resisted analysis.

Now new research by materials-science and engineering professor Carl Thompson and his collaborators at the National University of Singapore describes a way to systematically find and analyze the most promising metallic-glass candidates from among dozens of metal alloys. "We found a way of doing surveys to find compositions that easily form glass," says Thompson. His team's technique also begins to help researchers' quest to understand why certain alloys easily form glass.

Catching Waves

Ocean waves hold a tremendous amount of energy, but capturing that power has proved a difficult task. Civil- and environmental-engineering professor Chiang Mei has been working on the problem since the gas crisis of the 1970s. Now, in a new collaboration with colleagues at the Technical University of Lisbon, in Portugal, Mei is working to optimize and implement a pilot device that he and his team believe has the potential to capture significantly more wave energy than do existing systems.

Most designs in use today are made to take advantage of ocean currents of a very specific range of sizes and frequencies. But nature is rarely so predictable, and wave size and rate can vary to huge degrees on the open sea. To capitalize on all wave sizes and frequencies, Mei and his collaborators are working to predict how a coastline's shape affects energy-capture efficiency. Mei's calculations also showed his Portuguese colleagues that the device they're using, a cylindrical chamber with a turbine on top, could be more efficient if it were bigger: when waves compress air inside the chamber, that compression provides additional energy. The larger the chamber, the more energy the device produces.

NEWS LINKS

A better way to pinpoint underground oil reserves
web.mit.edu/newsoffice/2009/oil-recovery-0116.html

DUSP's Briggs joins Obama administration
web.mit.edu/newsoffice/2009/briggs-0120.html

Burgeoning field of neurotech spawns brainy businesses
web.mit.edu/newsoffice/2009/neurotechnology-0129.html

Surprising find could lead to better manufacturing options for cancer-fighting antibodies
web.mit.edu/newsoffice/2008/antibodies-1222.html

MULTIMEDIA LINKS

The Army's Remote-Controlled Beetle
www.technologyreview.com/video/?vid=217

Science Policy and the Obama Administration: Advice to a New President
mitworld.mit.edu/video/639

Sustainability at MIT: Greening MIT's Campus and Beyond
techtv.mit.edu/videos/1706-sustainability-at-mit-greening-mits-campus-and-beyond

Computing Emotion

The Affective Computing Research Group develops tools that may help people with autism communicate emotion

Being misunderstood is a daily frustration for someone living with autism. For example, in a classroom setting, a student may appear calm and attentive, but, unbeknownst to the teacher, may experience escalating anxiety that she doesn't know how to express. If the teacher calls on the student for an answer, it may trigger an outburst or a meltdown that, from the teacher's perspective, seems to come out of the blue.

Rosalind Picard, director of the Media Lab's Affective Computing Research Group, envisions a small, wearable band that fastens around the student's wrist and monitors physiological signs such as heart rate and perspiration. The wristband would transmit this information wirelessly to a device like an iPod or a PDA that the teacher could check periodically. If the student's heart rate sped up, the teacher could quietly go over and calm her down, averting a meltdown.

Picard and her students are developing just such a system, which she sees less as a medical device and more as a communication tool to allow people with autism to convey their emotional states to those they trust. She also wants to give the user complete control over the type of information transmitted. For instance, a person may have the option of passing along her actual emotional state, or she may choose to manipulate the information to make herself appear less agitated than she is. "A measure of privacy and control is being able to fool people when you want," says Picard. "So we're kind of wrestling with, what kind of control do they want? But at the same time, we want to know that the system can be extremely accurate if that is the goal."

Currently, the team is testing several prototypes—small wristbands outfitted with various sensors and a wireless transmitter, along with a handheld device that receives and visualizes the data. In exercises within the lab, members wearing the wristbands were able to wirelessly transmit their heart rate to the handheld device, which displays the data on a screen, much like an echocardiogram, with peaks along a line that signify heartbeat.

Picard plans to integrate a measure of data control into future versions of the system. For now, the group is working on improving the readability of the device's display. For example, some people with autism are hyperaware of flicker, and blips on a screen may trigger an adverse reaction. The team is looking into different ways to present information in a way that is both accurate and comfortable for the user. Eventually, Picard hopes that the system can be used to continuously monitor the physiological, and hence emotional, states of autistics in day-to-day life.

"What we have to do now is to get data from people as they go about their daily life," says Picard. "Because if you bring them into a doctor's office for a few minutes, and measure and try to characterize them, it's kind of like saying we can characterize Beethoven's Ninth by measuring a few bars in the middle somewhere. It's just not telling you what's really going on."

The group is using similar technology to study physiological signs of autism during early development. In collaboration with physicians in the Boston medical community, Picard is starting to measure variables such as heart rate and perspiration in infants born into families with a history of autism. "These children are at elevated risk of getting a diagnosis themselves," says Picard. "And so we're going to look at how their physiological systems come on line, how the patterns change from birth on up to 30 months, and see if there are differences associated with the development of autism."

In these studies, Picard's group has placed sensors and wireless transmitters in padded socks and shoes, which parents can easily slip on their infants' feet. The idea, Picard says, is to precisely and continuously measure physiological signs over a long period of time. "Autism is described and diagnosed by its behaviors, yet nobody really understands what gives rise to them," says Picard. "We have an opportunity to measure what precedes those behaviors, and as we look for things we can measure, we can make precise a lot of the issues that are very serious in autism."

Picard's collaborator, Martha Herbert, a pediatric neurologist at Massachusetts General Hospital, will soon start recruiting up to 30 newborns for a three-year study. Herbert says that the ultimate goal of the study is to identify physiological signs of autistic behavior before they occur.

"We don't know how much of the behavioral outbursts and problems that are difficult for people to handle are preceded by some kind of stress response," says Herbert. "If you can catch those early, you can help in the day-to-day management and develop an early-warning system for problems that may arise."

IN BRIEF

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Affective Computing Research Group

DIRECTOR
Rosalind Picard

CONTACT
affect.media.mit.edu/

MAJOR PROJECTS
Engineering wearable affective technology

Developing machine-learning algorithms

Developing facial-recognition tools

Software Sale

A company whose software analyzes the performance of computer networks to optimize them and to detect possible security breaches has been bought for $25 million in cash. Riverbed Technology of San Francisco said that it would acquire Mazu Networks, of Cambridge, MA. Riverbed will pay up to an additional $22 million based on sales targets. The deal is expected to close by the end of the first quarter of 2009.

Mazu's Profiler software analyzes the behavior of computer networks in real time, keeping tabs on which machines are communicating with one another, which servers and routers are carrying the data, and what kind of protocols they're running. The software can provide alerts to any suspicious activity that might indicate a security breach. Riverbed, which provides data services over wide-area networks, says that the software can also analyze how well a network is performing and suggest ways to optimize it.

Mazu was founded in 2000 by Max Poletto, who earned his PhD in computer science from MIT in 1999, and Eddie Kohler, whose 2000 PhD thesis at MIT evolved into the Mazu platform. Kohler serves as chief scientist, and Poletto is technology strategist.

www.mazunetworks.com

Tagged Out

An MIT spinoff founded to make wireless electronic name tags for business meetings has reportedly filed for bankruptcy. The company, nTag, of Boston, filed in the city's federal court on December 26, according to the *Boston Business Journal*. Citing the company's Chicago-based competitor Spotme as its source, the website for *MeetingNews* magazine said that nTag filed a Voluntary Petition for Liquidation under Chapter 7 and dismissed its employees on December 31.

The company's website does not reflect any changes, but nTag's two prime backers, Pilot House Ventures Group and Sevin Rosen Funds, do not list it among the companies in their portfolios. Attempts to reach nTag were unsuccessful.

The company was founded in 2002 by Rick Borovoy, who earned a master's degree and a PhD from the Media Lab and became nTag's chief technology officer. The technology is based on work that he did in the lab of Mitchel Resnick, associate professor of media arts and science. The company had raised about $23 million in three rounds of venture financing and had 48 employees in 2007, with plans to grow to 75 by the end of 2008.

www.ntag.com

Form a Company

A trio of researchers from the Broad Institute of Harvard and MIT has founded a company that will use its technology and emerging genomic information to find new targets for anticancer drugs. Todd Golub, director of the Broad Cancer Program; Michael Foley, director of the Chemical Biology Platform; and Stuart Schreiber, director of Chemical Biology, founded Forma Therapeutics in January. Joining them were Steven Tregay, who will be president and CEO, and Nikolai Kley, who will be head of drug discovery.

The company has $25 million in funding from Novartis and BioOne Capital of Singapore. It also has a licensing agreement with Novartis for new drugs—a deal with the potential to be worth over $200 million. Forma will look for new ways of treating cancer, such as interfering with protein-protein interactions or with the functional activity of transcription factors, which are essential to translating the genetic information in DNA into proteins. Forma's technology includes a cell-based screening platform that can test discrete targets within cells as well as profile a whole genome. The company also uses computational and structural-biology techniques to discover new drugs. Forma is based in Cambridge, MA, with research operations in Connecticut, Singapore, and Beijing.

www.formatherapeutics.com

Revenue Stream

A company that makes software to analyze streaming data in real time has closed a Series D round of financing. StreamBase Systems, of Lexington, MA, raised $6.24 million, bringing its total funding to $47 million. The round included existing investors Accel Partners, Bessemer Venture Partners, Highland Capital Partners, and In-Q-Tel.

StreamBase makes software for processing complex events. For instance, it can allow hedge funds and investment banks to analyze market data as it is delivered, allowing them to test predictions of market performance by comparing stored data with current activity. The software also allows the government, military, and other industries to quickly process complex streams of data.

StreamBase was cofounded in 2003 by Michael Stonebraker, adjunct professor of computer science and electrical engineering at MIT, and Richard Tibbetts, who earned his master's degree in engineering in Stonebraker's lab. Stonebraker developed the software and had served as the company's chief technology officer. Tibbetts, who had been the company's chief architect, took over as chief technology officer last month. Stonebraker serves on StreamBase's technical advisory board.

www.streambase.com

DATEBOOK

February 11, 6:00 P.M.–7:30 P.M.
MIT Energy Club Lecture Series: Future of Energy Panel
Building E51-335, MIT
events.mit.edu/event.html?id=9304176

February 16–21, 1:00 P.M.–4:00 P.M.
National Engineering Week Activities
MIT Museum
events.mit.edu/event.html?id=10004579

February 25, 6:00 P.M.–8:30 P.M.
Paint It Black: Avoiding the Financial Beast of Burden in 2009 and Beyond
Wong Auditorium, MIT
enterpriseforum.mit.edu/network/broadcasts/200902mit/index.html

March 2–3
EmTech India 2009
Delhi, India
www.emtechindia.in

March 6–7
2009 MIT Energy Conference: Accelerating Change in Global Energy
Kendall Square Marriott, Cambridge, MA
www.mitenergyconference.com/

See www.technologyreview.com/events/ for more technology events.

Grants and Fellowships 2008

Each year, MIT faculty and centers receive support for research from government agencies, corporations, and private institutions. Here is a sampling of the grants and fellowships that have been awarded to MIT and its faculty over the past year.

RECIPIENT	FUNDER	AWARD	PROJECT SUPPORTED
Broad Institute of Harvard and MIT	U.S. National Institutes of Health	$15 million over five years	Establishment of a Reference Epigenome Mapping Center to study the biochemical interactions that activate and deactivate genes
Center for Materials Science and Engineering	U.S. National Science Foundation	$19.2 million over six years	Study of the design and properties of various nanomaterials
Isaac Chuang, associate professor, engineering and physics	U.S. National Science Foundation	$3 million	Establishment of the Interdisciplinary Quantum Information Science and Engineering graduate training program
John Gabrieli, Grover Hermann Professor in Health Sciences and Technology and Cognitive Neuroscience; Nancy Kanwisher, Ellen Swallow Richards Professor of Cognitive Neuroscience	Ellison Medical Foundation	$8.5 million	Development of scanning tools for children's brains to help pinpoint the origins of autism and dyslexia
Ahmed F. Ghoniem, Ronald C. Crane (1972) Professor of Mechanical Engineering	King Abdullah University of Science and Technology (Saudi Arabia)	$10 million over five years	Development of high-efficiency, low-carbon energy systems
Scott Manalis, associate professor, biological and mechanical engineering	U.S. National Institutes of Health	Exceptional, Unconventional Research Enabling Knowledge Acceleration (EUREKA) grant, $800,000 over four years	Development of a mass sensing technology that can measure the size of cells
Daniel Nocera, Henry Dreyfus Professor of Energy and professor of chemistry; Christopher Cummins and Jonas Peters, professors of chemistry	U.S. National Science Foundation's Chemical Bonding Center	$20 million over five years	Funding of the Powering the Planet Alliance, with California Institute of Technology, which is developing nanoscale catalysts to make hydrogen fuel from sunlight and water
Christine Ortiz, associate professor, materials science and engineering	U.S. Department of Defense	National Security Science and Engineering Faculty Fellowship, $3 million over five years	Study of engineering designs for protective defense applications
Aviv Regev, assistant professor, biology	U.S. National Institutes of Health	Pioneer Award, $2.5 million over five years	Research into how the regulatory networks that control cell function change over time in development, disease, and evolution
Alice Ting, Pfizer-Laubach Career Development Associate Professor of Chemistry	U.S. National Institutes of Health	Pioneer Award, $2.5 million over five years	Development of new technologies to image and study proteins in living cells
Alexander van Oudenaarden, W.M. Keck Career Development Professor in Biomedical Engineering and professor of physics	U.S. National Institutes of Health	Pioneer Award, $2.5 million over five years	Exploration of the role of random variables in gene expression during cellular development and specialization