SCIENCE NEWS of the week

Plants: The New Plastics Makers

In these times of environmental woe, turning plants into biodegradable plastics would really prove a blessing.

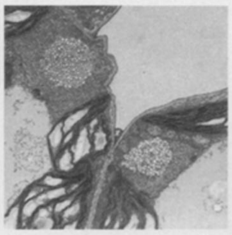
A recent development may set the stage for such a modern-day miracle. Plants can be genetically engineered to produce commercially useful quantities of a biodegradable plastic that resembles polypropylene, Chris Somerville, of the Carnegie Institution of Washington at Stanford University, and his colleagues assert in the Dec. 20 Proceedings of the National Academy of Sciences (PNAS).

The finding expands the list of valuable substances, including fibers and oils, made by plants, and may give farmers a new use for their crops.

Most plastics are synthetic, and only a few biodegrade. Researchers have experimented with increasing the starch content of plastic to make it easier for microbes to attack the material (SN: 5/6/89, p.282). Companies also use a bacterium to make polyhydroxybutyrate (PHB), a biodegradable plastic.

But these processes are too expensive for producing commercial amounts of plastic, scientists say.

So Somerville and his colleagues decided to try to make PHB in plants. An initial attempt, reported in the April 24, 1992 Science, proved successful, except the plants made very small quantities of the plastic and grew poorly.



Somerville

Electron micrograph of plastic granules in plant cells.

His team recently revamped its technique and achieved a 100-fold increase in the amount of PHB accumulated in the plants. Twenty percent of the dried plant now consists of PHB, Somerville says.

The new study "is a very nice scientific demonstration of the feasibility of making large amounts of plastic from plants," says John B. Ohlrogge of Michigan State University in East Lansing.

However, "PHB by itself is not a very useful plastic," warns Ganesh M. Kishore of Monsanto Co. in St. Louis, which is developing plastic-producing plants using some of Somerville's techniques. Monsanto researchers want to engineer plants to produce compounds that improve on PHB, he says.

Now, when his group melts PHB in order to mold it, 50 to 60 percent of the compound decomposes, Kishore says. Also, the plastic is brittle.

Nevertheless, the PNAS study demonstrates that plants can withstand a much higher concentration of PHB than anyone would have guessed previously, he asserts. Companies will begin selling plastics that use PHB in 5 to 6 years, Kishore predicts.

In both recent and previous experiments, Somerville and his coworkers inserted into mustard plants the genes that encode three enzymes crucial to a bacterium's synthesis of PHB.

In their latest work, they made sure that the PHB would get produced in the plant's chloroplast, the site of photosynthesis. In the chloroplast, PHB can't "steal metabolites away from the cell that are needed for growth," Somerville says.

Somerville

Arabidopsis thaliana *(mustard plant).*

Almost any plant can be genetically engineered to produce plastic using his group's technique, he contends. Also, "we can cause a gene to be expressed pretty much anywhere in the plant that we would like," Somerville adds. Commercial producers will probably grow the plastic in soybean plants, he says.

While PHB resembles polypropylene, its chemical properties differ enough that enzymes secreted by bacteria will break it down, Somerville says. This releases methane.

"You could harvest the [methane] that comes off during biodegradation of the [discarded] material," he notes.

— *T. Adler*

Microlight: Lasing with single atoms

The process of generating a laser beam typically involves great crowds of atoms or molecules. Now, researchers have developed a microlaser that produces light from interactions between a mirrored cavity and atoms passing through that cavity one at a time.

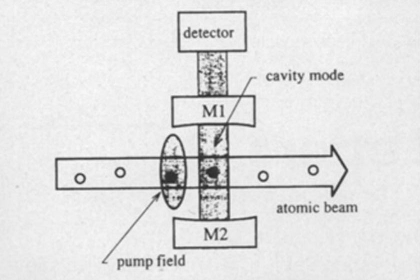
Kyungwon An, Michael S. Feld, and their coworkers at the Massachusetts Institute of Technology report their results in the Dec. 19 Physical Review Letters.

In a conventional laser, an electrical jolt or a flash of light excites atoms or molecules of a lasing material, such as a ruby crystal or a mixture of helium and neon gas. The photons emitted by excited atoms bounce back and forth between two mirrors, inducing additional atoms to emit light of the same wavelength. These photons move in step to create a coherent light beam.

To construct a microlaser, the researchers had to create a mirrored cavity, or resonator, of sufficiently high quality to strictly limit the number of photons that could escape. They did this by fabricating a pair of precisely aligned, highly reflective mirrors for the project. The resulting resonator was about 10,000 times more capable of storing photons than a resonator in an ordinary laser.

A "pump" laser was used to excite barium atoms from their ground state to a higher energy level just before the atoms entered the 1-millimeter gap between the two curved mirrors (see diagram). Interactions between the empty cavity and the first atom entering the gap induce the atom to emit a photon. The next excited atom traversing the cavity interacts with this photon, emitting a photon of its own, and so on.

The number of photons present in the cavity quickly builds to a certain value, and a portion of the light can then emerge as a laser beam. Storing about 11 photons at a time in their resonator, the researchers generated a detectable laser beam having a wavelength of 791 nanometers.



An et al./Phys. Rev. Lett.

Schematic diagram of a microlaser.

Such a microlaser may prove a useful tool for investigating how photons couple with individual particles. "This development has been long sought, and it is expected to lead to further fundamental advances in our knowledge of light and its interaction with atoms," Feld says.

— *I. Peterson*