SDSU RESEARCH NEWS

SOUTH DAKOTA STATE UNIVERSITY

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Cutline: Plant science researchers Jose Gonzalez, left, and Arvid Boe, right, are studying prairie cordgrass as a potential biofuels crop as one aspect of a major Sun Grant award to fund research at South Dakota State University.

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Sun Grant biofuels project looks at feedstocks, processing

BROOKINGS, S.D. — SDSU scientists are renewing ties with the engineers who helped SDSU launch today's corn-based ethanol industry in the late 1970s — only this time the focus is cellulosic ethanol.

It's part of a new South Dakota State University project that will focus $1.8 million of research funding on biofuels feedstocks and processing, partly through important partnerships with private industry.

SDSU researchers have landed one of five grants approved recently through the SDSU-based North Central Sun Grant Center. Project director William Gibbons leads a team that will work to develop sustainable feedstocks and next-generation processing technologies for biofuels production.

The four-year project will receive a total of $1 million in funding through the Sun Grant Initiative, plus $100,000 annually from each of two companies, for a total match of $800,000 from private industry.

SDSU Vice President for Research Kevin Kephart noted that SDSU competed with about 60 other proposals that were submitted from every state in the North Central Region.

"With only 10 percent of the projects receiving awards, the program was very competitive and only the very best ideas could be supported. This project is a good demonstration of the strengths SDSU has developed in biofuels research," Kephart said.

The two companies working with SDSU on the project are Brookings-based VeraSun Energy Corp. and ICM Inc. of Colwich, Kan.

Gibbons said it's worth noting that SDSU already has old ties to President and CEO David Vander Griend and his brother, process engineer Dennis Vander Griend, of ICM Inc.

Dennis Vander Griend was an SDSU student in 1978 when he and his brother, Dave, a skilled welder, built the first licensed fuel-alcohol still. The U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives issued them the first commercial fuel ethanol manufacturing permit for their two-column, 190-

proof distillation equipment. That first set of distillation columns was known as “Old Blue” because of its bright paint.

That work was done in cooperation with SDSU microbiology professor Paul Middaugh, giving SDSU and the Vander Griend brothers legitimate claims to having helped launch today’s corn ethanol industry.

Now the Vander Griends and ICM Inc. are preparing for a new generation of ethanol plants that will be designed to process cellulose.

“For nearly 30 years, my brother Dennis and I have been grateful for the strong ties we’ve forged with SDSU,” ICM President and CEO Dave Vander Griend said. “We could not have made ‘Old Blue’ a reality without the support of Dr. Middaugh and others. Because of our relationship over the years with SDSU, we understand the importance of innovation – and we’ve aggressively applied it at ICM. We’re very excited to work with SDSU again, and our collaboration with VeraSun on this project shows how passionate the academic community and industry leaders are when it comes to innovation.”

Similarly, Brookings-based VeraSun, a leading producer of corn-based ethanol, has strong ties to SDSU through its founder and CEO Don Endres, an SDSU alumnus. VeraSun, founded in 2001, worked with ICM to design and build the industry’s first 100 million-gallon-per-year capacity ethanol biorefinery near Aurora, S.D. It began production in 2003. VeraSun’s expertise in large-scale ethanol production will help bring this potential next-generation design to market.

”We are very excited and optimistic about the prospects for both next-generation feedstocks and technologies for the ethanol industry,” said Don Endres, VeraSun chairman, CEO and president. “At VeraSun, we believe corn-based ethanol will continue to play an integral role in the fuel stream for years to come, and as additional technologies are proven out, existing infrastructure at large-scale plants can be leveraged for efficient commercialization.”

Gibbons said the SDSU project is an integrated effort between university researchers and industrial collaborators. “We’ll not only be developing innovative technologies in three key areas — feedstock, pretreatment, and conversion — but will simultaneously address the cost and energy issues critical for commercialization.”

Mike Twedt of SDSU’s Department of Mechanical Engineering will lead the team in developing the cost, energy, and material balances for these new technologies.

Gibbons said the SDSU project is in three stages.

Four investigators in SDSU’s Department of Plant Science — assistant professor Jose Gonzalez, professor Arvid Boe, professor Vance Owens, and assistant professor Jeff Stein — are looking at prairie cordgrass as a potential biomass crop. Prairie cordgrass produces higher yields than other warm season biomass crops because it breaks dormancy earlier and stays active longer in the fall. The research team will select cultivars from throughout the state and region, gather yield and compositional data, and evaluate the genetic structure of the plant to develop a gene linkage map. They want to identify the genes responsible

for high yields and other traits. They will also look at the vulnerability of prairie cordgrass to plant disease pressures.

The second component is developing pretreatment processes for prairie cordgrass and other feedstocks such as corn stover. Professor Jim Julson and professor Kasiviswanathan Muthukumarappan in SDSU's Department of Agricultural and Biosystems Engineering, and assistant professor Douglas Raynie in the Department of Chemistry/Biochemistry are involved in that part of the project.

They will evaluate various solvents and processing strategies to break down biomass into its components – lignin, cellulose, and hemicellulose.

"Lignin is the biological 'glue' that holds everything together and protects the fibers of cellulose and hemicellulose. These fibers are composed of sugar chains that we need to get access to," Gibbons explained. "We then use enzymes to chop those chains up into sugars, and then we use organisms to ferment those sugars into useful products."

The last aspect of the project seeks to develop a single-step conversion process. Scientists want to develop a reactor that will allow the conversion of polymers to sugars and the fermentation process to occur at the same time in the same reactor in a high-solids environment.

Professor Bill Gibbons and professor Tom West in SDSU's Department of Biology/Microbiology are involved in that aspect of the work along with professor Basil Dalaly in the Department of Nutrition, Food Science and Hospitality.

Gibbons explained that one of the challenges of processing biomass is that so much water must be added that it dilutes the concentration of sugars. A processor might achieve only 4 to 5 percent ethanol in a fermented biomass mixture compared to the 15 to 18 percent ethanol that the corn ethanol industry is able to achieve. Consequently, existing processes for converting biomass would require more energy, plus bigger plants in order to generate as much ethanol as corn-based plants.

"Our idea is to develop a high-solids reactor where you would add a minimum amount of water and the reactions would occur in a thin film of water on the surface of the substrate," Gibbons said.

That part of the project also would try to develop yeasts that would function well at higher temperatures. Most enzymes operate optimally at 50 degrees Celsius, while yeast work best at 30 degrees Celsius.

"We need to find yeast that are able to tolerate higher temperatures and still produce ethanol efficiently," Gibbons said.

In addition, that segment of the project examines ways to immobilize and re-use enzymes to try to keep down processing costs.

Gibbons said VeraSun and ICM scientists and engineers will provide critical input regarding process technology, economics, and energy issues. They'll help identify potential trouble spots that need addressing before the research can move into the commercial marketplace.

"In a sense, this new project brings us full circle," Gibbons said. "The Vander Griends built our original distillation columns, and we have renewed this association with ICM and expanded our relationship with VeraSun to develop this new process for cellulosic ethanol."

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