Better 'listening' through chemistry

More than 100 years ago, Alexander Graham Bell noticed that intermittently shining sunlight on a device made of the element selenium produced a sound that could be heard by a nearby observer. Bell had discovered the optoacoustic effect: the conversion of light (opto) energy into sound (acoustic) waves. For a long while after Bell's experiments, scientists — although they acknowledged its existence — largely dismissed the effect as a curiosity. However, in the past decade, due to the development of an array of specific laser light sources plus sensitive microphone systems that can produce and detect signals much subtler than those Bell observed, an optoacoustic research renaissance has occurred. And scientists are exploring a wide range of applications for the optoacoustic effect, including its ability to signal the presence of trace pollutants.

Now, in research that ultimately may enhance that ability and lead to other applications, Michael T. O'Connor and G. J. Diebold of Brown University in Providence, R.I., have found a way to amplify, by about 10,000 times, the subtle signals produced in a particular optoacoustic system. That system, described in the Jan. 27 NATURE, could be used to determine whether samples contain very minute amounts of chlorine-containing contaminants.

In the usual optoacoustic set-up, the sample is vaporized and placed in a chamber. Then, a laser with a specific wavelength that chlorine can absorb beams the chamber. So, for example, if the sample is contaminated with 2,3,7,8-TCDD — a hazardous substance often referred to simply as "dioxin"—the chlorine on that substance will absorb the light, "jump" to an excited state and eventually release heat upon returning to its normal, relaxed state. "Chopping" (intermittently shining) the laser light therefore causes periodic temperature rises, which in turn result in waves of pressure. It is these subtle pressure waves, which can be "heard" by special microphones, that signal the concentration of the trace contaminant.

Using the new version of this optoacoustic effect, the subtle pressure waves would be greatly amplified, further increasing the ability of the system to detect trace contaminants. This amplification would be achieved by adding to the chamber not only the possibly contaminated sample to be analyzed, but also known amounts of hydrogen (H_2) and chlorine (Cl_2) gas. Then a laser light with a wavelength that could break a chlorine off the sample would trigger a chain of reactions. First, the free chlorine would react with the hydrogen gas that had been added to the chamber: $Cl + H_2 \rightleftharpoons HCl + H$ (Reaction 1). And that freed hydrogen in turn would react with the chlorine gas that had been added to the chamber: $H + Cl_2 \rightarrow HCl + Cl$. Finally, this chlorine would repeat Reaction 1, and the entire process would recycle about 10,000 times. Heat would be released in each step, so a strong set of signals (pressure waves) would result. The total signal emitted would depend on the total amount of chlorine (the known amount added plus the unknown amount in the sample) in this system. Variations of this technique—using different chemical amplifiers—could be used to analyze for other contaminants.

The research also has important implications for the study of chemical reaction "basics." For example, "By monitoring the optoacoustic signal as a function of time it is possible to observe the concentration of the reactants as the reaction takes place," notes A. I. Ferguson of The University, Southampton, in an editorial accompanying the NATURE paper. "A tantalizing possibility is that the speed of the chain reaction could be monitored by observing the optoacoustic signal as a function of chopping frequency," Ferguson suggests; "the range of potential applications of optoacoustic detection is enormous." These potential applications of optoacoustic detection will be explored in May at the "Third International Topical Meeting on Photoacoustic Spectroscopy" in Aussois, France.

Luring engineers back to academia

Colleges and universities have been having a difficult time recruiting and keeping well-qualified faculty in their engineering schools. The problem, lament faculty deans, is that industry can usually offer better salaries, access to more sophisticated equipment and freedom from teaching. A comprehensive survey by the American Council on Education in 1981 pegged 1980 engineering-staff vacancy rates at between 8 and 11 percent, on the average. What's more, industry salaries are so tempting to baccalaureate and masters graduates that the number of Ph.D. candidates in engineering is beginning to dry up.

Presidential Young-Investigator Awards are being developed by the National Science Foundation as one carrot for luring young engineers back to academia. During a briefing Jan. 31, Presidential Science Adviser George A. Keyworth II said it would not make sense for the government to simply hand out checks to make up the salary differential between what academic and industrial engineers earn; so the Reagan administration has taken another tack—enriching the research environment with awards of up to $100,000 a year for five years.

The award is to be applied toward the investigator's research, and is expected to help compensate for the fact that most young researchers (defined as those who received their last degree within the past 7 years) have not "mastered the art of grantsmanship." A substantial share of the money for each award would be donated by an industrial sponsor, the rest by the federal government. Noting that he has already encountered overwhelming enthusiasm when he discussed the idea "with dozens and dozens of companies," Keyworth said he was "confident" sponsors (whose name would appear on the awards) could be found easily for the 200 awards he expects to see made in fiscal year 1984. Eventually he expects to see 1,000 recipients annually; and with 20,000 engineering faculty in the United States, he said, this program could have an important impact on making the academic research environment enticing.

How to identify and choose recipients has not yet been decided, though Keyworth said one could rule out candidates nominating themselves or industrial sponsors making the selection. Though the competition will technically be open to those exhibiting "promise and great talent"—engineers and scientists alike — Keyworth said he emphasized the award in connection with engineers since the critical shortage of faculty in that field "was the principal motivation that drove us to this."

Upgrading science and math education

Three new National Science Foundation programs are aimed at improving the teaching of precollege science and math. Beginning this year, Presidential Awards for Teaching Excellence will go to 100 high school teachers. Certificates will recognize the teachers' outstanding performance; accompanying $5,000 grants will go for upgrading the winners' departments.

Another program due to begin this year will help fund training programs and workshops aimed at tackling substantive issues involving the content and declining quality of science and math in grades 6 through 12. To qualify, programs must involve collaboration between research professionals and school personnel (including teachers), and the recipient must pay half the program's costs — either with money or "in kind" contributions (such as overhead). Accepting proposals in March, NSF requests that anyone interested send self-addressed mailing labels to its Office of Scientific and Engineering Personnel and Education, NSF, Washington, D.C. 20550 for copies of the guidelines.

Most sketchy of all is a program offering financial assistance to precollege science and math teachers who are willing to invest substantial blocks of time — including a year's sabbatical for college study — to upgrade their science or math skills. Announced Jan. 31, the program will begin in FY 1984.