Energy Alchemy
By JEFFREY A. TANNENBAUM Staff Reporter of THE WALL STREET JOURNAL
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Researchers Say Sugar Made From Cellulose May One Day Provide New Food, Fuel Source

By JEFFREY A. TANNENBAUM
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NATICK, Mass.—Leo A. Spano is a jolly sort with a broad grin. One thing he gets a big kick out of lately is the small jar of glucose crystals on his desk. His associates made the sugar out of some old copies of The Boston Globe.

If that sounds crazy, you should meet Charles R. Wilke of Berkeley, Calif. Mr. Wilke says he has been turning copies of The Wall Street Journal into sugar—and then making the sugar into ethanol, a process that conceivably could someday help reduce reliance on petroleum.

Leo Spano and Charles Wilke are for real. They're chemical engineers; Mr. Spano's employer is the U.S. Army at its scientific facilities here, and his effort to perfect a new way to make sugar is in earnest. The Army's small and little-publicized project—and related efforts by others, including Mr. Wilke at the University of California—may even prove eventually to be of major economic importance.

Constant New Supplies

So far, nobody has proved that the Army's method for converting old newspapers and other waste materials into sugar will be economic on a large scale soon. But what they lack in hard data, the scientists make up for in enthusiasm. "This is going to be the greatest thing since motherhood," says Mr. Spano, running his fingers through the sugar on his desk. "We're taking a renewable resource and making it into a high-energy material that can be used as food or fuel."

The "renewable" resource to which Mr. Spano refers is cellulose, the principal material making up the cell walls of plants. Cellulose is ubiquitous—it's in trees, crops and many waste materials—and new supplies are constantly generated by the sun. Some cellulose is used for energy now, as when wood is burned in a stove, and scientists are seeking ways to make it a major energy source.

According to Clayton D. Callihan, a professor of chemical engineering at Louisiana State University, important chemicals and plastics now derived from petroleum—such as polyethylene, polypropylene, styrene and butadiene—"are either going to disappear or be so expensive that they will find little application in our daily lives." The consequences could be drastic, unless cellulose saves the day. Says Mr. Callihan, "The obvious replacement for the organic base of these polymers is cellulose because of its perpetual nature."

To derive chemicals like that from cellulose, the first step is making glucose, a form of sugar. Glucose differs somewhat from sucrose, or table sugar, but it's the kind that's used in commercial baking. Authorities agree that the best of several methods to make glucose from cellulose is the Army's. That method, strangely enough, traces its origins to a rotted cotton cartridge belt found in New Guinea during World War II. Army scientists discovered that the belt was being consumed by a greenish-yellow mold of microorganism called Trichoderma viride. In effect, the mold was turning the belt into glucose and living off that. The Army's studies of these and other microbes led to the development of longer-lasting cartridge belts.

About four years ago, when Army researchers here started a program to find new ways to clean up the environment, somebody remembered Trichoderma viride. What better way to clean up waste, the Army figured, than to convert it into something useful? Why not use Trichoderma viride to make glucose out of cellulosic wastes? There ensued intensive experiments with the microorganism, including genetic mutations. By using cobalt radiation, scientists altered the microbe to make it more efficient at producing glucose.

Just recently, the Army's laboratory-scale experiments have blossomed into a full-blown pilot plant with a maze of processing tanks and electronic controls—and a young Army recruit, in black boots and olive fatigues, who spends hour upon hour tearing up newspapers into small pieces. A limited budget—$317,000 this fiscal year—apparently doesn't permit purchase of a paper-shredding machine. Despite such problems, the plant is expected to be fully operational soon.

The Natick process begins when Trichoderma viride are grown on spruce pulp in a tank of water and nutrients that spur the microorganisms' production of cellulase, an enzyme that is used to produce glucose. The microbes discharge the enzyme into the tank.

The next step is removing the Trichoderma viride—any microbes that were left around would simply consume any glucose produced. What's left is a broth resembling beer—and "beer" is indeed what the scientists have dubbed it. The beer consists of cellulase and water.

Pancake Syrup

The newspaper shreds, meanwhile, have been milled into a grayish powder. Now the powder is added to the beer, with a resulting chemical reaction that produces glucose and some residues, most of which are filtered out. The glucose produced couldn't be eaten without further processing to remove the impurities, but it can be used to make alcohol and other chemicals. One Natick researcher did purify a batch, though, and made it into a pancake syrup.

The Natick project has attracted a flood of visitors from government and industry, not only in the U.S. but also in many other countries. The Soviet Union has purchased equipment to duplicate the Natick effort, and a team of two dozen Japanese scientists is due for a visit soon. Several U.S. companies reportedly have begun projects of their own, notably Gulf Oil Corp.

The most intriguing aspect of the Natick process, observers agree, is the possibility of making useful chemicals from waste materials ranging from cow manure and bagasse, or sugar-cane waste, and municipal trash. Just the wastes from forestry and agriculture theoretically could provide for 10% of the nation's energy needs, Thomas F. Reed, a Massachusetts Institute of Technology chemist, testified at a U.S. Senate subcommittee hearing last year.

Already, researchers are plunging ahead with projects to make ethanol, or ethyl alcohol, from glucose derived from cellulosic wastes. The U.S. uses over 300 million gallons of ethanol a year in numerous applications including chemicals, toiletries and cosmetics; the ethanol now comes from ethylene, which comes from petroleum.

The chemistry for making ethanol from glucose is well-known—it's the way hillbillies make moonshine whisky, by yeast fermentation. Indeed, before petroleum and ethylene became the major source of ethanol, most ethanol was produced by fermentation. (While wood waste is a possible raw material, "wood alcohol" is another chemical, methanol.)

With the cost of petroleum having soared, the University of California's Mr. Wilke and Gulf Oil Chemicals Co., a division of Gulf Oil, separately are attempting to prove that ethanol production by fermentation is again economic on a large scale, mainly because the Natick process is better than previous methods of producing glucose. Says William F. Gauss, a Gulf researcher: "This idea has a lot of moxie to it. If we can pull this off, it will be quite important for the country."

If the ethanol process proves economic, some scientists predict, the chemical soon may be used as a major ingredient for gasoline, which would further reduce reliance on petroleum. And ethanol might be only a first step, with other important chemicals to follow.

Scientists also note that cellulose could bring other benefits, for it has numerous possibilities as a food source. Research is burgeoning in these areas as well. Bechtel Corp. and Louisiana State University, for example, have started a joint venture to make single-cell protein, a possible animal-feed supplement, from bagasse. And Natick says that some of the waste from its own process—the very Trichoderma viride after the microbes' job is done—could be fed to cattle. Says Mr. Spano: "It's like when you butcher a pig and use everything but the squeak."