Artificial photosynthesis toward better harmony with this planet

Hirokazu Kobayashi

A new technology from the Toyota Group may become a hope for modern society. Even though the technology was from the Toyota Group, it is not about car technology this time. It is about artificial photosynthesis.

Environmental issues are one of the most pressing challenges we are facing now. In environmental issues, climate change and energy issues are probably the familiar ones. Looking at climate change, changes in ecosystems and rising sea levels caused by global warming are globally concerned. As another more familiar example, global warming may worsen the damage of guerrilla rain and typhoons. On the other hand, looking at energy issues, concerns about the depletion of fossil fuels and air pollution are being actively discussed. However, issues such as the safety of nuclear power and the spread of artificial photosynthesis seem to be complicated. In this way, environmental issues need to be addressed as soon as possible, but the issues are tied up in each other and the circumstances surrounding them are extremely complex. Therefore, we must address environmental issues from a multiple and broad perspective.

The handling of carbon dioxide may be one of the common themes in many environmental issues. Carbon dioxide is mainly produced when we burn things, such as fossil fuels, and said to be a major cause of global warming because it prevents the heat from the sun to be released from the earth into space. This effect is known as the greenhouse effect. Another major problem with carbon dioxide is that once carbon dioxide is produced, it is very difficult to change it into other substances. In other words, carbon dioxide can be said to be the end of the energy source. Therefore, not

only reducing carbon dioxide emissions but also how to handle the emitted carbon dioxide is a very important issue.

The most famous way to utilize carbon dioxide might be photosynthesis. Animals, including us humans, take in oxygen through breathing and produce energy and carbon dioxide by “burning” organic materials such as carbohydrates in our bodies. On the other hand, plants also breathe, but they can use light energy to produce carbohydrates from carbon dioxide and water. This process is called photosynthesis. The great thing about photosynthesis is not only that it uses light energy, which is a renewable energy source, but also that it breaks down carbon dioxide. Therefore, photosynthesis can be said to be one of the major keys to solving environmental issues.

While photosynthesis has such a great impact on the global environment, human activities are causing the decrease of forests. Today, there is a movement to protect forests, but, once they are lost, it takes a very long time to recover them. Furthermore, there is a limit to natural photosynthesis. Therefore, it will be necessary to take other approaches against environmental issues at the same time. One of such approaches is artificial photosynthesis.

Attempts at artificial photosynthesis are said to have existed since the early 20th century and various studies and improvements have been carried out up to now. Researchers at Toyota laboratory then succeeded in developing a device to perform artificial photosynthesis in 2021. The device uses solar cells to generate electricity, and the electrical energy is used to react water and carbon dioxide. As I will explain later, the photosynthesis performed by this device is slightly different from that performed by plants, but it has two major advantages over existing devices.

The first advantage is the high energy conversion efficiency. As mentioned earlier,

through photosynthesis, both plants and devices convert the energy of sunlight into chemical energy. However, they cannot convert all the sunlight energy into chemical energy. Ten years ago, in 2011, the energy conversion efficiency of the device created by the same research laboratory was only 0.04%, which means that over 99% of the sunlight energy is wasted. On the other hand, the efficiency of the new device made by Toyota group is 7.2%. In a simple comparison, this conversion efficiency far exceeds even the conversion efficiency of plant photosynthesis, which is said to be 3% at most.

The second advantage is the compactness of the device. The device is 36 x 36 square cm, and easy to scale up. Until now, one of the major obstacles to practical application has been the problem of declining efficiency when scaling up. Therefore, the new device gets much closer to practical use.

However, as mentioned earlier, the photosynthesis performed by this device is slightly different from that performed by plants. In fact, the device's artificial photosynthesis produces formic acid, a type of acid, rather than carbohydrates. Formic acid is known in nature to be used by some ants and with industrial use value. However, it can be said that its simple usefulness is not equal to that of carbohydrates. Therefore, finding the better use of formic acid is the next challenge. If we could use formic acid as an energy source, it would help to solve the energy problem at the same time. Although there are also problems needed to be solved, such as durability, I believe that this technology of artificial photosynthesis has the potential to change our society drastically.

Artificial photosynthesis alone will not solve all environmental problems because in addition to removing carbon dioxide from the air, forests play a variety of roles, such as preventing flood damage. However, with scientific technology such as artificial photosynthesis, human beings may be able to live in better harmony with this planet.

References

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