A path away from reliance on oil

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Biomass such as this waste from palm oil production could replace petrochemicals for making nylon. Credit: A*STAR Institute of Chemical and Engineering Sciences

The dream of replacing petrochemicals with renewable resources in the manufacture of synthetic fibers and plastics has moved a step closer. A*STAR researchers have genetically modified the bacterium Escherichia coli to produce a compound that can be converted into a base material for manufacturing nylon and other synthetic products.

"We need to reduce consumption of oil and gas and move toward more sustainable technologies," explains Sudhakar Jonnalagadda who carried

out the work with colleagues at the A*STAR Institute of Chemical and Engineering Sciences.

Production of most synthetic fibers and plastics begins with crude oil; a finite resource whose extraction and processing has significant environmental impact. The alternative sustainable route uses bacteria to make the precious starting materials from simple substances such as glucose. The glucose can be extracted from biomass which includes crops and other biological materials that can be grown to meet demand (see image).

Bacteria do not naturally produce the required products in significant quantities, so the trick is to persuade these microorganisms to become mini manufacturing plants for chemicals required by industry. One such chemical is muconic acid, which can be readily converted into adipic acid, a chemical used in huge quantities to manufacture nylon.

The A*STAR team inserted three genes into E. coli to establish the metabolic pathway that produces muconic acid. Adding these new genes, however, was the first step in a complex genetic engineering task. "A major challenge was to modify the normal E. coli pathways to divert more glucose toward our desired product," says Jonnalagadda.

He explains that the combined activity of the foreign and the native genes must be controlled to prevent the accumulation of metabolic intermediates as well as to maximize the efficiency of muconic acid production. This was achieved by using computer simulation to analyze the metabolism of the modified bacteria which helped to pinpoint the required genetic changes.

The researchers are now investigating other ways to make the production of muconic acid more efficient. Already, though, this new process produces the compound more efficiently with use of inexpensive and

less complex raw materials compared with alternative options.

"We are at the early stage," says Jonnalagadda, assessing the path from the current achievement into commercial applications. The same research route is also leading the A*STAR researchers and others worldwide to make a wide range of compounds to free the chemical manufacturing industry from its reliance on oil.

More information: Sudeshna Sengupta et al. Metabolic Engineering of a Novel Muconic Acid Biosynthesis Pathway via 4-Hydroxybenzoic Acid in Escherichia coli, *Applied and Environmental Microbiology* (2015). DOI: 10.1128/AEM.01386-15

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