Researchers use sunlight to produce chemicals and energy

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Researchers at the University of Copenhagen have discovered a natural process they describe as "reverse photosynthesis," by which the energy in solar rays breaks down plant biomass rather than building it, as is the case with photosynthesis. The sunlight is collected by chlorophyll, the same molecule used in photosynthesis. Combined with a specific enzyme, the energy of sunlight breaks down plant biomass, with possible applications in chemicals, biofuels or other products that take a long time to produce. By increasing production speed and reducing pollution, the discovery has the potential to revolutionize industrial production. The research results have now been published in *Nature Communications*.

The petrochemical industry is problematic for both environment and climate. Danish researchers based at the University of Copenhagen have now made a breakthrough with the potential to transform the way industry uses natural resources. "This is a game changer, one that could transform the industrial production of fuels and chemicals, thus serving to reduce pollution significantly," says University of Copenhagen Professor Claus Felby, who heads the research.

Faster production, decreased energy consumption and less pollution

"It has always been right beneath our noses, and yet no one has ever taken note: Photosynthesis by way of the sun doesn't just allow things to grow; the same principles can be applied to break plant matter down,

allowing the release of chemical substances. In other words, direct sunlight drives chemical processes. The immense energy in solar light can be used so that processes can take place without additional energy inputs," says Professor Claus Felby.

Postdoc David Cannella, a fellow researcher who collaborated on the discovery, says, "The discovery means that by using the sun, we can produce biofuels and biochemicals for things like plastics—faster, at lower temperatures and with enhanced energy efficiency. Some of the reactions, which currently take 24 hours, can be achieved in just 10 minutes by using the sun."

What reverse photosynthesis is all about

Researchers have discovered that sunlight multiplies the effectiveness of monooxygenases, natural enzymes also used in industrial biofuel production. "We use the term 'reverse photosynthesis' because the enzymes use atmospheric oxygen and the sun's rays to break down and transform carbon bonds in plants, among other things, instead of building plants and producing oxygen as is typically understood with photosynthesis," says postdoc Klaus Benedikt Møllers

Researchers do not yet know how widespread the process is in nature, but there are many indications that fungi and bacteria use reverse photosynthesis as a "Thor's hammer" to access sugars and nutrients in plants.

The future

Reverse photosynthesis has the potential to break down chemical bonds between carbon and hydrogen, a quality that may be applied to convert plant-sourced methane into methanol, a liquid fuel, under ambient

conditions. As a raw material, methanol is very attractive because it can be used by the petrochemicals industry and processed into fuels, materials and chemicals.

Additional research and development is required before the discovery can directly benefit society, but its potential is "one of the greatest we have seen in years," according to Professor Claus Felby.

How it works

The result can be recreated by following this recipe:

- Take a large sugar molecule to be oxidized—broken down from straw and wood, for example. (biomass)
- An enzyme called lytic polysaccharide monooxygenase, which is found in many fungi and bacteria
- Some chlorophyll containing green extract from leaves

Mix ingredients in a test tube and expose to sunlight. The biomass is then completely or partially broken down. In practice, this means that it becomes easier to break down larger sugar molecules into smaller constituents, which can then be used as clean energy in ethanol production for cars and ships, plastics, biogas, methanol and other industrial applications. Without sunlight, it would take hours or days to achieve the same transformation. The process takes only five minutes.

Provided by University of Copenhagen