**Solar Energy Conversion to Chemicals by Bacteria**

In chemical production, there are different production mechanisms that are currently used to effectively create chemicals. There are systems that take advantage of the molecular engines bacteria possess and with manipulation, they are a small factory to produce a product of interest. Atmospheric carbon dioxide, CO2, are and dangerously high levels and this detriment is only perpetuated by dependence on fossil fuel usage that continues to produce this harmful gas. There are a plethora of options available as alternatives to indirectly decrease our dependency on this source of energy such as renewable sources, such as wind, solar, and hydropower. Though development of these alternate resources provide alternatives, there is still enough of a dependency on CO­2 emitting that continues to lead to record high levels of emission. This leads to the purpose of this paper, to introduce bacteria to directly take CO2 out of the air and convert, via fixation, the gas into a usable product. This would be vital as a direct solution to the high levels of CO2 production where the purpose is to, on a large scale, recycle atmospheric CO2­ and reduce the negative effects of CO2 pollution that include ocean acidification. Looking at bacterial manipulation of CO2, bacterial metabolism often possess the ability to use energy from the sun to decrease costs of CO­­2­­ from thousands of dollars’ worth of reaction dependent upon catalysts. In recent advancements, manipulation of molecular CO­2­ fixation had led to one of the most efficient and cost effective method of reducing atmospheric CO­2.

The question that you are asking as a reader may be, “But why haven’t we used this method for CO­2 utilization sooner?!” As simple of an idea as this may sound, there are a few limitations in solar energy conversion. Of course, we have is solar technology, such as solar panels, that are able to extract quite a bit of energy from solar light but they fail to actually store the energy effectively. Much like the solar panel, there is a lot of product that is being produced from solar energy, where the panels produce enough energy for a house, in our case a bacterium can produce chemicals such CH­3COOH, acetic acid but we were the issue was the utilization of the chemical by the organism. Previous mechanisms involve a photosynthetic organism,such as *Clostridium acetobutylicum,* that produces chemicals at a low yield. This is what has led to the production a non-photosynthetic bacterium, *Moorella* (*M*.) *thermoacetica* can produce 4 equivalents fused Cysteine molecules (CySS), 2 moles of water (H2O), and 1 mole of acetic acid by utilizing two moles of CO2, 8 equivalents of Cysteine, and 8 photons of light­.

There are organisms that have the natural ability to utilize CO2. Typically there is a process that involves multiple steps, CO2 is transformed into a new chemical that is used by the organism for another pathway. The problem with these organisms is that there isn’t much scientific utilization of the product, so research has used organisms that would not use the product due to it not naturally being found within them, non-photosynthetic. In the recent advancements in microbial engineering, scientists, Kelsey Sakimoto; Andrew Wong; and Peidong Yang, were able to improve on this process in an organism called *Moorella thermoacetica* by using a hybrid system. The mechanism being utilized is the manipulation of *M. thermoacetica*, to become photosynthetic via incorporation of the nanoparticles, Cds. Cds functions as a semiconductor that allows for *M. thermoacetica* to become photosynthetic, *M. thermoacetica-Cds.* With the introduction of Cadmium (Cd2+) into the medium, *M. thermoacetica* is able to fix a sulfur to the ion to create CdS. Studies have shown Cds to be secreted as tiny, light-sensitive nanoparticles that allow for energy absorption. CdS, are useful for their ability to effectively transform energy.

The idea that is particularly vital to the success of these experiments is that *M. thermoacetica* is not typically able to use photosynthesis. Organisms that naturally fix CO2 typically produce a low yield of product. The process to make energy from *M. thermoacetica* is done by utilizing a known pathway that turn CO2 into acetic acid. Acetic acid has significant potential to be used for synthesis and extraction due to its utilization for alcohol synthesis. The key point of the Sakimoto study is that they found a method to make acetic acid in high quantity, about 90% yield. This compared to previous microbial engineered organism were about 20% is a significant increase. This system produced acetic acid as waste and is not depleted after synthesis. Acetic acid is made more effective by increasing cysteine available that the organism requires to make the product and by regulating available light levels for the photosynthetic reaction.

The Sakimoto paper gives a great introduction to the potential future of hybrid organisms and their likeliness to be used for synthesis of other molecules. As the future of microbial engineering progresses, they are effective in their ability to produce products with the low cost of starter bacteria and affordable materials like Cadmium and cysteine exhibit the cost effective manner of the process. Bioengineering is certainly one of the greenest ways to make chemicals. With continual expansion, hybrid engineering can be mixed and matched to create an important tool for chemistry that aides in the understanding of biological systems that will allow for more efficient utilization in the future.

**Works cited**:

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