Bacteria are key to 'green' plastics, drugs

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Trials have begun in Kansas on a "green" production method for succinate, a key ingredient of many plastics, drugs, solvents and food additives. Developed at Rice University, the technology uses a genetically modified form of the bacteria E. coli that metabolizes glucose and produces almost pure succinate.

Finding "green" methods to make key chemical intermediates like succinate is a high priority for the chemical industry. Green technologies use renewable resources like agricultural crops rather than non-renewable fossil fuels, and they produce less waste.

"Succinate is a high-priority chemical that the U.S. Department of Energy has targeted for biosynthesis," said process co-developer George Bennett, professor and chair of the department of biochemistry and cell biology at Rice. "One reason for this is succinate's broad utility -- it can be used to make everything from non-corrosive airport deicers and non-toxic solvents to plastics, drugs and food additives. Succinate's also a priority because some bacteria make it naturally, so we have a metabolic starting place for large-scale fermentation."

The centerpiece of Rice's succinate technology is a mutant form of E. coli that makes succinate as it's only metabolic byproduct. The bug contains more than a half-dozen genetic modifications. It was created over the past four years by the research groups of Bennett and collaborator Ka-Yiu San, the E.D. Butcher Professor of Bioengineering and professor of chemical and biomolecular engineering.

The technology is taking its first step from the lab to the marketplace this month with the start of industrial scale-up efforts in Kansas. These efforts resulted from an $80,000 award from the Small Business Innovation Research (SBIR) program of the U.S. Department of Agriculture. Bennett and San are working with Manhattan, Kansas-based AgRenew Inc., which just began testing how to use farm-grown products like grain sorghum as feedstocks for the succinate-producing bacteria.

"We are very pleased for the opportunity to continue our collaboration with our colleagues from Rice and work to further the development and commercialization of the succinate technology," said Praveen Vadlani, principal research scientist for AgRenew. "We are excited about the prospects this project offers to meet a market need for the benefit of both institutions and American agriculture itself. We also appreciate the support of the U.S. Department of Agriculture for this work to create another high-value product from agriculture."

Many researchers are trying to create a succinate-producing bacterial mutant. They use biotechnology to either insert genes that boost succinate production or delete genes that interfere with it. The goal is to maximize the rate -- the speed of the conversion -- and the yield -- the amount of succinate produced per pound of glucose converted.

Bennett and San's bug -- known only by the designation SBS550MG -- contains an ingenious bit of metabolic engineering that allows it to produce succinate in two different ways. One method exists in wild strains of E. coli and has been modified with the deletion of four genes, each of which codes for a protein that interferes with or limits E. coli's ability to turn glucose into succinate. Bennett and San activated a second pathway and stimulated production by adding genes from lactococcus bacteria and sorghum.

Each genetic pathway metabolizes glucose and produces succinate via dissimilar chemical reactions. That means the two don't compete or interfere with one another. In fact, Bennett and San designed the paths to be complimentary, but even so, they were gratified to see how well the process worked once both paths were put in place.

"Our experiments in the laboratory have produced near-maximum yields, with almost all the glucose being converted into succinate," said San. "The implementation was actually easier than we expected because the cells did the balancing themselves."

Bennett and San said they will continue to refine the organism to produce higher yields and fewer byproducts.

Source: Rice University

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