Sun, water, CO2 and algae: A recipe for biofuel?

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Credit: AI-generated image (disclaimer)

Plant-based biofuels were initially hailed as the answer to all problems posed by traditional fossil fuels. Supply is unlimited and they are also neutral to emissions harmful to the environment also. But using plants has led to other problems, which a team of European scientists hopes to get around by using aquatic organisms to create fuels from the sun, carbon dioxide (CO_2) and water.

The nine-partner team behind the EU-funded project DIRECTFUEL ('Direct biological conversion of solar energy to volatile hydrocarbon fuels by engineered cyanobacteria') believes the answer could lie in aquatic organisms. The team is developing photosynthetic microorganisms able to catalyse the conversion of solar energy and CO_2 into engine-ready fuels.

Plant biomass is definitely cleaner than fossil fuels. However, the plants used to create fuel are frequently in competition with food crops, particularly in poorer countries, while cultivation of plants for biomass can also have a detrimental impact on neighbouring agricultural land. Plants also convert solar energy relatively slowly.

The research by DIRECTFUEL's team involves three key steps: enzyme discovery and engineering, metabolic engineering of cyanobacteria (a type of micro-algae) and design of the production process.

The target fuels are non-toxic and have been shown to be compatible with combustion engines that have been slightly modified and even with normal ones.

Central to the project is the construction of biochemical pathways not existing in nature for the synthesis of ethylene, ethane and propane. The team's research has already increased understanding of the factors important for catalytic conversion by studying the mechanism of a candidate enzyme. The next step is to use enzyme engineering to program the enzymes to act on desired substrates.

Work on targeted enzyme engineering at the biosynthesis of volatile alkanes is underway, and the team is now working to engineer the metabolism of the host organisms in order to enhance CO_2 assimilation and thus increase yield.

To be able to engineer the metabolism of cyanobacteria, the researchers needed to first understand and be able to predict which modifications in the biochemical pathways will have which impact on metabolism.

To make this possible, the team is using a computational model developed by one of the DirectFuel partners. The model will also be improved and expanded during the project to boost its effectiveness in predictive engineering.

In addition, a preliminary process layout has been prepared and a laboratory-scale photo-bioreactor constructed.

Cultivation of the essential cyanobacteria can be carried out on land unsuitable for agriculture, and in enclosed containers that require no soil, thus eliminating any competition between land for food and fuel production.

It will take time before the technology developed within DIRECTFUEL is on the market, but the eventual impact is likely to be considerable in the production of carbon-based fuels and chemicals. The research has already attracted interest from petroleum gas associations.

The DIRECTFUEL project has received almost EUR 5 million in EU funding and runs from 2010 until 2014. It is coordinated by the University of Turku in Finland.

More information: www.directfuel.eu/index.html

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