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Steps to industrial scale-up of fourth generation biofuels by synthetic biology

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Abstract:

Biofuels are the current, commercial solution to mitigating dependence on fossil petroleum and are fundamental for the transition to a low carbon economy. Existing biofuels – alcohols and biodiesels – are derived from plant sugars or oils, mixed with gasoline and diesel respectively. So called "blend walls" limit the amounts of biofuels that can be added to fossil petroleum distillates. Moreover, the use of comestible sugars and vegetable oils as the precursors for biofuels diverts much needed calories from food to fuel and alters food production and markets on a global scale.

We used Synthetic Biology to design and construct artificial metabolic pathways for the production of fuel molecules that are structurally identical to fossil fuels; i.e. bio-alkanes and -alkenes of varying C-chain lengths and branching configurations. However, a number of challenges remain before such solutions can be deployed in the marketplace, notably the improvement of biomass-degrading and hydrocarbon synthesis enzymes, the identification of reliable and predictable molecular control systems and the "domestication" of bacterial hosts that are compatible with industrial fermentation.

The thermophile, Geobacillus thermoglucosidans, is a promising candidate for development as an industrial microbial host and has previously been engineered for bioethanol production. G. thermoglucosidans grows between 40 – 70 °C, can naturally degrade a variety of biomass sugars, is genetically competent and belongs to a large genus with a number of sequenced genomes.

This seminar will use G. thermoglucosidans as a model case-study to describe the challenges and opportunities of deploying new, non-model bacteria for industrial-scale biofuels production.

Production of fuel-grade alkanes in engineered bacteria: Synthetic, molecular modules (in green, blue and red) were engineered into bacteria to transform the native fatty acid pool (in black) to bio-alkanes of different sizes and chemical properties. The green module is used to generate branched products, the blue module to change the C-chain length and the red module to generate the bio-alkanes. Rectangles represent genes; circles denote metabolites.

Biography

John Love is Professor of Synthetic Biology & Director of the BioEconomy Centre at the University of Exeter. John's research uses a multidisciplinary combination of microbiology, genomic engineering and AI-guided experimentation to develop microbial systems for the industrial-scale production of 4G biofuels.