Chemistry

Janet Raloff reports from Boston at a meeting of the American Chemical Society

White paper — with less dioxin

Last year's finding that chlorine bleaching of wood pulp generates some 250 different chlorinated contaminants, including the most toxic dioxin, sent paper mills scurrying to modify or redesign their bleaching operations (SN: 8/5/89, p.94). One new technology promises not only to reduce these toxic residues in pulp and its wastes by more than 90 percent, but also to cut costs and bleaching time, reports I.J. Wilk, a consulting chemist in Menlo Park, Calif.

His system passes an electric current through a saltwater bath containing 10 percent wood pulp. As the briny solution decomposes, oxygen, chlorine and ozone are generated at the positive electrode. Wilk observes that this "very potent" bleaching combo takes only 4 to 15 minutes to accomplish the same degree of whitening obtained after 1 hour or more with conventional pulp-bleaching mixes.

Moreover, in 15-minute test runs, his electrolytic system produced only 0.6 to 0.8 percent as much chlorinated organic pollution as conventional chlorine bleaching and only 8 percent as much as chlorine-dioxide bleaching. "By adjusting ozone levels, we think we might be able to totally eliminate any chlorinated [organic contaminants]," Wilk told SCIENCE NEWS. However, he adds, because the test data show that this system can also destroy chlorinated organic chemicals, any contaminants that do form might be purged by simply recycling the contaminated wastewater — minus the pulp — through the electrolytic cell. Though his team has not yet assayed for dioxin in the pulp and waste, Wilk says, "we don't expect to find any dioxin" because the process generates such a low overall level of chlorinated contaminants.

Last week the U.S. government added impetus to the search for cleaner pulp-bleaching techniques when EPA and FDA announced plans to formally regulate dioxin levels in pulp wastewater, sludges and possibly paper products. Said EPA Deputy Administrator Henry F. Habicht, "Even though dioxin levels in paper products are small enough to be no cause for alarm, our intention is to reduce those levels even more."

Swallow hard: Tobacco is nutritious

The enzyme that helps green leaves incorporate carbon dioxide is also a good dietary protein, containing a balanced mix of the amino acids essential for maintaining human health, suggests new research by Shuh J. Sheen, a plant geneticist at the University of Kentucky in Lexington. And tobacco appears to represent an ideal source of this protein, Shuh reports.

The enzyme is ribulose 1,5-bisphosphate carboxylase-oxygenase, also known as fraction-1 protein. Sheen has identified the amino acid groups making up this water-soluble protein in tobacco and several other crops, including soybeans and alfalfa. In each, the protein is almost—but not entirely—identical. Some slight, crucial difference in the makeup of tobacco's version apparently accounts for its being so much easier to extract as pure hexagonal crystals, Sheen says. Because crystallizing this colorless, tasteless and odorless protein excludes nicotine and other potentially toxic "antinutrients," tobacco's fraction-1 protein could offer a safe food additive or pharmaceutical-grade (ultrapure) nutrient, he says.

Young, preflowering plants represent the richest source of the protein, so adapting agricultural practices to maximize its production should quadruple the leafy yield tobacco farmers currently reap per acre by allowing repeated harvests from the same plants. This suggests that tobacco farming could provide a rich, low-cost protein source, especially in the developing world, Sheen says. Moreover, he says, the protein has the potential to serve as a foaming or emulsifying agent in processed consumer products like ice cream, salad dressings and whipped desserts.

Physics

Secret of the vacuum: Speedier light

The notion that no particle or signal can travel faster than the speed of light in a vacuum is one of the cornerstones of modern physics. Now two physicists have challenged that well-established idea by uncovering a subtle quantum phenomenon that allows particles of light, or photons, under certain circumstances to travel at a slightly faster rate. That minuscule increase in the speed of light hinges on the peculiar effect of two parallel, conducting plates, or mirrors, on the properties of the vacuum.

In the Feb. 22 PHYSICS LETTERS B, Klaus Scharnhorst of the Humboldt-Universität zu Berlin in East Germany uses the theory of quantum electrodynamics, which describes the way photons interact with matter, to calculate what happens to electromagnetic waves (or photons) between a pair of closely spaced, parallel plates. Electromagnetic waves propagating at right angles to the plates would travel a little faster than light in the free vacuum, Scharnhorst reports. "This is simply the result of the change in the vacuum structure enforced by the plates."

Taking a somewhat different approach, Gabriel Barton of the University of Sussex in Brighton, England, comes to the same conclusion.

"One could say that between parallel mirrors, even at zero temperature, there is a disturbance of the electromagnetic field, and it is as if between the mirrors, the energy density of the electromagnetic field were less than zero," Barton says. "So it seemed to me that if a positive energy density makes light go slower, then in a sense, a negative energy density, such as you have between mirrors, would make light go faster." Barton's analysis appears in the March 22 PHYSICS LETTERS B.

Fundamental to both approaches is the theoretical picture of the vacuum as a turbulent sea of randomly fluctuating electromagnetic fields and short-lived pairs of electrons and positrons (the antimatter counterparts of electrons) that appear and disappear in a flash. According to quantum electrodynamics, light propagating through space interacts with these vacuum fields and electron-positron pairs, which influence how rapidly light travels through the vacuum.

The presence of a pair of mirrors modifies the vacuum so that certain types of interactions between photons and the phantom electron-positron pairs can no longer occur. This allows light to travel a little faster than it normally would. The same type of modification in vacuum properties is responsible for the so-called Casimir effect, which predicts that two such plates would also attract each other.

But the predicted increase in speed is exceedingly small and occurs only for light propagating perpendicular to the plates. For parallel plates just 1 micron apart, the change amounts to roughly one part in 10^{36}.

"It's laughably small," Barton says. "The effects are too small by many orders of magnitude to be measured, but appear fascinating as matters of principle."

The results don't call into question anything basic about relativity theory, Barton argues. "All this says is that if you really had infinitely extended, parallel mirrors, then at right angles to these, there is still a maximum speed — in the same way that ordinary relativity says there is a maximum speed called *c* in empty space."

Nonetheless, the new findings suggest a number of technical questions worth exploring further. "The vacuum is certainly a most mysterious and elusive object that makes itself known by only the most indirect of hints," Stephen M. Barnett of the University of Oxford in England comments in the March 22 NATURE. "The suggestion that [the] value of the speed of light is determined by its structure is worthy of serious investigation by theoretical physicists."