Environmentally friendly maleate production using genetically modified microorganisms

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Video Abstract

Keywords: maleate, maleic acid, E. coli, bacteria, production, synthesis, dicarboxylic acid, microbial, microorganism, polyketide biosynthesis, benzene ring cleavage, metabolic engineering, bioengineering, genetic engineering, genetic modification, chorismate, gentistate, fermentation, Riken, Nature Communications

Posted Date: September 20th, 2019

DOI: <https://doi.org/10.21203/rs.2.15179/v1>

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Abstract

Researchers at the RIKEN Center for Sustainable Resource Science have developed a new genetic pathway that can be used to co-opt *E. coli* bacteria to produce maleate, one of the most important industrial chemicals in use today. A chief component in the coatings of substances like nylon and galvanized steel and an important stabilizing agent in pharmaceuticals, maleate is typically produced through harsh treatments of crude oil. But by using genetically engineered microorganisms to produce maleate, the researchers have developed a much more sustainable approach. Maleate is the end product of a complex chemical reaction. Bacteria don't normally come equipped with machinery to power this reaction, so the researchers had to design a ground-up approach before they could start harvesting maleate. This required careful analysis of the intermediates needed for maleate synthesis and the identification of genes that could help *E. coli* make each of these molecules. The team started with a cell line they'd previously engineered to convert glucose into 3HBA, a key molecule needed to jumpstart the maleate reaction. Glucose is an attractive starting material due to its widespread availability, low cost, and renewable nature. Using the cell line as a foundation, the researchers popped in different genes borrowed from other organisms known to convert 3HBA into the molecules needed to fuel the reaction. Through trial and error, they isolated the genetic recipe needed to synthesize maleate. The next goal was to optimize maleate output. By fine-tuning the culture conditions for the bacteria and the number of extra genes to be put into each cell, the team drastically increased both the yield of maleate and how fast it could be produced. In the end, the researchers produced 7.1 grams of maleate per liter of starting material in less than 5 days. Scaling up these conditions for industrial applications could revolutionize how maleate is made. Although more work is needed to get to that point, the study is an important first step towards environmentally friendly maleate production. And the benefits don't end there: by tinkering with which molecules are used to initiate maleate synthesis, the researchers believe they can coax *E. coli* into producing maleate from waste materials and biomass derivatives rather than glucose. Bringing this element of reusability into the mix contributes to the United Nation's 2015 Sustainable Development Goals – particularly those for responsible consumption and production.