COMMENTARY

by Bernard Dixon

IF ALCHEMISTS COULD ONLY MEET TODAY'S FINNS

It's not hard to imagine the open-mouthed delight shown by a delegation of 12th century alchemists, ferried forward by time machine to inspect the achievements of science in the 1980s. Within their longed-for speciality of transmutating the elements, they would cheerfully and admiringly concede victory to the high-energy physicists and cyclotron technicians of today. Greater adulation still would attach to the high priests of biotransformation who now fashion powerful potions for the pharmaceutical industry. These are the wizards who have brought together most spectacularly the twin arms of traditional alchemy—the subtle conversion of one chemical into another and the healing conversion of sickness into health. Whether we think of Durey H. Peterson and *Rhizopus arrhizus* hydroxylating progesterone as a step towards Upjohn's cortisone in the early 1950s, or Douglas C. Cameron, Charles L. Cooney, and *Clostridium thermosaccharolyticum* making R(-)-1,2-propanediol from D-glucose three decades later (*Bio/Technology* **4:** 651, July '86), the story of transformation is one of striking elegance and power.

But when they had finished with being awestruck, yester-year's alchemists might well look further afield and notice some puzzling terrestrial facts of a quite contrary kind. They might begin to contemplate the chemical conversions which 20th century biotechnologists do *not* make. Finland, for example, would surely attract their curiosity. Each year, that splendid, sturdy, independent-minded country exports some 500,000–800,000 tons of barley (the only grain crop that can be reliably husbanded in arctic latitudes). But every year, too, Finland imports 60,000–80,000 tons of starch, 60,000–80,000 tons of raw sugar, 70,000–100,000 tons of soybean, and 8,000–12,000 tons of industrial ethanol from other nations. Assuming that our alchemists understood the molecular relationships between these materials, they might indeed raise a flutter of eyebrows.

As I learned during a recent visit to Helsinki, however, the idiosyncracy of this flow-sheet has also struck the Finns themselves. So, working over the past two years at Alko Ltd. (the State alcohol monopoly), Antti Lehmussaari and his colleagues have dreamed up, designed, and built a plant at Rajamaki which rationalises the picture dramatically and integrates three processes that normally run quite separately. Grinding an input of 50 tons of barley each day during its pilot phase, the plant has been producing fine starch, barley molasses, ethanol, and animal feedstuffs (protein-enriched barley protein meal and energy-enriched barley protein feed). The facility has operated like a dream, and next summer at Koskenkorva its production-scale counterpart will come on stream, devouring 150,000 tons of Finnish barley each year. With virtually no waste, the annual output will range from 15,000 tons of ethanol and 65,000 tons of feed, to 10,000 tons of high fructose syrup and 10,000 tons of carbon dioxide. The alchemists will be able to applaud all over again.

One of the keys to the new Alko process is the separation of barley starch into its two different particle sizes. High quality A-starch is recovered as prime starch and then turned into starch syrups, starch sweeteners, and other products for the paper and food industries. The less pure B-starch fraction is converted into alcohol. Although the factory at Koskenkorva is nominally designed to divert equal quantities of the two types into the two groups of products, it is sufficiently flexible to alter the proportions considerably in response to changing market demands.

A second key feature of the Finns' highly streamlined and economic plant is the nature of the animal feed it disgorges. That produced during conventional alcoholic fermentation is, of course, distiller's dried grains with solubles (DDGS). Only cows and other ruminants can digest DDGS, because it contains a large proportion of roughage. In the new integrated operation, the feed will be fractioned into barley molasses and barley protein (which are high in protein, low in fibre, and thus suitable for non-ruminants) and a husk-rich product for ruminants. Animal nutritionists have worked closely with process engineers in evolving this near-perfect system. For example, judicious drying methods and the addition of enzymes to degrade unwanted components such as beta-glucans promote overall utilisation of the feeds.

I suspect that Alko's development team may well have come as close as is humanly possible to reaching maximum attainable efficiency in their Koskenkorva factory. But when it opens next August, I for one will be keen to know what other raw materials the company will then begin to subject to a similar process of exhaustive extraction and conversion. Closely relevant to that question is its intended uses for the main products that will begin to emerge thereafter from *another* Alko biotechnology factory under construction—cellulases excreted by the mould *Trichoderma reesei*. Their commercial exploitation is an unfinished story that takes us back to the early 1970s when Alko got together with a Finnish paper and pulp manufacturer to research the enzymatic hydrolysis of lignocellulose to ethanol. Unlike several other groups whose endeavors feature occasionally in *Bio/Technology*, the Finns concluded long ago that the economics of this process were nonsense. Despite all of those conifers which thickly carpet the length and breadth of their handsome country, Alko's cellulase king, Jaakko Oksanen, and his colleagues are convinced that this is a road to nowhere.

But they *do* remain keenly interested in the use of cellulases in malting, brewing, silage making, fruit and vegetable treatment, and many other domains. They are also now taking an active interest in tailoring improved enzymes via recombinant DNA technology—and no-one knows precisely where this will lead. I wonder whether they will really continue to ignore the trees outside the window.

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