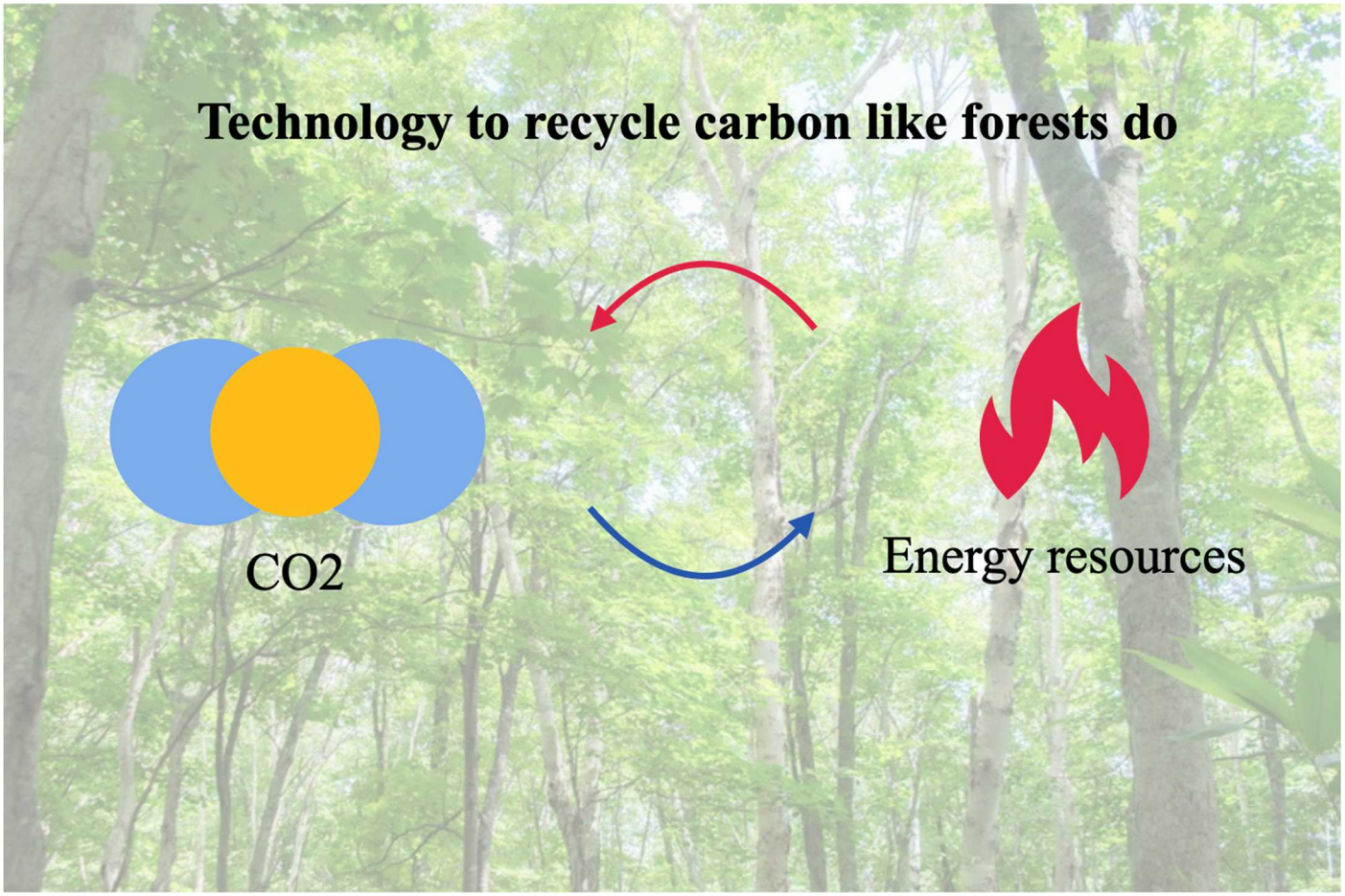

Title: Technology to recycle carbon like forests do

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Carbon is an essential element in our lives. Woods for building houses and almost all foods contain carbon. 18% of human body is also made up of carbon [1]. Humankind have improved their environment using various carbon compounds. On the other hand, our society faces a big problem related to carbon compounds now.

One side of the problem is global warming, which is thought to be caused by greenhouse gases such as carbon dioxide (CO_2). It is well known that as the average temperature of the Earth rises, Antarctic ice melts and sea levels rise. Global warming also brings us extreme weather such as giant Hurricanes and droughts. Because these effects are causing serious damage to human society, we have to stop them as soon as possible.

The other side of the problem is about fossil fuel resources. They are widely used as energy sources for power generation and gasoline for cars, but their reserves are limited. If we continue to use them as before, we will eventually run out of them. Though we may find new energy resources and make them available through technological progress, it can’t be a fundamental solution unless the resources are reusable. To

realize a sustainable society, we should change our main energy sources from the limited underground resources to renewable energy sources. These two sides of the problem may seem to be different. However, these are fundamentally the same in the sense that using fossil fuels directly leads to an increase in CO_2 in the atmosphere. They can be solved at the same time by new technologies for renewable energy.

One of the promising technologies to solve the problem is artificial photosynthesis. As photosynthesis in plants, artificial photosynthesis produces useful carbon compounds from water and CO_2 by using only solar energy. This means that artificial photosynthesis converts solar energy to chemical energy. Since the sun is thought to exist for a long time, sunlight falls on the Earth semi-permanently. This fact makes artificial photosynthesis a sustainable energy technology.

By using the technology, we can capture CO_2 emitted from factories and power plants, bringing net CO_2 emissions to near zero. This will help curb global warming. In addition, if we can use carbon compounds produced by artificial photosynthesis as an energy source instead of fossil fuels, we will also solve the resource problem. While burning fossil fuels means releasing carbon form underground to the atmosphere, burning products of artificial photosynthesis is merely returning CO_2 to the atmosphere where it originally existed. Hence, CO_2 in the atmosphere does not increase in this process. Ultimately, this technology enables us to build a carbon recycling system.

Because of such advantages, artificial photosynthesis is now widely studied. Toyota central R&D labs is one of the research facilities which try to develop the technology [2]. Their method provides formic acid (HCOOH) under normal temperature and pressure. Their equipment mainly consists of solar cells, anode catalyst, cathode catalyst and aqueous solution containing CO_2. The main processes are an oxidation of water and a reduction of CO_2. First, electrons are generated from solar energy with photovoltaic cells. Mediated by these electrons, hydrogen ions are obtained from water with the anode catalyst which contains Iridium oxide. Then, hydrogen ions and CO_2 are reacted at the cathode which is a Ruthenium-complex polymer to produce formic acid.

When the research team started the project in 2011, the solar to chemical conversion efficiency was just about 0.04 % [3]. However, they have now achieved artificial photosynthesis with the efficiency of 7.2 %, which exceeds that of plants. Their next goal of the efficiency is 10 % and they also try to increase the size of the device from 36 cm square to 1.6 m square to make it practical.

Formic acid produced by this study has the large potential to help with the energy issue. It contains hydrogen and can be an energy carrier. Though hydrogen can be used as a fuel, it is difficult to liquefy and store hydrogen efficiently due to its very low boiling point -253℃. On the other hand, the boiling point of formic acid is around 100℃. Hence it is possible to store hydrogen in the form of formic acid and take hydrogen from it when needed.

This study is just one example of artificial photosynthesis. Another group including the University of Tokyo tries to develop a similar method to make olefin (such as C_2H_4, C_3H_6) which is raw material for plastic [4]. Furthermore, considering that plants produce sugar through the natural photosynthesis, it may be also possible to produce food through artificial photosynthesis in the future. If it realizes, the food problem also can be solved. As you can see, artificial photosynthesis has great potential to improve our society. Please pay attention to the future development of the research of artificial photosynthesis and its social implementation.

Reference

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