Novel process for polymer production

A new era in man-made fibers, plastics, paints and adhesives may be opening. Industry chemists this week announced a fundamentally new process for making polymers, long chains of small molecules linked together chemically. They predict the approach will allow for new types of polymers and less expensive, less polluting polymer production. The process's first application under development is an improved acrylic finish for automobiles. Other early uses are expected in production of electronic components.

The technique is the first new polymerization method to be developed since 1953, says its inventor, Owen W. Webster of E.I. du Pont de Nemours and Company in Wilmington, Del. The process uses an initiator molecule containing an activating group. A small molecule, called a monomer, inserts between the initiator and the activating group. Then another monomer joins between the first monomer and the activator. Because the activating group is thus transferred along the chain, the process is called group transfer polymerization (GTP).

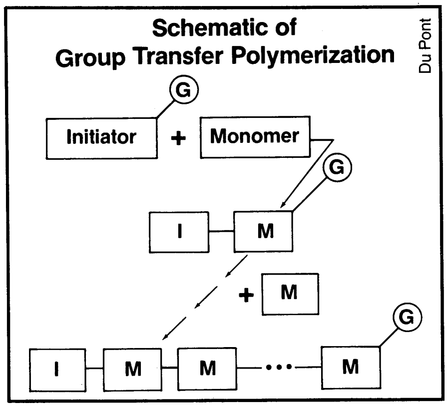
"No other method for polymerization of these monomers gives the synthetic latitude available by GTP," Webster and colleagues reported at the meeting in Washington, D.C., of the American Chemical Society. "Chain length is easy to control and you can attach functional groups that you couldn't get in by other methods," Webster says.

The Du Pont scientists call the growing chain a "living polymer" because, unless the ends are chemically inactivated, the chain continues to grow as long as monomers are available. The chemists demonstrated the "living nature" of the system by successfully adding monomers to an initiator-polymer-activating group complex that had been stored at room temperature for two days.

Specifically designed polymers can be produced by the new technique by "sequential monomer feeding." After one monomer is incorporated to the appropriate extent, and used up in the solution, a different type of monomer can be added and incorporated into the polymer.

Cost savings and reduction in pollution, as well as versatility in polymer structure, are expected from the new process, says Richard Quisenberry of Du Pont. Unlike current procedures, group transfer polymerization uses up all the monomer supplied to the system, so there is less waste of material and no monomer to be stripped out of the final product. The only thing that comes off in the end is the activating group, and that is non-toxic, the scientists say.

Another energy-saving characteristic of GTP is that the monomer is added to the system in a more concentrated solution than with other polymerization techniques. For example, in the automotive finish a 60-percent-resin solution is used instead of 20 percent. This change means that less energy, and lower temperatures, are required for evaporating the solvent, and that less solvent is released into the air. The ability to evaporate the solvent at a lower temperature will also allow more extensive use of plastics in products, such as cars, that are coated with polymers. (Currently, temperatures of about 250°F are required for drying solvents from polymerization processes.)



In the new method of making polymers, small molecules, called monomers (M), insert between an initiator (I) and its activating group (G), so that the activating group repeatedly is transferred to the last monomer of the chain.

Another innovative aspect of the technique is the use of an unusual catalyst — bifluoride ion. Fluorides have been widely used for polymer production, but this is the first report of bifluoride ion being useful in such catalysis, Webster and colleagues say. Webster says Du Pont chemist Dotse Y. Sogah made the "startling discovery" of the ion's potential when a defective moisture-proof cabinet allowed humid air to mix with fluoride ion, producing bifluoride ion, during experiments on fluoride catalysis.

So far Du Pont has concentrated its research on the class of polymers known as acrylics, but it has begun exploratory research in other areas. The company is now building a pilot plant to produce automotive finish by the new process and expects to have the finish on the market in about two years.

At the meeting in Washington, D.C., Webster and colleagues reported the details of using a chemical called methyl trimethylsilyl dimethylketene acetal (the trimethylsilyl group is the activator group) as the initiator. At room temperature they generally were able to rapidly polymerize such monomers as *alpha, beta*-unsaturated esters, ketones, nitriles and carboxamides. They conclude, "This new method offers new dimensions in the construction and design of polymer chains from these monomers."

—J.A. Miller

Virus-cancer cluster found in South

A generally rare human cancer called T-cell leukemia-lymphoma, which appears to be caused by a virus called the human type C retrovirus, has been found to be unduly prevalent among blacks born or raised in rural areas or small towns in the southeastern United States.

This finding comes from Douglas W. Blayney of the National Cancer Institute in Bethesda, Md., and colleagues.

The presence of the retrovirus in T-cell leukemia-lymphoma has made it the strongest contender for a virally caused human cancer to date, with Burkitt's lymphoma running second (SN: 9/9/78, p. 180). Persons in certain areas of Japan and the Caribbean basin have been found to be especially susceptible to the human type C retrovirus and to T-cell leukemia-lymphoma, implying that the virus and the cancer are endemic to these regions.

In the Aug. 26 Journal of the American Medical Association, Blayney and his co-workers report some interesting medical features pertinent to four patients with T-cell leukemia-lymphoma, their family members and healthy persons living in identical or similar geographic areas. Specifically, all four patients were black, as have been most Americans found to have this kind of cancer in the past. These findings suggest that American blacks are especially prone to this kind of cancer. All four patients had antibodies against human type C retrovirus, implying that they had been exposed to this virus. Yet none had traveled to the Caribbean or Japan, ruling out the possibility that they had acquired the virus and cancer from these regions. On the other hand, all four had been born or raised in rural areas or small towns in Georgia or Alabama, suggesting that they might have picked up the virus and cancer from these areas.

Further evidence that this was the case, in fact, came from the discovery that the apparently healthy mother of two patients, the apparently healthy brother and father of one patient and the apparently healthy wife of a patient also had antibodies against the virus in their blood, and that all five of them had also been born or raised in rural areas or small towns in the southeastern United States. (The reason why they had antibodies against the virus and no cancer may have been due to their immune systems killing the virus.) Yet more evidence that the patients had gotten the virus and cancer from rural areas or small towns in the area came from the finding that the incidence of antibodies against the virus was very low among local healthy blacks and whites in general.

Thus blacks born or raised in rural areas or small towns in the southeastern United States are "at increased risk of human T-cell leukemia-lymphoma infection," Blayney and his team conclude, possibly because of environmental exposure or household practices.

The researchers also estimate that blacks in the southeastern United States are at about the same risk of type C retrovirus and T-cell leukemia-lymphoma as are blacks in the Caribbean, yet at a considerably lower risk of such infection than persons in high-risk areas in Japan. The reason is that they compared the prevalence of antibodies to the virus in a sample of healthy blacks in Georgia to the prevalence known for persons on the Caribbean island of St. Vincent and to the prevalence known for persons on the high-risk Japanese island of Kyushu. —*J. A. Treichel*

Pre-life chemistry found in meteorite

All five of the chemical compounds that provide the genetic information for life on earth have been identified in samples of a single meteorite, a scientist this week told the American Chemical Society's annual meeting in Washington, D.C. "We have not found E.T.," says Cyril Ponnamperuma of the University of Maryland in College Park — the compounds, called bases, are merely "prebiotic" material. But confirming that the full suite of them can form on an extraterrestrial body could certainly bear on the loaded question of whether earth is one of many abodes of life or an incredibly lonely oasis in the universe. Also essential in exploring the issue is understanding the ease or difficulty with which such material can form, and Ponnamperuma reported that all five bases have also been produced in a laboratory experiment. The result, he says, "makes the creation of life chemicals appear to be simple, almost inevitable."

Four of the five bases — adenine, guanine, cytosine and thymine — comprise the "letters" of the genetic code, structured into the double helix of DNA. The fifth, uracil, along with adenine, guanine and cytosine, is part of the protein-making instructions coded in RNA. All five, according to Ponnamperuma, have now been found in samples of the Murchison meteorite, which fell in Australia in 1969. (Some of the bases had been previously reported in the Murchison meteorite and others, but the presence of the complete set was not certain.)

In the laboratory, he and colleagues exposed a model of a primitive atmosphere (methane, nitrogen and water) to an electric discharge. Past studies had produced one or more of the bases, Ponnamperuma says, "but here, for the first time in one experiment, we see that they are all there." Because the result is born of such an essentially simple process, he adds, "this I consider to be of even greater importance than the discovery of the bases in the meteorite." —*J. Eberhart*

Computing a machine's world view

When most people look at a cartoon, they generally have little trouble recognizing a set of squiggly lines drawn on paper as a familiar face, a penguin or some other figure. Somehow, the human brain can come up with the right answer even when descriptions are incomplete or partly wrong.

For years, researchers in artificial intelligence have sought ways to mimic the human brain's remarkable ability to recognize objects and ideas. Furthermore, they wanted a machine that could learn from its experiences by steadily widening its ability to identify similar objects in different settings. Last week, three scientists reported success in designing a machine that, in their view, meets these requirements and behaves more like neurons in the brain than any other model available.

Scott E. Fahlman and Geoffrey E. Hinton of Carnegie-Mellon University in Pittsburgh and Terrence J. Sejnowski of Johns Hopkins University in Baltimore described their "Boltzmann machine" at the National Conference on Artificial Intelligence, held in Washington, D.C. Their machine is designed to find and settle into a "state" that best suits or interprets a particular observation without requiring an exact match.

The machine consists of a network of simple binary units that can be either "on" or "off." These units may each be connected to, perhaps, a thousand others. A numerical weight assigned to each connection represents the strength of the link. The connection weights store knowledge within the network about the plausibility of each interpretation of an observation. In this model, a "concept" (say, a penguin or an elephant) is stored as an "on-off" pattern spread over many units. The weights act as constraints on the system.

A small number of the machine's units have connections with "the outside world" to provide for input and output of information. The rest, hidden inside, represents encoded knowledge. Fahlman says the game is to satisfy the constraints as much as possible for a given input signal. How well the constraints are satisfied can be represented by a number that behaves very much like potential energy in a physical system. The lower the "energy," the more happy the system is, says Fahlman.

In a physical system consisting of, for instance, a ball rolling through an undulating landscape of hills and valleys, the ball will try to settle into the deepest valley, where it will have its lowest potential energy. In the Boltzmann machine, this potential energy is the sum of all the unit states (1 or 0 for each) and the weights between the units. For a given input, the units make local decisions, based on constraints imposed by their neighbors, to switch on or off so that the total potential energy is a minimum. As these adjustments occur, the network eventually settles into a minimum that best satisfies the input signal and all the constraints.

A common task for such a system is to find the stored description that best matches a set of observed features, even if the match is imperfect. The most likely interpretation of, say, a diagram, will be the one that drives the network into its lowest energy state. This corresponds to the description that best fits the weighted combination of observed features and expectations. If there are several good descriptions, it is biased toward the best.

"No single weight or unit in this thing is critical," says Fahlman. "You still end up in the same general region." Many people have suggested that such a distributed representation of memory would be more reliable than a memory in which each unit represents a particular idea. It is also more consistent with what is known about the workings of the brain.

Learning occurs because input signals that do not match exactly what is already represented in memory modify the weights and unit states slightly. The researchers introduced a random noise element into their network to reduce the chances that the system will get caught in a local minimum (like a ball getting stuck in a valley that may not be the lowest point in the landscape). This probabilistic procedure, somewhat akin to "shaking" the system, also alters the weights assigned to network connections so as to reflect better the structure of the outside environment.

The Boltzmann machine, unlike conventional computers that must process information one step at a time, has a large number of processing elements working on a single task at the same time. This kind of "massively parallel" organization, Fahlman and his colleagues believe, is necessary to provide the enormous computational power that some aspects of intelligent behavior seem to require.

"This is a very new theory," says Fahlman. The researchers have done computer simulations of networks with up to 50 units, but much larger simulations are needed to study more realistic situations. Eventually, a Boltzmann machine (right now only a computer program) will be built into a silicon chip for large-scale studies.

"We need a better handle on how big a Boltzmann machine we need in order to get a given complexity of behavior," Fahlman says. "A human brain, set up this way, has probably at least 100 million units."

Fahlman concludes, "Whether what we're talking about here in the Boltzmann machine is in fact what happens in a neural network is an open question. . . . But of the models [available] it comes closest or is least obviously wrong." —*I. Peterson*