

The World of Separation Science

"THE SMARTER THE CHROMATOGRAPHER, THE SHORTER THE COLUMNS"*

Robert Stevenson

In late June 1999, more than 300 scientists gathered in the high mountains of Park City, UT, for the 21st International Symposium on Capillary Chromatography & Electrophoresis. Dedicated to the extreme, they rejected the magnificent mountains and warm spring sun to talk shop on capillary technology in chromatography and electrophoresis.

Prof. Milton Lee (Brigham Young University, Provo, UT) opened the symposium with the sad news that Prof. John Phillips (Southern Illinois University, Carbondale, IL) had passed away a few days before. In addition to the tremendous personal loss, John's passing led to somber reflection in the GC segment about having a critical mass of researchers developing and promoting the field. Prof. Csaba Horváth (Yale University, New Haven, CT) pointed out that GC is a billion dollar per year business. However, the number of scientists, especially in American academic institutions, is not sufficient for continued, vigorous R&D, especially research. Some would argue that GC is mature, with not much opportunity or need to improve. These are the people who came to Park City and went hiking or swimming. If they had been in the lecture halls, that would not have been their response.

The meeting started with Prof. Carl Cramers (Eindhoven University of Technology, Eindhoven, The Netherlands) presenting the M.J.E. Golay Award to Prof. Horváth. The award recognized Prof. Horváth's long and numerous contributions to separation science, especially in the liquid phase. An engineer by training, Prof. Horváth has helped firm up the mathematical infrastructure of chromatography, particularly liquid chromatography. He has recently turned his attention to capillary electrochromatography (CEC). While CEC is supposed to be the combination of the best of high-performance capillary electrophoresis (HPCE) and HPLC, the physics of the process is much more complex than either alone. But Prof. Horváth is pushing back the shades of ignorance on old concepts, such as electrical double layer and its contribution to electroosmotic flow. It is probable that CEC will be a sensitive technique, used to probe in detail the physics and chemistry of liquid-solid interfaces. One example is the effect of percent acetonitrile (ACN) on retention. In reversed-phase liquid chromatography (RPLC), increasing the % ACN decreases resolution in a well-behaved (usually monotonic straight lines) manner. In CEC, the effect of ACN concentration on retention time is not even monotonic. It shows local maxima and minima, which must be due to regions where one mechanism dominates, then falls off. This will all have to be analyzed. In the meantime, several lectures and posters demonstrated that CEC is being adopted for applications in which low cost, high speed, and resolution are of interest.

Prof. Horváth also pointed out that CEC might really be an interesting preparative technique since one can envision a separation cell similar to thin layer chromatography (TLC). This also might enable making parallel runs in lanes similar to TLC or gel electrophoresis. Interesting! He went on to show that large-pore-diameter particles offer very high efficiency since the "C" term is very small in CEC.

CEC

Prof. Milos Novotny (University of Indiana, Bloomington, IN) used CEC for the high-resolution

analysis of lipids. He used continuous-bed or monolithic capillaries that generated 400,000 plates/m. The separations provided an intraday RSD for retention time of $\pm 1\%$. Interday RSD was $\pm 2.5\%$. He also pointed out that for the lipids, MS-MS would be a powerful detector.

LC-MS

Prof. Karen Markides (Uppsala University, Uppsala, Sweden) presented a very interesting lecture on the practical points of nanoscale inlets for capillary separations to mass spectrometers. The first tip was to include 0.1 mM dodecylamine in the run buffer. This removes much of the background interference with other buffer components. For small-scale electrospray ionization (ESI), she wanted to avoid dilution with sheath liquids, which many use to provide electrical contact at the spray tip. Prof. Markides found that plating the tip with chromium and then gold produced a tip that was suitable for electrospray for more than 100 hr. It is even simpler to coat a thin film of epoxy on the outside of the capillary tip, then roll it in colloidal gold, which she referred to as "fairy dust." This produces a robust and inexpensive electrode for ESI. Prof. Markides was asked how long this lasts. She had had only weeks of experience with the process, but it had not failed yet.

Fast GC

To me, selectivity was the leading or most noteworthy theme at the meeting, but the Belgium dioxin/PCB (polychlorinated biphenyl) incident was receiving the most attention in the global press, and Prof. Pat Sandra (University of Ghent, Ghent, Belgium) was right in the middle of it, even from Park City. The problem started with the hatching of many deformed chicks. An unusually high number did not even hatch. Belgian health officials started a quiet investigation, quickly focusing on the dioxin contamination of chicken feed. However, dioxin analysis takes a week and \$2000/sample to perform. Plus, the Belgians are very proud of their food. So, the ministers sat on it while trying to figure out what to do. They came to Prof. Sandra, who asked a few questions, as good analytical chemists are trained to do. He hypothesized that if dioxin was found, it may have come from PCB contamination, probably from heat exchanger fluid used in power transformers, etc.

Prof. Sandra was able to find a retention sample of the chicken feed and found 50,000 ppm PCB. This confirmed the suspected contamination with arochlor. He told the ministries, who reacted with disbelief. During this time, the PCBs spread through the food chain. One complicating factor is that Brussels is also the *de facto* head of the European Union. Well, the European Commissioners finally found out, and went after the Belgian officials, at least two of whom were fired. Then, the trade groups got into the act. For example, the Germans found that one sample of Belgian meat contained 2.0 pg of dioxin, while the composite of German meat had 1.7 pg. It was immediately proposed that Belgian meat be banned for sale in Germany since it had "much more contamination." I can understand the difficulty in explaining to some farmers that 0.3 pg is probably not significant, especially if they can use this difference to get a better price. Even worse,

the significance of 2 ± 0.3 pg is not known in humans. Many doubt that the levels determined in rodents are a good predictor of the effect on humans.

But back to fast GC. The method Prof. Sandra used for PCBs took about 1 hr. Belgian authorities wanted to analyze tens of thousands of samples . . . immediately. Prof. Sandra looked at the problems and decided to use a short, 10-m column with 100 μm i.d. and thin, 1- μm film. This reduced the run time to 10 min. The resolution is more than required for identification and segregation of definitely (not borderline) hot and cold sample. Meanwhile, the records of the feed origin and distribution were analyzed, which helped to locate farms that had received the feed. Thus, one only needs a quick test to confirm that the majority of the food products contain only background levels.

GC

The capillary chromatography meeting has been one of the only and certainly the best forum to communicate advances in the technique. With the advent of capillary columns, especially fused-silica capillaries, chromatographers slowly abandoned the myriad of stationary phases in favor of a few with tremendous numbers of plates. This has worked well, but this year at the capillary chromatography meeting, the emphasis returned to selectivity. Selectivity is obtained with programming the stationary phases or with increasingly powerful mass spectrometers. In many cases, the MS adds a third or higher dimension, enabling analysis with only limited resolution.

Fast GC played a strong supporting role this year. Short capillaries with 100 μm i.d. and a thin, 100- μm film were used for fast primary separations or occasionally in second dimension in 2-D GC. Scientists at **Tekmar-Dohr mann** (Cincinnati, OH) explained that their fast GC injection system had improved resolution and detection limits as expected, since the peaks are narrower. But some laboratories are using the improved speed to run replicates for improved precision. The long run times of conventional injection and column technology often made running replicates impractical. But the ChromatoFast 500 (**ChromatoFast**, Ann Arbor, MI) typically reduces run time by 6-10 times. Thus, even running triplicates, the productivity is at least doubled.

The instrumentation and computing power are now able to support these high-resolution modes, making complex methods easy to understand, develop, and operate routinely, even in a manufacturing environment. From my perspective, it seems that the column technology is rapidly catching up with the instruments. However, experience shows that the equilibrium will be perturbed by an unexpected advance in columns or instrumentation, setting off another design cycle.

Time-of-flight (TOF)-MS

Fast GC with TOF-MS detection was clearly the most important new development in instrumentation at the meeting. **LECO** (St. Joseph, MI) featured two well-attended seminars to expose the commu-

*Jaap De Zeeuw, June 1999, at the 21st International Symposium on Capillary Chromatography & Electrophoresis.

nity to the powerful capability of the Pegasus II and its data station. **Sensar** (Provo, UT) showed the Jaguar TOF-MS. Both the Jaguar and Pegasus offer speed sufficient to follow peaks in fast GC. (Subsequent to the meeting the Jaguar product line was sold to **LECO**.) George Reiner presented a lecture that described how GC-TOF-MS enabled a team at Exxon Research Center (Annandale, NJ) to reduce chromatography cycle times, including cooldown, by 75%. The capillaries were 10 m or shorter. The new fast technology has been used for the analysis of petroleum fuels by hydrocarbon type (paraffins, isoparaffins, aromatics, naphthenes, olefins, or PIANO) in less than 10 min compared to the prior 90-min cycle. He reported that the combination of TOF-MS and short, thin capillaries has greatly speeded up methods development.

The Jaguar was originally designed for capillary electrophoresis, since that was the high-interest field at the beginning of the program. However, the development program was longer than planned, and gas chromatographers are searching for faster detectors to keep up with today's narrow peaks. Plus, there may be a patent problem with HPCE-MS. Battelle Pacific Northwest Laboratory (Richland, WA) has obtained a patent on HPCE-MS and is itching for a fight. With such a mass of prior art in GC-MS, LC-MS, and indeed supercritical fluid chromatography (SFC)-MS, it is difficult to see how HPCE-MS is not obvious to scientists skilled in the art. In any event, it appears that HPCE's loss will turn out to be a gain for fast GC.

The Jaguar features orthogonal injection to a 50-cm drift tube terminated in an array of 36 detectors. The array of detectors is able to extend the dynamic range. A large detector area increases the chance of catching ions when only a few are present. The lower detection limit of the Jaguar is listed at 100 attomoles. When many ions are present, saturation is less of a problem. Thus, the Jaguar boasts both improved detection limits and high dynamic range. **Sensar** reports that six have been sold in the last few months, including one to Oak Ridge National Laboratory (Oak Ridge, TN).

LECO uses reflecting ion optics to double the length of the drift tube. It is actually better than that, since the reflecting optics act to focus the ions on the second collector. Ions from the source do not all move with the same velocity, since some have velocity components either parallel or antiparallel to the field when the ion gate is opened. However, ions with higher than average velocity penetrate deeper into the field of the reflectron, which delays them a bit. Ions that have significant velocity components antiparallel to the field penetrate less deeply into the reflectron and hence emerge more quickly. The net effect is that the ions are focused, which improves the mass resolution at the detector. **LECO** has placed about 20 Pegasus detectors in the past 30 months, including one in the laboratory of Prof. Richard Sacks (University of Michigan, Ann Arbor, MI).

Prof. Sacks performed an evaluation of the Pegasus, including the data system that supports the detector. The detector can accumulate 5,000 full run spectra per second. Even bundling every 50 provides more data than mortal minds can digest; hence, the data system is essential. Prof. Sacks used the selectivity programming system described above to shift retention of two peaks. Chromatographers are often interested in knowing if a peak is actually a composite of two or more compounds. Coelution is a real problem in the analysis of petroleum fuels and some environmental samples. Plus, in legal situations, lawyers have a field day asking expert witnesses if they are sure this peak is really, totally the identified compound. Clearly, the more resolution the better, but coeluters are often more than just a philosophical problem.

Prof. Sacks studied this with his selectivity pro-

gramming system, since it enabled fine-tuning of the separation just by adjusting the intermediate pressure point between the two columns. One column is very polar, such as a carbowax, and the other is nonpolar. The columns are connected in series, but the junction also contains a T-piece that allows the pressure to be controlled with an electronic pressure controller. The effect is dramatic. With only small adjustments, the elution order of closely spaced peaks can be changed. And there is about a 0.2-psi range in which the peaks coelute. Prof. Sacks was able to resolve the peak into its two components, provided the retention times of the two components were separated by 2 Hz. The accumulation rate was 200 Hz; thus, the peaks only had to differ in retention time by 0.01 sec.

Vacuum GC

Dr. Jaap De Zeeuw (**Varian-Chrompack**, Middelburg, The Netherlands) is one of the more colorful lecturers in GC. He really gets into it, and if you listen carefully, he loads the lecture with "zingers." He does bring an independent viewpoint. Vacuum GC is a case in point. By inserting a restriction column just after the injector and then using a wide-bore capillary (530 μm i.d. \times 10 m) coupled directly to the high-vacuum MS, he is able to run the separation at less than atmospheric pressure. In a vacuum, the optimal velocity for the capillary increases by more than 10 \times (to 100 cm/sec), plus you can run higher-boiling compounds. In one case, the run time for U.S. EPA Method 524.2 Volatile Organics was completed in 8 min. Dr. De Zeeuw added that vacuum GC has another advantage that is especially important with higher boilers: The separations are usually run at a temperature about 80 $^{\circ}\text{C}$ lower than with normal injection. This is not surprising when one considers that it is analogous to vacuum distillation.

Practical GC

Several lectures touched on practical aspects of GC. Many extolled the advantage of using hydrogen as the carrier gas. The problem has been about the hype over its flammability, since no one can forget the Hindenberg. Still, hydrogen is really benign in small quantities, especially compared to other chemicals in the laboratory. Hydrogen generators are now very inexpensive and even more reliable. Plus, a GC uses hydrogen for the flame ionization detector (FID), so the gas supply needs to be there anyway. But the chromatographic resolution improves 40% due to improved mass transfer.

Dr. Domenic J. Barsotti (**DuPont**, Deepwater, NJ) discussed the problems of cycle time in temperature-programmed GC. After one optimizes the capillary, the cooldown time is the next area to focus on to improve productivity. Isothermal operation is the best, provided one is not wasting time for some late eluters. But today's complex samples often require temperature programming. This is fine, but ovens do not cool down quickly. A chemist from **Agilent Technologies** (Palo Alto, CA) described a system in which a refrigeration coil was installed ahead of the inlet for the oven air. Others dump liquid CO_2 into the oven. But Dr. Barsotti pointed out that if the column can be adjusted so that the initial temperatures are higher, the cooldown time is actually reduced. **Tekmar-Dohr mann** offers programmed-temperature injection devices.

Changing columns in GC-MS instruments is seldom pleasant. Usually, the ion source must be cooled down and the vacuum bled off before the column is removed. What happens if the capillary just breaks near the MS inlet? The problem, of course, is that when air gets into the ion analyzer, it can oxidize the metallic parts. Plus, the vacuum pump oil can get into the ion source. **SGE** (Austin,

TX) has developed an accessory called the ms-NoVentTM that provides a helium purge of the ion source that prevents air from getting into the ion source. One can even condition the new capillary by temperature cycling in the GC before connecting the outlet end to the MS inlet. The accessory is available in two versions: one for the HP 5890 and the other for the HP 6890 GC (**Agilent**).

Macherey-Nagel (River Vale, NJ) introduced a new series of capillaries for GC that use autoselectivity to improve resolution. Autoselectivity is the process by which the analyte induces a counter dipole in the stationary phase, which improves retention. The columns were developed in Switzerland, but are manufactured and distributed by **Macherey-Nagel** of Easton, PA. Crosslinking of the stationary phase provides low bleed, making the columns ideal for MS detection, even at 340–360 $^{\circ}\text{C}$. I asked what the stationary phase looked like. I got a smile and was told that it did not contain CN or CF_3 groups, which probably contributes to the high-temperature performance. The selectivity of the δ -3 phase is similar to SE-54 and OV-1701. The δ -3 phase has a higher concentration of polarizable groups. It is similar to OV-17 and OV-210.

Industrial odors are difficult to track down for many reasons. The fact is that the mixture may smell quite differently than the components. A report from Roswell Analytical Science and Technology Center for **Kimberly-Clark Corp.** (Roswell, GA) used a GC equipped with a sniffer for GC olfactometry combined with a parallel MS to identify offensive compounds. Most compounds are below the odor threshold in GC; therefore, the samples were concentrated in a sorbent trap or with solid-phase microextraction (SPME) prior to analysis. The system was applied to a wood pulping process that had a history of serious odor problems. The offending chemicals, mostly C_7 – C_{10} aldehydes, were identified and traced to the processing conditions in the sheet dryer. Process changes were made, including lowering the temperature of the dryer; the problem has not recurred in 18 months.

Varian's (Palo Alto, CA) new pulsed flame photometric detector (PFPD) is an interesting extension of conventional FPDs. Changing the flow rate of the combustion gases does not support a continuous flame. The flame is pulsed on for short periods to give the signal and is then quenched. The net effect is to improve the signal-to-noise ratio. This can be exploited to allow the oxidizable gases to build up with time, and then they are ignited, which sends off a pulse of light, as in the conventional FPD. After the oxidizable gases are depleted, the flame self-terminates, and the analyte gases build up again for a repeat cycle. The design was developed originally by Prof. Aviv Amirav (Tel Aviv University, Tel Aviv, Israel). He showed that the PFPD is also capable of detecting Sn, As, Mn, Se, and Ge, as well as the standard sulfur and phosphorus compounds.

Ultrahigh-pressure LC

Traditional designs of HPLC instruments have used instruments designed for about 6000-psi maximum pressure. A few have ventured as high as 10,000 psi. This was adequate for several reasons. The column technology was not very advanced, and the systems solved most analytical and preparative problems. But the interest in fast GC is spilling over to HPLC. Laboratories around the globe are overloaded and bosses demand improved throughput. Plus, there is a need for higher peak capacity in generic separations. The MS cannot do it all by itself.

Thus, there is research interest in exploring LC at higher pressure. The math is not very attractive, since the pressure required goes up exponentially

as particle size decreases and the optimal velocity increases. But with a capillary, one can possibly minimize the overall force, since the cross-section will be small. This was described by Dr. M. Arthur Moseley from Prof. Jim Jorgenson's laboratory (University of North Carolina, Chapel Hill, NC). Dr. Moseley was interested in developing a sensitive system for identifying proteins starting with spots from 2-D gel electrophoresis. The spots were excised and digested. The peptides were first analyzed by matrix-assisted laser desorption ionization (MALDI)-TOF. The ones that were not identified on this basis were then run as a proteolytic map on an ultrahigh pressure capillary LC coupled to a TOF-MS. The system used a 25-cm-long capillary packed with 1.5- μm nonporous silica (MICRA Scientific, Darien, IL), which produced 200,000 plates at 1 mL/min. The pressure was 14.8 kpsi. This produced useful spectra with a few femtomoles of protein. μHPLC was found to be 20 \times better in lower detection limits than nanospray LC, and much more reproducible. This precipitated much discussion among the vendors at the meeting. Several appeared to be exploring the subject. It will be interesting to see if this kicks off a psi race in the research-grade instruments.

Lab-on-a-chip

Detection is an emerging problem, as scientists develop the lab-on-a-chip (LOC) technology. Path-lengths are too short to be useful, even with fluorescence. Prof. Takehiko Kitamori (University of Tokyo, Tokyo, Japan) described photothermal detection. Detection limit was as low as a single molecule in the detection volume. Since the system was flowing, one can at least talk about how many molecules per second, which will give even lower concentration.

Prof. Kitamori showed 0.6 molecule as the lowest reported value. Photothermal detection uses two lasers. One is focused on a small sample volume. The wavelength is chosen so that the sample will absorb the light. The other laser probes the same sample volume with a highly focused beam. In the absence of absorbance, the beam is not perturbed and the baseline is drawn. But if a molecule enters and absorbs light, then it also undergoes a rapid decay, in which the light is converted internally to heat. This heat is rapidly dissipated to the solvent around the analyte, which defocuses the probe laser beam, producing a peak in the chromatogram. Photothermal detection has been used for very thin-film electrophoresis gels as well as flowing systems. Its advantage is that the sample volume is very small, about a femtoliter. Prof. Kitamori also pointed out that the LOC is benefiting from the scale factors that favor rapid mixing and rapid reactions with micron-sized reaction chambers.

Prof. Jed Harrison (University of Alberta, Edmonton, Alberta, Canada) followed with information on the evolution of the μTAS concept, where there were fixed positions for electrodes and waste lines. Standardizing the format to a limited extent facilitates designing the LOC so that the external circuit element, such as pipettors and power supply electrodes, can load and operate the chip. In many cases, the wells for the electrodes are larger than the channels. Thus, it is prudent to carefully design the interconnecting channels. Recently, Prof. Harrison supervised the design and construction of a six-channel, optical scanner.

Several contributions from the Sandia National Laboratory (Livermore, CA) showed interesting activity there. In one contribution, liquid was simply pumped through a short capillary column packed with 1.5- μm particles. The end of the capillary was placed against an electronic pressure transducer to see how much static pressure could be generated: 4000 psi in one case. The pressure equilibrium was

generated by electroosmotic flow pushing against the transducer, and pressure-induced reversed flow.

GC-MS

Compared to off-line extraction, large-volume injection saves time and, if done correctly, reduces discrimination. This was the gist of a poster presented by Dr. Jessie Butler and colleagues of the **Finnigan** division of **ThermoQuest** (Austin, TX). Looking at semivolatiles in water, they chose the new large-volume on-column injector (LVOCI) combined with the GCQTM Plus ion trap mass spectrometer. The MS was designed to monitor the foregone pressure during the filament delay time for monitoring the solvent peak. This avoids loading up the source or the MS with solvent, which would decrease performance on later peaks and increase the need for cleaning. Plus, the injector avoids heat cycling during the injection step.

The retention gap is the key to the success of the LVOCI technique. The gap consists of 15 m of 0.53-mm fused silica. The last 3 m of the gap are coated with diphenylsiloxane. The entrance end of the analytical column is inserted into the exit end of the retention. The junction is actually located in a T-piece with the base of the T being controlled with a solvent vapor exit (SVE) valve. The SVE is vented to atmosphere at the start of the injection sequence. A computer-controlled timer closes the SVE after most of the injection solvent has been vented. The remainder (typically about 5 μL) is thus diverted to the analytical column. The most volatile analytes are concentrated in the narrow residual solvent band, which provides very narrow peaks on the low k' peaks. Narrow peaks are desired, since they improve resolution and detection limits. The system software provides an initial forecast of the timing sequence to operate the LVOCI.

The performance of the injector was evaluated with a concentrated sample injected without splitting with a 100-fold dilution injected with 100 times the volume. The expectation is that both should be the same. The results for about 38 compounds showed a maximum deviation of 29%. The median value was 104% compared to a theoretical 100%.

Sample preparation

A good question presented to the audience at a discussion session on sample prep was: "How many of you are limited or constrained by inadequate throughput of your instruments?" Only one hand went up. Then the presenter asked: "How many are constrained by sample prep?" About 80 hands went up, which was about 80%.

There were many papers on sample prep at the meeting. One of the problems in reporting on them is that they all seem so diverse and specialized that it is difficult to weave a common theme. Dr. Joe Levy (**Levytech**, Gibsonia, PA) discussed supercritical fluid extraction (SFE) with numerous examples showing excellent recovery. The power of SFE is that the pressure can be used to control the selectivity. It is usually not hard to find conditions that provide good recovery of the analyte and leave other material behind. He also demonstrated that the SFE of petroleum is complemented by GC equipped with the Pegasus II TOF-MS detector.

Dr. John Berg (**Varian**, Walnut Creek, CA) and others showed that SPME is growing into a field of its own with numerous sampling protocols, including direct immersion; headspace; timed adsorption; and a variety of phases for the adsorber, including ion exchangers, imprinted polymers, poly dimethyl silane (PDMS), as well as polyimide.

One poster reported the development of an immunoaffinity extractor for phenylurea herbicides by a group in the Laboratory of Environmental

Analytical Chemistry (Paris, France). The extracting phase was placed in a 20 \times 1 mm pre-column. The calibration line was linear over the range of 0.1–5 $\mu\text{g/L}$. The limit of detection (LOD) was 10 ng/L in drinking water. Extraction efficiency for all phenylureas studied was over 80%. The main advantage is that the huge peak at the beginning of the chromatogram is absent, since the immuno-adsorbent does not retain these matrix elements.

ATAS USA (Whittier, CA) presented a complete package for sample preparation and injection for fast GC. Called the Focus, the system includes modules for automated liquid-liquid extraction and on-line derivatization followed by injection, even with samples as large as 150 μL . The Focus utilizes a robotic arm to address the various modules, such as the vibrating extractor and trays for sample and reagents.

ATAS also exhibited the Optic 2, which is claimed to be the world's most powerful GC injector. The programmable injector is the key to the system. The injector condenses and concentrates the samples on a wide-bore quartz liner, then blasts them off when the liner is heated rapidly. This can be as fast as 16 $^{\circ}\text{C}/\text{sec}$. The result is that the peaks are very narrow, even at the front of the chromatogram; plus there is little sample discrimination, even up to C_{100} . Applications notes describe the use of the Optic 2 for the chromatography of semivolatiles according to U.S. EPA Method 8270, and for the measurement of volatile organics in air.

Credits

Park City is a beautiful spot for a small meeting such as this. The mountains are beautiful, and the Olympic Park Hotel is ideally situated across the street from the state-run liquor store. This was especially appropriate since the hotel was in the midst of renovation and the food and beverage facilities were closed. Frequent visitors to Utah know that many of the laws are years behind most of the country.

Construction in the Salt Lake City and Park City areas was running at a blistering pace in anticipation of the Winter Olympics. Major highways were being renovated, which made driving a bit unpredictable. Still, Ms. Joy Wise (Symposium Coordinator) managed hundreds of details, including getting a tent for the posters and working with the construction crews to keep the meeting room quiet and have the refreshments in place on time. Prof. Milton Lee served as General Chairman. He was assisted by the Scientific Committee. All worked together to make the meeting a technical success.

I'd also like to add a personal plea to the many people who are experimenting with Microsoft PowerPoint for making the visuals for the lectures. The colors on the video screen often are not readable, even in the front row. Red on blue or green is simply not readable. Also, some of the color-coding in pie charts and graphs does not correlate well. The colors in the key seem to be different than in the lines. This year, I really began to appreciate black on clear overheads because they were readable.

The 22nd International Symposium on Capillary Chromatography was held in November 1999 in Japan, and a review will appear in *American Laboratory News* in the near future. Next year, the 23rd Symposium is scheduled to return to Riva del Garda, Italy, June 5–10, 2000. More information can be obtained from Prof. Pat Sandra, fax: (32) 56 204 859; e-mail: ric.sandra@ven.be.

Dr. Stevenson is Editor of Separation Science for International Scientific Communications, Inc.