Super pressures heat up superconductors

Normally, when scientists say the pressure is on to find a higher-temperature superconductor, they don't mean it literally. This time, though, they do.

Two research groups, obtaining nearly simultaneous results, now report superconductivity at temperatures above 153 kelvins — a 20-kelvin jump from the former record — owing not to a change in materials but to an increase in atmospheric pressure. The new data emphasize the previously identified, but poorly understood, effect of elevated pressure on superconductors: namely, that higher pressures can ease the free flow of electrons in these specially tailored materials.

In the Sept. 23 NATURE, Paul C.W. Chu, a physicist at the University of Houston, and his colleagues describe a way to achieve superconductivity in a mercury-based material by pressurizing the atmosphere around it. By raising the pressure to 150,000 times that at sea level, the scientists saw a transition temperature — the point at which superconductivity kicks in — at 153 kelvins.

In addition, Chu has told SCIENCE NEWS that his group has just attained a transition temperature of 161 kelvins in the same compound at 230,000 atmospheres and is preparing to publish these results soon.

On the heels of the Chu report comes one from Manuel Nuñez-Regueiro, a physical chemist, and his colleagues at France's National Center for Scientific Research in Grenoble. In the Oct. 1 SCIENCE, they describe their own, similar methods for causing superconductivity in the mercury-based material Hg-1223. They report a transition temperature of 157 kelvins at 235,000 atmospheres.

Both research groups work with nearly identical compounds, variations of a mercury oxide containing barium, calcium, and copper. In May, a research group at the Eidgenössische Technische Hochschule in Zurich announced a then-record superconducting temperature of 133 kelvins using the same material. By pressurizing the mercury compound — which has a layered structure — the scientists now believe they are effectively reducing the distances between the layers and enabling electrons to flow more freely. "My speculation is that the effect is due to charge transfer, plus some other effect we haven't yet identified," says Chu.

He notes that this mercury compound is quite different from other superconducting materials in that the main layer of mercury atoms tends to have an oxygen deficiency. "Not all the sites are filled with oxygen. So when we apply pressure, there's a greater charge-transfer effect," he explains.

Chu says he is encouraged by the findings of the Nuñez-Regueiro group, since they're reporting "essentially the same thing," lending greater credence to the results.

Indeed, the stage is now set for both research groups to nudge this and related compounds to even higher temperatures. "We can do two things to raise the transition temperature of these materials at normal pressure," says Nuñez-Regueiro. "The first is to improve the doping process" by adding other trace elements to improve conductivity. "The second is to introduce chemical pressure, which means chemically mimicking pressure's effects by incorporating smaller atoms into the material," he adds. "This change compresses the material's atomic lattice. It's the same effect as pressurizing with a press. So we're trying these two things now. Just raising the pressure won't do much more."

From Chu's point of view, breaking the 150-kelvin barrier has some practical advantages as well. "For one thing, we can now cool the materials with freon, using ordinary household air-conditioning technology. That alone is a big advantage."

As for the stepwise rise in transition temperatures, he sees another jump yet to come.

"Six years ago, people said the temperature could never go above 40 degrees [kelvin]. People published theories about this," Chu says. "Then the temperature broke 90 degrees. So people stopped speculating for a while. They said, 'Maybe there's no ceiling.' And the temperature rose to 128 degrees. But then, no big advances happened for a long time, no matter how hard people worked. So in 1990 a very prominent chemist said the temperature could never go above 160 degrees kelvin."

"Now we've reached 161," Chu adds. "That's interesting to me. I believe 180 degrees is within sight, although we're not sure how to do it yet. But there's a good possibility." — *R. Lipkin*

Take-home message: No AIDS magic bullet

Almost daily, in venues as varied as chemistry journals and gene-therapy conferences, scientists report progress in the race to understand and quell AIDS. Sometimes, the media and researchers champion advances as leaps forward. Other times, they take a more conservative view, calling results tiny steps no more deserving of headlines and air time than any other research finding.

Fortunately, science eventually provides the perspective to put these advances in their proper places. Unfortunately, that perspective all too often reminds AIDS researchers that HIV, the virus responsible for this disease, can outmaneuver efforts to control it.

Such was the case with an unusual anti-AIDS strategy proposed last February. Researchers studying the effects of various drug combinations on HIV replication in cells grown in the laboratory discovered that sometimes, as the virus evolves resistance to these drugs, it also becomes less able to survive.

To deflect the toxic effects of anti-AIDS medications such as zidovudine (AZT) or dideoxyinosine (ddI), HIV mutates. Each mutation causes a change in a key HIV enzyme, reverse transcriptase. When bombarded with AZT, ddI, and another anti-AIDS compound called pyridinone, mutations change the enzyme so much that the virus cannot replicate, Yung-Kang Chow and his colleagues at Massachusetts General Hospital in Boston reported in the Feb. 18 NATURE. They tested this concept by creating mutant HIV that contained the four genetic changes known to lead to resistance to these drugs. As suspected, the virus could not infect cells.

But the triple whammy doesn't always work, British AIDS researchers now report. Sometimes, viable HIV that is resistant to multiple drugs does evolve, says Brendan A. Larder of Wellcome Research Laboratories in Beckenham, England. In the Sept. 30 NATURE, he and his colleagues describe experiments in which they subjected HIV that was already resistant to AZT and ddI to another drug, nevirapine. Later, they exposed the virus to all three drugs. In one case, HIV with the same mutations as the virus created by the Boston group remained viable, in contrast to the Boston results.

In August, another research team, headed by Emilio A. Emini of Merck Research Laboratories in West Point, Pa., also reported that this same mutant HIV could still replicate. A reexamination of the genetic makeup of the Boston mutant revealed that the virus actually had a fifth, previously unnoticed mutation, says Martin S. Hirsch at Massachusetts General Hospital.

It seems, therefore, that a three-drug attack does not necessarily lead to a less functional enzyme — and thus to a disabled virus. However, treatment with combinations of medications may still prove useful because of the individual effects of each drug, notes Douglas D. Richman at the University of California, San Diego. Clinical trials now under way should reveal whether this strategy stems HIV infection in people, Hirsch notes. — *E. Pennisi*