Microwaves accelerate chemical extractions

Microwave ovens can do more than reheat a leftover casserole. A Canadian chemist has harnessed them to selectively remove one or more chemicals from a material for analysis. Sometimes the new technology can achieve in 30 seconds what conventional extraction chemistry now requires 24 hours to do.

In announcing a licensing agreement negotiated with Hewlett-Packard Co. of Palo Alto, Calif., Environment Canada, that nation's environmental agency, briefly described the ability of its patented process to dramatically reduce the time, energy, process steps – and costs – associated with solvent extractions. In a few months, says J.R. Jocelyn Paré, the technology's developer, Environment Canada will describe a second major application: the process' ability to selectively vaporize desired chemicals out of materials – such as organic pollutants contaminating water or soils.

"Right now, the holdup on a lot of analytical testing at hazardous waste sites is how long it takes to extract [compounds]," says Philip R. Campagna, a chemist with the EPA Environmental Response Team in Edison, N.J. If this new technology lives up to its promise, "it will become the procedure of use because it's so much faster and has the potential for automation," he adds.

The technique may also facilitate testing of animal tissue. Humayoun Akhtar of Agriculture Canada in Ottawa found that microwave extraction sped his search for growth hormone residues in pig tissue. "It's very promising," he says.

Solvent extraction, a workhorse of process chemistry, diffuses one chemical through some material – a sample of contaminated soil, for example, or an herb from which essential oils will be harvested. As the solvent slowly passes through the target material, it picks up and carries away any soluble chemicals it encounters. After leaving that target – the soil or leaf, say – the solvent will be analyzed to identify what it acquired in transit.

While effective, this process has inherent inefficiencies, notes Paré, head of analytical programs at Environment Canada's Environmental Technology Center in Ottawa. First, the diffusion takes a lot of time – typically hours to a day. And because heat drives the diffusion, energy must be applied throughout the process. But lacking a way to selectively heat only the target, the process unnecessarily heats up the solvent and its container.

Microwaves heat something when a material stops or slows the radiation, causing it to deposit some of its energy. The new process involves immersing a target material in a solvent that is relatively "transparent" to microwaves. The result: Only the target heats up.

Moreover, because microwaves tend to heat quickly and from the inside of the target, energy builds up dramatically, Paré says. When applied to a mint leaf, for instance, the microwaves expel any oil bound in the plant's cells into the solvent bath within seconds.

Conventional solvent extraction also tends to extract more than the desired compound. This often requires repeated cleanup steps to separate out only the desired extract. With Paré's new process, chemists set how much energy they deposit to the target so that only the desired extract emerges.

Since some extract is lost during each cleanup step, eliminating the need for such procedures can reduce dramatically the sample size needed for analysis – in some cases, from 250 grams down to just 10 grams, Paré notes.

In recent years, a high-pressure separation technique that uses supercritical-fluid carbon dioxide (CO_2) as its solvent has become quite popular. This process is relatively fast and can also extract lipids and fats without leaving solvent residues. But the new microwave process can extract in a minute or so what supercritical CO_2 takes an hour to do – without the need for high-pressure equipment and compressors. And because CO_2 is transparent to microwaves, it can offer the same residue-free extractions. Indeed, Paré told SCIENCE NEWS, the marriage of his process and CO_2 as a solvent seems "almost too good to be true."

To carry out selective vaporization, chemists traditionally heat drinking water to below its boiling point and measure the volatile gases that emerge. The process can scout for toxic volatile organics – such as benzene and toluene.

However, water dissipates heat rapidly. Paré reasoned that if he microwaved a beaker of water briefly – raising its overall temperature just a few degrees – the water molecules would immediately transfer their heat to anything nearby. And that proved to be the volatile organic contaminants – chemicals themselves transparent to microwaves.

Because so much water shed heat and so few contaminant molecules picked it up, the organics "felt" as though they were boiling and vaporized. Paré could easily suck them off for analysis.

The microwave process is so rapid it may even allow, for the first time, the on-line quality analysis of products during manufacturing, he says.

Paré expects to report on these and related experiments early next year at the Pittsburgh Conference, a major analytical chemistry meeting. *– J. Raloff*

Milky Way starbirth: Some far-out action

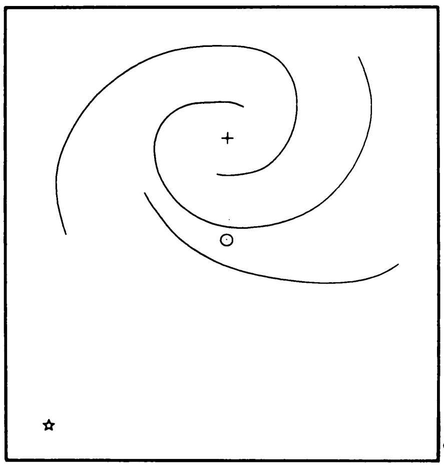
Astronomers have identified the first young star known to hover at the fringe of our galaxy. The finding surprised some researchers, who thought such a remote part of the Milky Way could not harbor young stars because the region now contains relatively little gas and dust – the raw materials needed to form them.

In challenging that notion, the new finding should shed light on the nature of starbirth in an environment drastically different from that in the star-producing regions near the sun, says Stuart N. Vogel of the University of Maryland at College Park. Vogel, Eugene J. de Geus, now at the California Institute of Technology in Pasadena, Robert A. Gruendl of the University of Maryland, and Seth W. Digel of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., report their work in the Aug. 20 ASTROPHYSICAL JOURNAL LETTERS.

The youthful star lies perhaps 90,000 light-years from the Milky Way's center – some 25,000 light-years beyond the visible spiral arms of the galaxy. In contrast, the sun lies well within the visible disk, about 27,000 light-years from the center.

Vogel notes that before he and his colleagues conducted their study, only elderly stars were known to reside at the Milky Way's periphery. Indeed, it seemed unlikely that the small amounts of gas and dust at the galaxy's edge could congregate into clouds of material dense enough for starbirth. In addition, Vogel says, outlying regions of the galaxy contain much lower abundances of elements heavier than helium and much less radiation – conditions common to star formation in the sun's vicinity.

Stephen E. Strom of the University of Massachusetts at Amherst calls the study significant. He notes, however, that it's not surprising to find a young star at the edge of our galaxy. Astronomers have



Vogel

The Milky Way, from above galaxy's disk, shows the galactic center (plus sign), the sun (small circle), and the newly discovered young star (bottom left).