Chemistry

Janet Raloff reports from Denver at the American Chemical Society's spring national meeting

C-14 dating for Shroud of Turin ?

The Shroud of Turin, a linen textile carrying what appears to be the bloody imprint of a naked man — one many believe to be the crucified Jesus — is among the best known and most revered of Christian relics (SN: 5/21/81, p.259). Carbon-14 dating and a battery of other tests to help scientists gauge the shroud's age, place of origin and, inferentially, authenticity could begin as early as this year, according to Garman Harbottle, a senior chemist with Brookhaven National Laboratory in Upton, N.Y., and a co-coordinator of the Shroud of Turin Research Project (STURP). Both the Pope and the Archbishop of Turin, Italy (custodian of the relic) have committed themselves to the textile's carbon-14 dating, he reports. Moreover, a protocol for conducting those tests was developed at a three-day meeting in Turin last fall, called jointly by the Vatican's Pontifical Academy of Sciences and the Archbishop of Turin. If the protocol is approved by the Pope, the Archbishop of Turin and the Vatican science adviser, the tests could begin within a month or two.

Owing to recent advances in the sensitivity of carbon-14 dating equipment, only 120 milligrams of fabric will be needed for six test samples — about the area covered by one or two commemorative U.S. postage stamps. Just four to five years ago, Harbottle notes, the minimum needed for *each* of the six samples would have been at least the size of "a large pocket handkerchief." The testing might even be completed with little or no obvious damage to the textile, Harbottle says, if the threads are taken from around scorched areas, now hidden under patches.

Present plans call for seven labs in Europe and the United States to analyze the six samples of fabric that will be taken. Most of the samples will be analyzed with accelerator mass spectrometers, which measure individual atoms; the rest will go for tests with miniature proportional counters, which measure the radioactivity of the carbon-14. As controls, samples from other ancient textiles will be included among the batch of "blind" threads analyzed by each lab.

To help determine the shroud's origins, researchers will analyze the isotopic ratios of heavy oxygen (O-18) to regular oxygen (O-16) and of deuterium, or heavy hydrogen (H-2), to regular hydrogen (H-1). Explains Robert Dinegar, who is not only a physical chemist from Los Alamos (N.M.) National Laboratory but also an Episcopal priest and co-coordinator of STURP, these ratios might help establish whether the flax used to make the shroud's cloth originated in a climate that was warm or cold, dry or moist.

Even if the Roman Catholic authorities agree to the protocol in principle, there is another factor that may complicate or hold up the start of the tests, Harbottle notes. The authorities want data to help them formulate proper conservation procedures. However, tests to collect such data were not considered in detail at the meeting in Turin last fall, nor are they included in the protocol that has been submitted. It's possible, Harbottle says, that full approval will not be granted unless a shroud-conservation analysis is included. Nevertheless, both Dinegar and Harbottle are confident the tests will occur. Says Harbottle, who is eager to pick up the samples: "I'm talking to a travel agent. [These tests] will happen."

Unlocking plants' secret potential

An experimental bioregulator being tested on crops has shown signs of increasing the photosynthetic capacity of plants. While the chemical's mechanism of action remains a mystery, its overall effect on crop production is not. Greenhouse tests and limited field experiments at the Agriculture Department's Fruit and Vegetable Chemistry Laboratory in Pasadena, Calif., are producing bumper crops, according to lab officials. For example, radishes grow as big as lemons, sugar-beets contain 50 percent more sugar per pound and bush-variety green beans produce 60 percent greater yields.

The chemical responsible for all this has the unwieldy name 2-(3,4-dichlorophenoxy)-triethylamine — DCPTA, for short. According to Henry Yokoyama, a supervisory research chemist directing its tests, the chemical not only spurs development of a stronger secondary-root system, but it also increases essential-oil content (a factor that can intensify flavor) and protein content. Moreover, treated plants tend to mature an average of one to two weeks earlier than untreated controls.

For annuals, these major changes are initiated by a single treatment of the seeds — a six-hour soak in water containing a mere 10 or 20 parts per million (ppm) DCPTA. Much higher treatment levels — 50 or 100 ppm — show no advantage over untreated plants. And levels higher than that may actually stunt yields. For perennials, the whole plant is sprayed with a much more concentrated form of the chemical — from 100 ppm for citrus fruit to 2,000 ppm for guayule. The result: When lemons are sprayed during their emergence as fruit, the potency of their essential oils is increased 50 to 100 percent over that of untreated lemons; sprayed guayule plants yield two or three times more natural rubber than untreated plants.

Although the compound has not been approved for use on food crops, Yokoyama anticipates that tests will show that "we're not going to find any [DCPTA] in the mature plant." He says that's because the concentration is so small, and because DCTPA appears to be only a "triggering" chemical, not the one actually responsible for the better crops.

Initial studies suggest the chemical would benefit any plant. Yokoyama says the nature of changes seen in the microstructure of the chloroplasts — the organelles containing the photosynthetic system — suggests that treated plants may just be making more efficient use of sunlight. In other words, the DCPTA may simply let plants recover any previously untapped potential locked in their genes.

Tanking up on biomass gas

Researchers at the Solar Energy Research Institute (SERI) in Golden, Colo., are developing a new biomass-to-gasoline process that they say yields a high-octane, high-energy-density product. While not the only such technology, it appears to be the first to convert the primary vapors of pyrolyzed biomass wastes — anything from wood scraps, crop residues and paper to municipal solid wastes — in a single-step process.

SERI data now suggest "there may be advantages in yields from using a single-step process," says James P. Diebold, one of its developers. His data suggest this process would yield 60 gallons of gasoline per ton of wood. Moreover, he says, unlike most competing processes, this one takes place at low atmospheric pressure — a factor that could keep its costs low.

In the SERI process, biomass wastes are vaporized. Then the vapors are passed over a zeolite (silica alumina) catalyst, which converts them to gasoline, carbon monoxide, carbon dioxide and water. (The carbon dioxide can later be recycled to help fuel the process, Diebold says.) The zeolite catalyst not only removes oxygen — which can degrade the energy value of a fuel — but also produces a high-octane, "aromatic" (ring-shaped hydrocarbon) gasoline. Its highly aromatic structure means the gasoline also carries more energy per gallon than regular gasoline, according to Diebold.

Although this gasoline could be used in its pure form, Diebold says it's more valuable to refiners as a blending stock used to upgrade the quality of low-octane gasoline. Since refiners can produce more gallons of low-octane gas than high-octane gas per barrel of oil, this blending stock would allow refiners to maximize their gasoline output, he says.