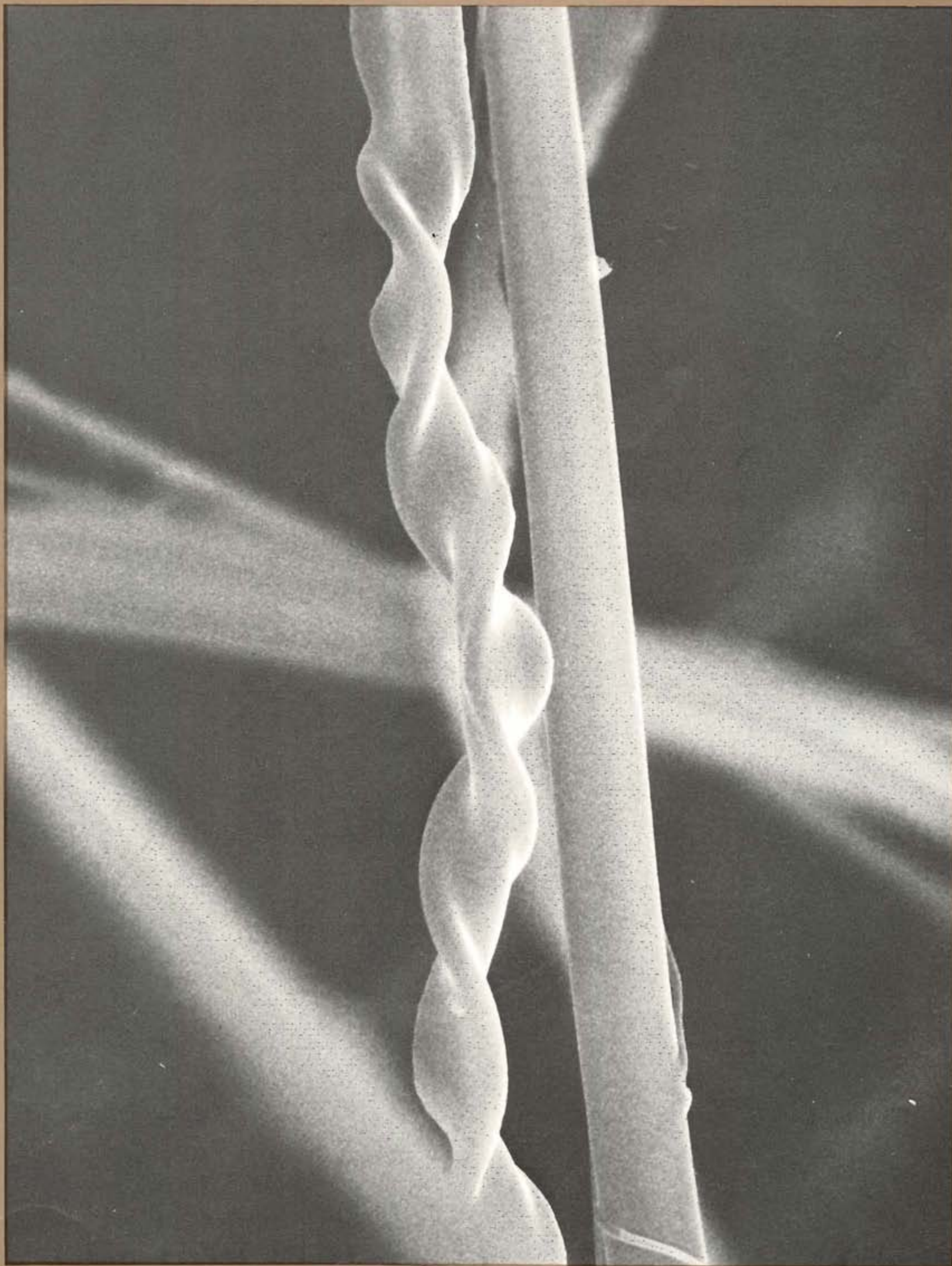
OU is in the microfibers business! The extremely thermoplastic fibers in this scanning electron micrograph were made with unique equipment available only in CEMS.

OKCHE

SCHOOL OF CHEMICAL ENGINEERING AND MATERIALS SCIENCE THE UNIVERSITY OF OKLAHOMA



PP MELT BLOWN 5-2 5-15-86

010.0 u

10-2 20.0 15 000 011

OKCHE

Contents

Winter 1987–88

2 Notes from the Director
3 OU Centennial Commission Announces Campaign
4 OU Vice President David A. Burr Dies
4 New Professorship Endowed in Engineering
5 New Energy Center Director Appointed
6 Billy Crynes Named New Engineering Dean
6 Exxon Grant Facilitates Computer System Selection
7 OU CEMS Research Update
22 Distinguished European Presents 13th Annual Harry G. Fair Lecture
22 CEMS Master's Candidate Awarded Kodak Fellowship
22 Seminar Series 1986–87
23 Program of Excellence Scholarships and Achievements Awards 1987–88
23 Outstanding Paper Presentation Recognized by AOCS
24 New Alumni 1986–87
24 Alumni Notes

OkChE Magazine
Published by
The University of Oklahoma
School of Chemical Engineering
and Materials Science
100 East Boyd, Room F-339
The Energy Center
Norman, Oklahoma 73019

OkChE is a production of University Publications. Managing editor, Professor Jeffrey H. Harwell; assistant editor, Rick D. Wheeler.

This publication, printed by University Printing Services, is issued by the University of Oklahoma and authorized by the director of CEMS. 2,200 copies have been prepared and distributed at no cost to the taxpayers of the state of Oklahoma.

Notes from the Director

This issue of *OkChE* magazine focuses on research activities within our school. It serves the dual purpose of informing prospective graduate students of our research activities and of reporting to our alumni and friends the current status of those activities.

This past year the university initiated a process of program review in which each academic program will undergo an internal review every five years. CEMS was selected as one of nine programs to be examined in the first year. The self-analysis involved in the review enabled us to take stock of where we stand within the university and among chemical engineering programs nationally.

Some interesting indices that we found included the fact that our undergraduate students, on average, are among the best in the university. Average ACT scores for entering freshmen in the fall 1986 were 26.5 in ChE, 24.0 for the College of Engineering and 21.1 for the university.

Over the last three years CEMS faculty have brought in more than $2.2 million externally for research. In 1986–87 alone, the school received over $1 million in new contracts and grants. Research contract and grant expenditures per faculty member were over $65,000, making our externally sponsored research budget greater than our university budget for the third year in a row.

Peer-reviewed technical publications by the faculty have increased substantially in recent years, approaching four per faculty member. This research and publication activity places us among the top-ranked chemical engineering programs in the nation.

The program review was just the first step in a process of strategic planning that was initiated this fall. The planning process, called "Strategy for Excellence," is designed to replace the usual across-the-board incrementalism with a resources allocation and budgeting process that tracks institutional goals for excellence. We have every reason to believe that the School of Chemical Engineering and Materials Science will be one of the units targeted for additional resources in the process.

This new approach to budgeting within the university comes at an appropriate time, since our state regents are moving away from formula funding for higher education and propose to adopt program funding based on institutional mission and comparative program costs for qualitative competitiveness. Perhaps now, OU will be budgeted as a comprehensive university should be funded.

I am pleased to announce that we have hired Lance L. Lobban to fill one of our vacant faculty positions. Lance just completed doctoral work at the University of Houston. He earned his undergraduate degree in chemical engineering at the University of Kansas, and we welcome him.

With Rex Ellington's retirement this past spring, the employment of Lance brings our faculty strength back up to 11, still two short of our budgeted positions. Rex, though technically retired, is teaching part time for us this fall semester. We have received permission to recruit to fill one of the remaining faculty vacancies, and we are initiating the recruiting process now, with the expectation of filling the position by August 1988.

Our OkChE Board of Directors met here on Sept. 11. In this meeting, OkChE board members and CEMS faculty developed plans for a project for OkChE alumni and friends' participation in the celebration of OU's Centennial. Details of this project, to be conducted in concert with the Centennial campaign, will be sent to you within the next few weeks.

During the meeting, we took the opportunity to obtain a photograph of the group at that time. See how many of your friends you can recognize in the accompanying photograph without reading the caption.

Raymond D. Daniels
Professor and Director

In attendance at the Sept. 11 OkChE Board of Directors meeting were (left to right): Ed Lindenberg, past chairman; F. Mark Townsend; Bob Purgason, chairman; M.F. "Wirg" Wirges; Ray Daniels; David Kurtz; Tom Sciance, vice-chairman; Gary Kilpatrick, secretary/treasurer; Mary Anderson; Verne Griffith, Jr.; and K. C. Purgason. (Not pictured are Edward D. Holstein, Garmon O. Kimmell, Don W. Green and Charles R. Perry.)

OkChE Contributions

Alumni Contributions	$ 7,870.00
President's Partners	2,275.00
Associates Program	7,526.04
Graduate Program	230.00
Company Matching	23,624.10
	$ 41,525.14

OkChE Expenditures

Magazines	$ 6,716.42
Scholarships	10,929.46
Student Activities	1,690.70
Board Meeting Expenses	549.00
Faculty Presentations	90.00
	$ 19,975.78

OU Centennial Commission Announces Campaign

The University of Oklahoma Centennial Commission has announced a $100 million Centennial campaign to be conducted in association with plans for the observance of OU's 100th anniversary. The campaign focuses on several goals to bring additional quality to OU academic programs and facilities. OU already has raised $11.5 million toward this goal.

The university hopes to endow 40 positions on the Norman campus and 12 more at the Health Sciences Center to enable OU to attract outstanding teachers, scholars and researchers.

The endowed chair is a teaching position funded by an endowment, which enables the principal sum invested to remain intact while the interest it earns is expended to pay the full salary of the professor holding the position. Interest over and above salary costs can be used for clerical assistance, research programs and graduate support scholarships.

Named professorships can fund substantial portions of positions and can evolve into chaired professorships if principal investments increase at a later time.

Endowments for lectureships will provide honorariums for noted authorities and artists to visit the campus for brief periods of time.

Each endowed chair requires a principal of $750,000 to generate the necessary interest income, while named professorships can be established for $300,000. Lecture/visiting artist endowments require $50,000.

To attract the nation's best scholars, the university plans to establish an endowment for undergraduate, graduate and post-doctoral scholarships, with an emphasis on graduate support, to be awarded to students in all colleges on the Norman campus and at the Health Sciences Center.

Campaign goals include an endowment to establish an Honors College to provide integrated and coordinated programs geared to create a more challenging educational process for gifted students.

To enhance OU's literary resources, a library acquisition endowment is being sought for purchase of additional books and periodicals to sustain growth of collections of Bizzell Library and for preservation of present resources and materials, which deteriorate after 30 to 40 years. Funds would also provide an integrated computer system to make resources more accessible to faculty and students.

Another provider of OU literary resources, the University of Oklahoma Press, has applied for and received a grant from the National Endowment for the Humanities in the amount of $150,000. The university must match this challenge grant on a three-to-one basis for a total of $450,000 in private funds.

Centennial campaign funds would endow the Museum of Art to enable it to be competitive on the national scene in securing major exhibitions and increase the research potential of the permanent collection through significant acquisitions.

The purpose of an endowment to be called the Second-Century Fund is to provide flexible funds, one of the most critical needs at OU, to enable the university to provide seed money for new ventures, to take advantage of unexpected opportunities or to meet unanticipated but critical needs.

Campaign projects include completion of the Energy Center and the Stanley B. Catlett Sr. Music Center; expansion of the Huston Huffman Physical Fitness Center; and renovation of the Bizzell Library Reading Room for use for seminars, conferences, receptions and other important university events. Proposed new construction includes a facility to house and protect OU's valuable Western History Collections and the Oklahoma Museum of Natural History, a research tower at the Health Sciences Center and a child-care facility.

Other areas within the university where private contributions can have an important impact have been designated as targets of opportunity, providing a framework for donors who may wish to assist a particular college, department or program. Such target areas include funding construction of an addition to Copeland Hall to allow space for increased enrollment and to add state-of-art equipment; funding for the Committee for Biotechnology, which coordinates research efforts in molecular biology, to make possible collective efforts and major seminars; funding for international prizes in fine arts and science and technology; an addition to

continued

Planning the celebration of the University of Oklahoma's 100th anniversary in 1990 are members of the Centennial Commission, which is comprised of alumni from throughout Oklahoma and 10 states.

OU Vice President David A. Burr Dies

Sarkeys Foundation Endows Chair in His Honor

Longtime OU administrator David A. Burr died Aug. 6 in Norman Regional Hospital at the age of 62. Burr, who came to OU in 1948, was vice president for university affairs when he died.

In honor of the late OU vice president, the Sarkeys Foundation of Norman has donated $750,000 to endow the David A. Burr Chair in Letters at OU as part of the Centennial campaign, President Frank Horton announced Oct. 24 at the meeting of OU's Centennial Commission.

"Nothing brings increased quality to our educational programs as quickly as the endowed chair," Horton said, noting that the chair will honor Burr's achievements and add to the excellence he sought for OU's academic programs. "It is most appropriate that this gift will benefit students—the young people who

David A. Burr

so often sought David's advice and counsel—and that, by promoting an interdiciplinary concept, it will mirror his ability to bring to each task a universitywide perspective," Horton said.

Burr served as a senior administrator under five OU presidents and three interim presidents. In 1968, he was appointed vice president. He was OU's chief fund-raiser after that time, during which OU received $200 million in private gifts.

At the time of his death, Burr had been directing OU's $100 million Centennial campaign, which was announced last fall.

"The University of Oklahoma faculty, staff, students, alumni and friends lost a dear friend," Horton said. "David Burr loved and dedicated his life to the university, and we will all miss him a great deal.

"During his almost 40 years of loyal service to OU, David greatly influenced the direction of nearly every area of the university," Horton said. "His success as a fund-raiser enriched the university's academic programs, provided key scholarship support for thousands of students, and enhanced the physical growth of our campuses."

Centennial *continued*

Adams Hall for graduate business programs; renovation of Gould Hall for the College of Architecture; and funding for a family practice center at the Health Sciences Center.

Contributions to the Centennial campaign fund may be sent to University Affairs, 900 Asp Avenue, Suite 236, The University of Oklahoma, Norman, Oklahoma 73019. Checks should be made payable to "The University of Oklahoma Foundation, Inc." In addition to cash contributions, gifts of securities, tangible personal property, real estate, life insurance, life income plans and bequests in wills can be made. University Affairs and University Foundation staffs can assist donors with appropriate arrangements for any type of gift they may wish to make.

New Professorship Endowed in Engineering

A $300,000 gift from OU chemical engineering alumnus Robert W. Hughes of Austin, Texas, will endow a professorship in the OU College of Engineering.

In making the gift to OU, he said, "I feel indebted to the university for what it taught me years ago as a student, and I hope this professorship will enable the College of Engineering to move forward with the plans it has for the future." Hughes said he hoped his contribution would help show that some of "the school's alumni who were fortunate to succeed financially are willing to invest some of it back into the school."

"Nothing brings increased quality to the classroom and to the university's research programs as quickly as an endowed position," OU President Frank E. Horton said when he announced the gift. "Students in OU's College of Engineering will benefit from this gift for years to come."

Hughes, a native of Ponca City, earned his bachelor's degree in chemical engineering in 1958. He played varsity baseball at OU and was a letterman for three years and was a member of Phi Gamma Delta fraternity. After he graduated from OU, Hughes earned a master's degree from the Harvard Graduate School of Business Administration in 1962.

Hughes renewed ties with OU recently by joining the OU Associates program. Last spring, he became a member of the College of Engineering Board of Visitors and learned of the college's plans to strengthen its programs and build on its areas of quality.

"In the short range, the Hughes Professorship will help a new dean in attracting outstanding new faculty to the college," said Tom Love (then interim dean of the college prior to Billy Crynes' appointment). "In the long term, this and other professorships will be extremely important in attracting and keeping outstanding faculty to teach in the college. It is increasingly apparent that we will have to depend more on private support to develop excellence in the College of Engineering, which must compete with industry for the best engineers. This gift from Robert Hughes is a tremendous start for OU's Centennial goal of endowing more than 50 chairs and professorships throughout the university."

New Energy Center Director Appointed

While the second half of the massive lab base of the OU Energy Center rapidly nears completion, another major step has been taken in its development into a world-class teaching and research institution with the appointment of Barnet Groten—a man of considerable experience in the technological and financial sides of the oil and natural gas industries—to the position of executive director for the center.

"Dr. Groten knows the energy field from chemistry to public policy, nationally and internationally," OU President Frank Horton said. "He has the capability and determination to lead the OU Energy Center to the national position that its founders and our faculty aspire."

Groten is charged with the responsibility for developing interdisciplinary research in energy areas, operation of the center and public relations for Energy Center activities.

Groten comes to OU from Houston-based Texas Eastern Corp, where he had been director of research and business development for the firm since 1977, as well as vice-president for Texas Eastern Developments, Texas Eastern Synfuels and Drilling Developments.

"The Energy Center was a terrific concept when it was started during the height of the boom," Groten said. "It's even more important now when energy is down, because the way we're going to get ourselves out of the depressed energy situation is by being smarter. We have to add innovative approaches to the way we've done things historically."

The new director said the aim of the center is to merge disciplines to come up with new solutions to problems in the energy industry. He believes the research conducted there will be the most comprehensive of any university research in the country.

"The lines between the classic disciplines are blurring or disappearing altogether. The real frontier will be at the juncture of two or more disciplines," Groten said, reflecting an approach that has drawn support from corporations throughout the growth of the center.

John West, executive manager of the Phillips Petroleum Foundation, which has given $500,000 to the center since 1983, has called the center "a major resource for the state." West said that "by helping the school, we're planning for the future."

Groten said he thinks the center's research can directly benefit energy companies and would like to develop a close relationship with industry.

"One of our objectives is to be a place where industry would let us know what their problems are—and we would let them know what the potential is for solving those problems," he said. "The research picture is changing. Historically, fundamental research has been done by universities, and applied research has been done by industry.

"But the amount of research being done by the industrial sector is decreasing. Research is getting so diverse and so expensive. The universities should pick up some of that," he said.

"I'd like to see our students come out of here with a global view of energy matters," Groten said. "They need to understand the interaction between politics, economics and technology. They need to know their fundamentals well and have an open-minded, creative approach to problems," he said.

At Texas Eastern, Groten was responsible for the company's development of energy-related technology

Barnet Groten

through corporate research; administering the annual development budget; and representing the company in international, federal and local technology affairs.

Groten developed the company's synfuels policy and negotiated contracts for participation in the multibillion dollar Paraho oil shale and tri-state coal gasification projects.

Before joining Texas Eastern, Groten was at Exxon Chemical Co. U.S.A., serving as senior adviser to the specialty chemicals division. He also worked with the chemicals technology division and Essochem Europe in Brussels, Belgium.

The massive lab base of the OU Energy Center is rapidly nearing completion. The new section is scheduled to open in June 1988. The huge skylight is one of two that will flank the tower, allowing natural light into interior spaces such as the vast Energy Center library now taking shape around a huge central stairwell featuring ornamental brickwork.

Billy Crynes Named New Engineering Dean

Billy L. Crynes, a chemical engineer noted for his coal research and for excellence in teaching, was appointed dean of the College of Engineering by the OU Board of Regents in March and assumed the position on June 1.

Crynes fills the post vacated in April 1986 when Martin C. Jischke left OU to become chancellor of the University of Missouri at Rolla. Professor Tom Love of the School of Aerospace, Mechanical and Nuclear Engineering had served the college as interim dean while the nationwide search for a new dean was conducted.

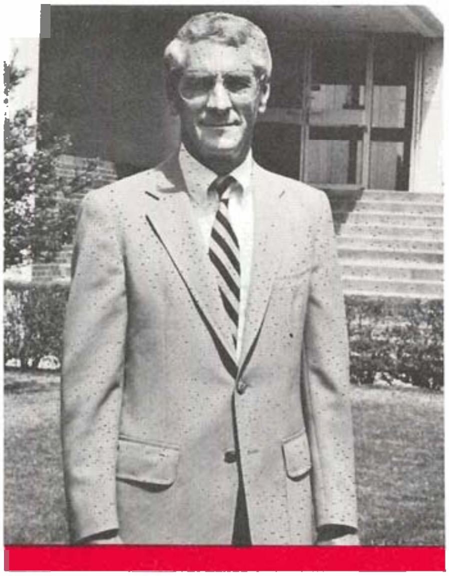
Crynes comes to OU from Oklahoma State University, where he was head of the School of Chemical Engineering in the College of Engineering, Architecture and Technology. While at OSU, he was honored four times as outstanding teacher in the School of Chemical Engineering.

Even before he arrived on the OU campus, Crynes began regular commutes from Stillwater to Norman to educate himself about the college's students, faculty, staff, programs and resources, and about the university, to prepare himself for his high-priority task of training the engineers of tomorrow through quality, accredited programs.

As dean, Crynes will oversee a college with 2,000-plus students, six schools, a department of engineering and a program in engineering physics.

"Ultimately, the college can be only as good as the students we recruit, the faculty we employ and the staff we hire," Crynes said.

The College of Engineering has been successful recruiting OU's best students.



Billy L. Crynes

Half of the National Merit Scholars attending OU have chosen engineering majors.

"The faculty at OU's College of Engineering is doing superb research, which I will encourage them to continue to develop," Crynes said, noting the toll the state's economy has taken on faculty, decreasing their numbers from about 110 to about 90 during the past few vears.

"We can't continue to ask facultv to increase their research duties, provide all the governance necessary and take care of all aspects of student nurturing without providing them with incentives," he said. A team player, the 49-year-old dean has called upon faculty to help him redefine goals for the college.

The new dean also brings a familiarity with Oklahoma businesses and industries and is committed to nurturing those relationships. "They need us and we need them; they hire our product," he said. "Three-fourths of all our graduates will be hired by industry, which also provides summer jobs and part-time consulting for our faculty."

Crynes earned his bachelor's and master's degrees from Rose-Hulman in Terre Haute, Ind., where he taught on the chemical engineering faculty in 1977–78, and earned his Doctor of Philosophy degree from Purdue. He joined the OSU faculty in 1967 as an assistant professor, was promoted to associate professor in 1969, and was named a full professor in 1974. He became head of the OSU School of Chemical Engineering in 1978.

Cyrnes has worked as a development engineer for E.I. duPont de Nemours Inc. and as a research engineer for Standard Oil and Nalco Chemical Co. In addition, he has served as a consultant to Oak Ridge National Laboratories, Kerr-McGee, Dow Chemical, Nalco Chemical and Global Engineering, among others.

His research interests are related to coal, an area in which he has published widely. Crynes is the recipient of some 20 grants for coal research.

He is active in numerous professional organizations, including the Oklahoma Society of Professional Engineers, which named him its Young Engineer of the Year in 1972. He recently served as chairman of the Industrial and Engineering Chemistry Division of the American Chemical Society.

Exxon Grant Facilitates Computer System Selection

The Exxon Education Foundation has granted $472,000 to the OU College of Engineering for selection and implementation of a digital data acquisition and processing system for the college's teaching laboratories.

The gift will be presented to the college over the next four years in equal installments to be used to support a committee of six faculty members, one from each school in engineering. The money will reimburse the college for a portion of those faculty members' time, allowing them to reduce their teaching loads and spend part of their time developing the system.

The savings to the college will also allow the hiring of graduate students to assist in the development of the computer system. With the introduction of the new system, students in the College of Engineering will be able to shed the clipboards and handheld measuring devices traditionally used in laboratory exercises.

OU CEMS Research Update

The United States economy, the world economy and the chemical engineering profession change continually. For that very reason, the research activities in the University of Oklahoma School of Chemical Engineering and Materials Science also change continually.

This issue of *OkChE* updates our major current research thrusts. If you have known the department for a long time, you will recognize areas of traditional strength, such as statistical thermodynamics and energy research, where activity remains strong.

But you will also find new areas, such as ceramics, surfactants, separations, polymers and biomedical research, where there are new emphases. We hope you will find the overview interesting. We are excited about the significant advances in many critical areas of science and technology being made by CEMS faculty and graduate students.

Why do a department's research emphases vary over time? For one reason, the faculty keeps changing. Some faculty move on to new opportunities, taking their expertise in an area with them. New faculty come, with new areas of interest.

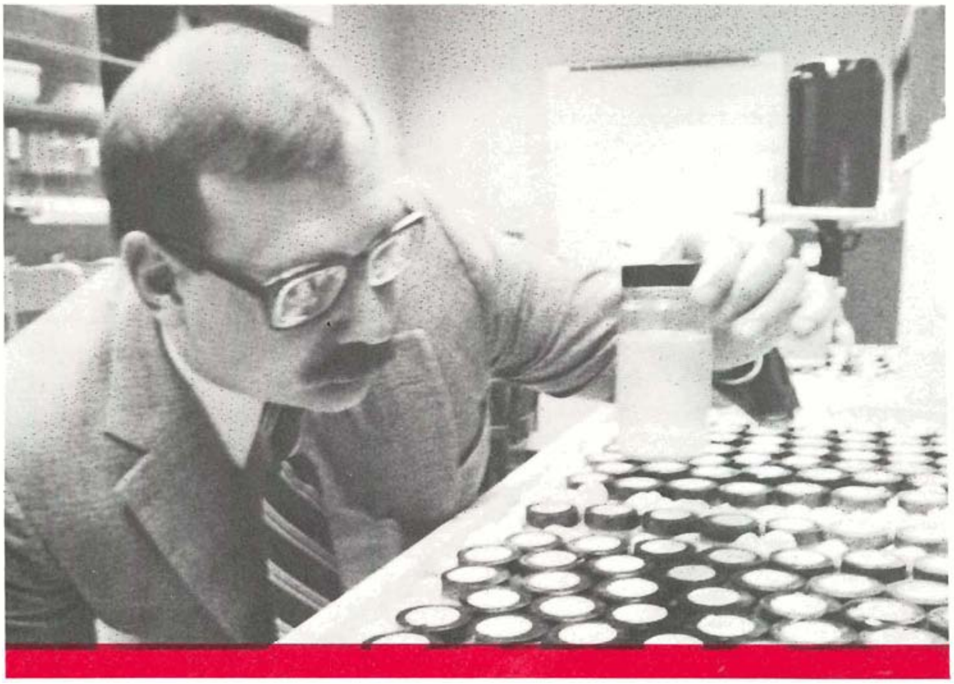
Then again, the perceptions of government and industry about areas of most pressing need also keep changing, and this produces fluctuations in the areas of research for which funding is available.

The challenge for faculty and students is to respond to the perceived needs of the consumer of our research while maintaining an academic atmosphere in which high standards of scholarship are upheld. We think CEMS is up to that challenge. We also invite you to judge this for yourselves as you read the following notes about our research program.

By the way, we have inserted a few selected literature references following each section to give you still more of a feel for the nature of the work described.

APPLIED SURFACTANT RESEARCH

Three faculty in chemical engineering, John Scamehorn, Edgar O'Rear and Jeffrey Harwell, have recently joined with two faculty in chemistry, Sherril Christian and B. M. Fung, to formalize ongoing collaborations in surfactant science and technology. This effort culminated in the creation of the Institute for Applied Surfactant Research (IASR) last year.



In the course of development of optimum surfactant mixtures, Prof. John Scamehorn examines precipitate in one of many test mixtures. Increased understanding of the dynamics of surfactant mixtures will result in more durable surfactant solutions and more efficient detergency.

This October, some 50 representatives from 35 companies attended an organizational meeting of the institute, where they were challenged to help provide direction and a base of funding for the institute's research activities.

Surfactants are molecules containing both water soluble and water insoluble parts. This dual nature gives them many unique properties. Here is a sample of some of areas in which IASR is seeking to exploit these properties.

Surfactant-Based Separation Processes

Separation techniques based on the use of surfactants have several important advantages over traditional methods. Surfactants are relatively mild chemicals, and they have many potential uses in biotechnology, as for example where delicate biochemicals must be recovered from a fermentation broth. Surfactant-based separations generally have low energy requirements. Surfactants are also relatively innocuous environmentally, so that their use in separations can avoid serious environmental problems associated with other methods. Wastewater clean-up is a prime target for the novel surfactant-based separations.

Surfactant-Based Separation Processes, J. F. Scamehorn and J. H. Harwell (Editors), Marcel Dekker, Surfactant Science Series, In Press.

Micellar-Enhanced Ultrafiltration

Micellar-enhanced ultrafiltration (MEUF™)* is a novel method to remove dissolved organics or metals from water. Surfactant is added to the water and forms aggregates called micelles containing about 100 molecules. Dissolved organic solutes solubilize in the interior of the micelles; dissolved metal cations (e.g., copper) bind or adsorb on the surface of the oppositely charged micelle. In this way, the vast majority of the dissolved organic and metal species become associated with these micelles. The solution is then passed through an ultrafiltration filter with pore sizes small enough to block the micelles. The resulting permeate passing through the membrane is very pure, while the solution rejected by the membrane (the retentate) contains the organics and metals in high concentration for easier disposal or recovery of these constituents.

The ability to remove organics and metals *simultaneously* from wastewater is a particularly valuable aspect of this method. It may be economical to treat water containing valuable organics or metals to recover these solutes. Examples are water from gold mine tailings or valuable biochemicals produced by genetically modified microorganisms.

*MEUF™ is a trademark owned by the Regents of the University of Oklahoma.

"Removal of Multivalent Metal Cations from Water Using Miscellar-Enhanced Ultrafiltration," J. F. Scamehorn, R. T. Ellington, S. D. Christian, B. W. Penney, R. O. Dunn, and S. N. Bhat, AIChE Symp. Ser., **250**, 48 (1986).

"Use of Micellar-Enhanced Ultrafiltration to Remove Dissolved Organics from Aqueous Streams," R. O. Dunn, J. F. Scamehorn, and S. D. Christian, *Sep. Sci. Technol.*, **20**, 257 (1985).

"Concentration Polarization Effects in the Use of Micellar-Enhanced Ultrafiltration to Remove Dissolved Organic Pollutants from Wastewater," R. O. Dunn, J. F. Scamehorn, and S. D. Christian, *Sep. Sci. Technol.*, In Press.

"Surfactant-Based Treatment of Aqueous Process Streams," J. F. Scamehorn and J. H. Harwell, in *Surfactants and Chemical Engineering* (D. T. Wasan, D. O. Shah, and M. E. Ginn, Eds.), Marcel Dekker, In Press.

Admicellar Chromatography

The phenomenon of solubilization is well known and widely exploited in industry. Its surface analogue, adsolubilization, is a relatively new subject of investigation. A new separation process based on the phenomenon of adsolubilization is admicellar chromatography. A dilute aqueous surfactant stream is passed through a fixed bed of adsorbent. As the stream equilibrates with the bed, surfactant aggregates, called admicelles because of their similarity to micelles, form on patches of the packing surface. When a process stream with a target solute is then introduced into the bed, the solute partitions into the admicelles on the surface of the packing. When the admicelles are saturated with the target solute, the flow through the bed is reversed, and the makeup of the influent is adjusted so that the admicelles containing the adsolubilizate desorb.

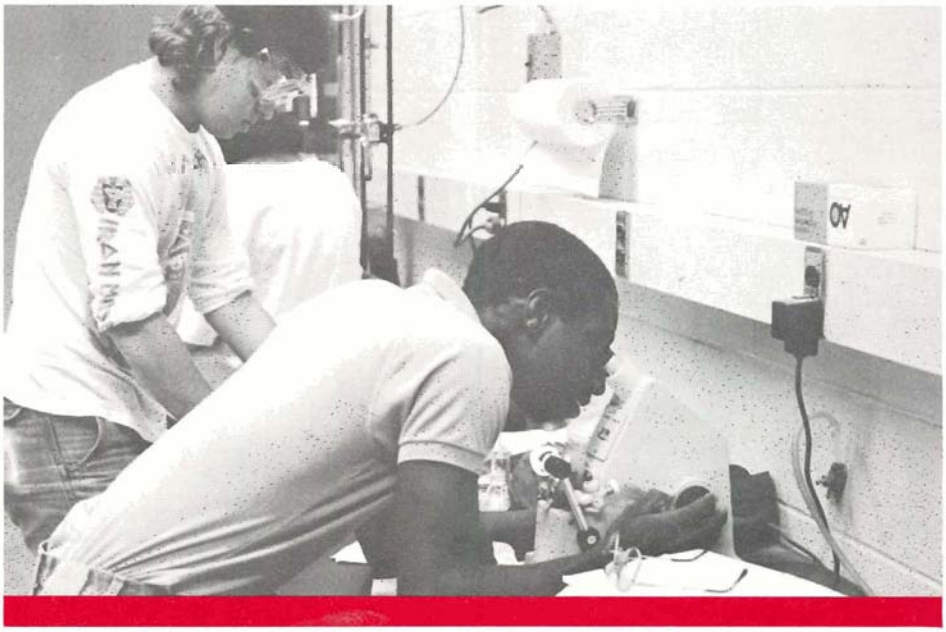
With use of proper operating parameters, the concentration of the solute in the effluent during this stripping stage can be several times the original concentration. The concentrated effluent can be treated further for recovery or for disposal. The bed has also been regenerated and is ready to be reused for removing solute. This is a low-energy process. It is also applicable for bioseparations because of the mild conditions under which it can be operated.

"Admicellear Chromatography: A New Low-Energy Separation Process," T. P. Fitzgerald and J. H. Harwell, *AIChE Symp. Ser.* **250**, 142 (1986).

"Surfactant Chromatographic Movement: An Experimental Study," J. H. Harwell, R. S. Schechter, and W. H. Wade, *AIChE Journal*, **31**, (3), 415 (1985).

Surfactant-Enhanced Carbon Regeneration

Activated carbon can very effectively remove dissolved organics from water. However, the regeneration of the saturated carbon is energy and labor intensive, using standard hearth regeneration technology. Surfactant-enhanced carbon regeneration (SECR) is a new in-situ regeneration technique invented at the University of Oklahoma. In SECR, a concentrated surfactant solution is passed through the saturated carbon. The adsorbed organic desorbs, and the regenerant solution exiting the adsorber bed contains the organic in high concentration. When the regeneration is complete, water can be used to flush residual surfactant from the bed.



Senior David Tamakloe examines the composition of the liquid-liquid extractor effluent stream in the ChE Design Laboratory.

Because the surfactant is not toxic, the flush solution can be discarded to the normal sewage system.

"Surfactant—Enhanced Carbon Regeneration," D. L. Blakeburn and J. F. Scamehorn in *Surfactant-Based Separation Processes* (J. F. Scamehorn and J. H. Harwell, Eds.), Marcel Dekker, In Press.

Liquid-Liquid Extraction into Coacervate Phases

When a nonionic surfactant is added to water, above a temperature called the cloud point, the solution separates into two phases, one concentrated in surfactant (coacervate) and the other dilute. If nonionic surfactant is added to water containing dissolved organic at a temperature above the cloud point, the organic solute will concentrate cin the coacervate phase. This low-energy separation has potential in oncentrating chemicals produced from biotechnology.

"Liquid-Liquid Extraction Above the Cloud Point," J. F. Scamehorn, J. H. Harwell, and N. D. Gulickson, *Surfactant-Based Separation Processes* (J. F. Scamehorn and J. H. Harwell, eds.), Marcel Dekker, In Press (1986).
"Phase Equilibrium in Aqueous Mixtures of Nonionic and Anionic Surfactants Above the Cloud Point," O. E. Yoesting and J. F. Scamehorn, *Colloid Polym. Sci.*, 264, 148 (1986).

Detergency

The field of detergency faces a number of important current challenges, such as the pressure to remove phosphate builders from formulations, the desire to combine fabric softening and cleaning in one step, and the need to add pleasant scents to washed clothes. CEMS research is focused on investigating the fundamental physical processes involved in detergency as well as more applied research on generic solutions to certain problems in the industry.

Use of Surfactant Mixtures

A common goal in CEMS detergency research is exploitation of the advantages of using mixtures of surfactants as opposed to single surfactant components. For example, hardness tolerance can be improved by adding nonionic surfactants to anionic surfactant formulations. In order to effect fabric softening in the wash cycle, cationic surfactant is added to the formulation. Precipitation of anionic/cationic surfactant mixtures must be avoided to make this process feasible.

Enhancement of Hardness Tolerance

Minimization or elimination of builder in surfactant formulations is a desirable goal. Systematic research into surfactant precipitation has elucidated the mechanisms involved in this complex phenomenon. The focus of the research has been on the use of nonionic/anionic surfactant mixtures to improve hardness or salinity tolerance as compared with anionic surfactant systems alone. Almost two orders of magnitude improvement in hardness tolerance has been achieved by the judicious addition of nonionic surfactant and sodium salt to anionic surfactant.

Air is separated into oxygen and nitrogen-rich streams in this membrane permeation experiment in the CEMS undergraduate laboratories. Graduate teaching assistant John Fagbemi works with Prof. Richard Mallinson in supervision of undergraduate student research in the lab.

"Enhancement of Hardness and Salinity Tolerance in Anionic Surfactant Solutions by Addition of Nonionic Surfactants," K. L. Stellner and J. F. Scamehorn, presented at 60th ACS Colloid and Surface Science Symposium, Atlanta (June 1986).
"Precipitation Phenomena in Mixtures of Anionic and Cationic Surfactants in Aqueous Solutions," K. L. Stellner, J. C. Amante, J. F. Scamehorn, and J. H. Harwell, submitted to *J. Colloid Interface Sci.*

Solubilization

The solubilization of oily soils by micelles can be an important phenomenon in detergency. In CEMS research in progress, we are systematically measuring the solubilization of a variety of solutes in mixed micelles. These studies have led to an improved understanding of mechanisms of solubilization and of mixed micelle structure. In practical applications, detergent formulations can be prepared either to minimize or to maximize solubilization. Ultimately, this work will be coupled with other measurements to deduce the importance of solubilization in actual detersive systems, a controversial topic.

"Solubilization of N-Hexanol in Mixed Micelles," C. M. Nguyen, J. F. Scamehorn, and S. D. Christian, submitted to *Colloids and Surfaces.*
"Solubilization in Mixed Micelles," S. D. Christian and J. F. Scamehorn, presented at 191st National ACS Meeting, New York (April 1986).
"Use of the Semi-Equilibrium Dialysis Method in Studying the Thermodynamics of Solubilization of Organic Compounds in Surfactant Micelles. System n-Hexadecylpyridinium Chloride-Phenol-Water," G. A. Smith, S. D. Christian, E. E. Tucker, and J. F. Scamehorn, *J. Solution Chem.*, 15, 519 (1986).
"Semi-Equilibrium Dialysis: A New Method for Measuring the Solubilization of Organic Solutes by Aqueous Surfactant Solutions," S. D. Christian, G. A. Smith, E. E. Tucker, and J. F. Scamehorn, *Langmuir*, 1, 564 (1985).

Adsorption

Adsorption of surfactant onto solid soils in clothes washing can be an important factor in their detachment from cloth and subsequent removal. The adsorption of surfactant onto solids is of obvious importance in hard-surface cleaning. Research to measure adsorption of surfactants on various surfaces is an extremely active program at CEMS. The goals are to understand the forces causing adsorption and to quantify the factors enhancing or reducing adsorption. Our ability to predict the effect of changing surfactant structure in single surfactant systems or changing surfactant composition in mixed surfactant systems on adsorption is continually being improved. Ultimately, this knowledge can be used with other detergency studies to design optimum detergent formulations on other than an empirical basis.

"Adsorption of a Mixture of Anionic Surfactants on Alumina," B. L. Roberts, J. F. Scamehorn, and J. H. Harwell, in *Phenomena in Mixed Surfactant Systems* (Scamehorn, J. F., Ed.), ACS Symp. Ser., Vol. 311 (1986) Ch. 14.
"A Pseudo-phase Separation Model for Surfactant Adsorption: Isomerically Pure Surfactants," J. H. Harwell, J. Hoskins, R. S. Schechter, and W. H. Wade, *Langmuir*, 1, 251 (1985).

Ultrathin Films

A new process for the formation of ultrathin polymer films has been developed at CEMS. First, aggregates of surfactant molecules are formed on the solid substrate by contacting the substrate with a surfactant solution. These surfactant aggregates can be formed on a great variety of surfaces in such a way as to result in bilayer coverage of the entire surface with surfactant.

In the second step, a monomeric species is introduced. The surfactant layer acts as a two-dimensional solvent to concentrate the monomer at the interface. In the third step, polymerization is initiated by chemical, thermal or photochemical means. The bilayer serves to localize the polymerization reaction at the solution-solid interface and thereby results in coverage of the solid surface. Films have been formed successfully by the above process on both high-surface-area inorganic powders and on the oxide layer of metallic films formed by vapor deposition on glass slides.

Current research at CEMS focuses on only a few of many possible areas of commercial application of the proposed film-forming process: ultrathin photoresists; wave guides for integrated optical systems; corrosion protection by barrier formation; industrial-scale chromatographic packings; high-capacity inorganic ion-exchange packings; membranes; films that protect against toxins or infective agents; insulative, conductive and semiconductive films; coatings for controlled release of chemicals or pharmaceutical drugs; lubricating coatings (solid lubricants); films for the controlled release of drag reducing agents; and modifiable supports for catalysts, enzymes or synzymes.

"Two-Dimensional Reaction Solvents: Surfactant Bilayers in the Formation of Ultrathin Films," J. Wu, J. H. Harwell, and E. A. O'Rear, *Langmuir*, 3, 531 (1987).

"Ellipsometry Measurements of Polymerized Ultrathin Films Constructed by an Adsorbed Two-Dimensional Reaction Solvent," J. Wu, J. H. Harwell, and E. A. O'Rear, *Colloids and Surfaces*, 26, 155 (1987).

"Two-Dimensional Solvents: Kinetics of Styrene Polymerization in Admicelles at or Near Saturation," J. Wu, J. H. Harwell, and E. A. O'Rear, *J. Phys. Chem.*, 91, 623 (1987).

Fundamental Surfactant Research

Sponsored research at CEMS encompasses a wide spectrum of technological applications as outlined in previous sections. However, CEMS faculty strongly believe that the underlying forces that are responsible for phenomena of interest must be understood to provide a firm basis for applying knowledge to practical problems. Fundamental research is a major part of our program in CEMS, both in relation to specific technological problems and as a part of the larger goal of improving our understanding of surfactant behavior.

Surfactant Aggregates

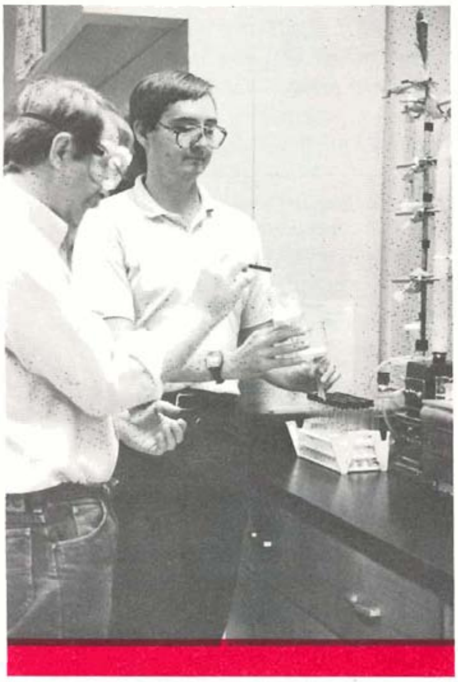
A characteristic property of surfactant molecules is their tendency to aggregate at interfaces. Examples are adsorption on solids and monolayer formation at an air-water interface. Surfactants will sometimes create their own interface by forming very small aggregates like micelles or vesicles to remove a portion of their structure from contact with a solvent. On the other hand, surfactant aggregates can form separate thermodynamic phases such as microemulsions and coacervates.

An important facet of research at CEMS is to investigate the similarities and differences between the many aggregates that surfactants can form, both in single surfactant systems and in mixtures of surfactants. Because some of the same effects are responsible for the formation of many of the aggregates, comparison of aggregation thermodynamics can shed light on surfactant interactions in the process of clustering under different conditions. This type of approach, which should lead to comprehensive theories of several aggregation processes, is a unique aspect of surfactant research in CEMS.

Surfactant Thermodynamics

An important area of both practical and fundamental interest is the study of thermodynamic properties of micellar solutions. The ability of surfactant micelles to bind or solubilize components in aqueous solutions gives these systems the unique properties responsible for many of the processes described in the brochure. Unfortunately, our understanding of the molecular equilibria and dynamic behavior of micellar systems is still fairly primitive.

Active areas of research at CEMS include thermodynamic studies of the formation of micelles from individual surfactant molecules, the binding or solubilization of individual compounds or ions by micelles, and the prediction of solubilization phenomena with molecular theories or models. All of these studies are fundamental in character, but advances in our knowledge of micellar properties will relate directly to many types of technological improvement. CEMS's experimental and theoretical expertise in the field of surfactant thermodynamics should enable the group to make substantial contributions in this important area of research.



Graduate research assistant David Steinhoff and Prof. Jeffrey Harwell examine recovered minerals from a flotation experiment in the CEMS Thin-Films Laboratory.

"Thermodynamics of Mixed Micelle Formation," C. M. Nguyen, J. F. Rathman, and J. F. Scamehorn, *J. Colloid Interface Sci.*, 112, 438 (1986).

"An Electrostatic Model to Describe Mixed Ionic/Nonionic Micellar Nonidealities," J. F. Rathman and J. F. Scamehorn, *Langmuir*, 2, 354 (1986).

"Thermodynamics of Microemulsion Formation by Mixtures of Anionic and Nonionic Surfactants," O. Haque and J. F. Scamehorn, *J. Dispersion Sci. Tech.*, 7, 129 (1986).

"Thermodynamics of Adsorption of Surfactant Mixtures on Minerals," J. H. Harwell, B. L. Roberts, and J. F. Scamehorn, submitted to ACS Symp. Ser.

"Counterion Binding on Mixed Micelles," J. F. Rathman and J. F. Scamehorn, *J. Phys. Chem.*, 88, 5807 (1984).

Surfactant Mixtures

As we have pointed out previously, surfactant mixtures have numerous synergisms in practical applications. However, the surfactant interactions in these systems are inherently of great interest. Interaction between dissimilar surfactants in various aggregation processes is being investigated.

Fundamental models are being developed to describe surfactant mixture effects in specific processes. Experimental data provide a test of these models. It is this type of approach, balancing theory and experimental verification, that CEMS is using to advance knowledge in this field.

"An Overview of Phenomena Involving Surfactant Mixtures," J. F. Scamehorn, in *Phenomena in Mixed Surfactant Systems* (J. F. Scamehorn, Ed.), ACS Symp. Ser., Vol. 311 (1986) Ch. 1.

"Behavior and Applications of Surfactant Mixtures: Future Perspectives," J. F. Scamehorn, in *Phenomena in Mixed Surfactant Systems* (J. F. Scamehorn, Ed.), ACS Symp. Ser., **311** (1986) Ch. 24.

"Surfactant Precipitation in Aqueous Solutions Containing Mixtures of Anionic and Nonionic Surfactants," K. L. Stellner and J. F. Scamehorn, *J. Amer. Oil Chem. Soc.*, **63**, 566 (1986).

"Optimum Injection Strategies for the Propagation of Surfactant Mixtures in Porous Media," J. H. Harwell, R. S. Schechter, and W. H. Wade, *AIChE Journal*, **24**, (5) 545 (1984).

Phenomena in Mixed Surfactant Systems, J. F. Scamehorn (Editor), ACS Symp. Ser., **311**, American Chemical Society, Washington, D.C. (1986).

Surfactant Synthesis

Our efforts in surfactant synthesis involve preparation of new fluorinated surfactants in connection with our research on perfluorochemical blood substitutes. The goal is to synthesize fluorinated surfactants that will form stable, non-viscous microemulsions containing high contents of fluorocarbons, with very small emulsified particles that are not adsorbed on the surface of red blood cells. The synthetic procedure should be simple, and the yield should be high. Our methods should lead to the production of fluorinated surfactants that are free from the toxic impurities that frequently result from conventional syntheses.

"Modification of Nonionic Surfactants with Perfluorinated Terminal Groups," M. Gangoda, B. M. Fung, and E. A. O'Rear, *J. Colloid Interface Sci.*, In Press.

"Synthesis of Perfluoroalkyl N-Polyethoxylated Amides," J. Afzal, B. M. Fung, and E. A. O'Rear, *J. Fluorine Chem.*, In Press.

THERMODYNAMICS

Contrary to popular notions, the classical formation of the second law of thermodynamics is not a dead subject. Many of the popular notions give rise to more questions and confusion than they in reality resolve. One fertile approach is in the anatomy of the entropy balance and the Gibbs equations, with particular attention to their simultaneous evolution from the first law energy and mass balance equations and energy dissipation functions. This activity has been an on-and-off obsession of C. M. "Cheddy" Sliepcevich for almost half a century.

Theoretical and applied thermodynamics has long been an area of emphasis in CEMS. This tradition continues. This fundamental area always remains central to chemical engineering, whether one is concerned with distillation, enhanced oil recovery, supercritical extraction or the recovery of biological molecules by aqueous/aqueous liquid extraction. These studies afford opportunities for both application of old theories and new theoretical advances. It is clearly impossible to completely separate thermodynamics from fundamental studies in surfactants, separations, kinetics or polymers. What follows is the research we have somewhat arbitrarily placed under the important fundamental area of thermodynamics.

Supercritical Extraction

The ability of certain solvents to extract large amounts of nonvolatile solids near or around the critical point has long been recognized. This phenomenon, known as "supercritical extraction," or more precisely solubility enhancement at supercritical conditions (SESC), is of particular interest to Lloyd Lee.

Current practice of supercritical extraction in energy and food industries is well established. Deasphalting operations for petroleum fractions also have been carried out using supercritical propane/propylene mixtures. For solvents such as carbon dioxide and ethylene the enhancement of the solubility of, say, phenanthrene or anthracene can reach a thousandfold for relatively small variations in pressure. Flooding with supercritical carbon dioxide is now a common practice in enhanced oil recovery. Toluene and water have been used as deashing solvents in coal conversion processes. In the food industry the nontoxic nature of carbon dioxide is exploited for decaffeination of coffee and removal of nicotine from tobacco.

Most of these processes, however, were developed without a firm theoretical understanding of the SESC behavior. This state of affairs hampers further use of supercritical extraction and delays many potentially efficient applications in other areas of energy and industrial operations. Only recently have there been fundamental thermodynamic analyses of the common factors underlying SESC.

SESC takes place at well-defined loci in the phase diagrams of the solvent-solute mixture. For vapor-liquid equilibria, the phenomenon occurs near the lower critical end point (LCEP) and/or the upper critical end point (UCEP). Two questions naturally arise: (a) Does existing experimental information support these theoretical conclusions, and (2) is it possible to use analytical means, such as an equation of state, to describe such behavior?

In this project, a step-by-step program is being pursued to answer these questions and to provide the capability of accurately predicting the supercritical behavior of systems of interest. First, existing data on supercritical solubility are examined using so-called Gitterman Procaccia criteria. This is achieved by developing highly accurate equations of state (EOS) for supercritical solvents (e.g., CO_2 and ethylene). Second, accurate mixing rules for the EOS are to be developed for the solvent-solute pair, since SESC is a mixture phenomenon. Research in CEMS has developed a basis for new mixing rules during the last decade. The choice now is the new local composition mixing rules developed for polar and highly anisotropic molecules. Third, a nonlinear regression parameter-search program has been developed at OU for determination of equation parameters and binary interaction coefficients. With these capabilities, we are at a position well suited for carrying out such a program.

"An Accurate Equation of State for Carbon Dioxide," F. H. Huang, M-H. Li, L. L. Lee, F. T. H. Chung, and K. E. Starling, *J. Chem. Engr. of Japan*, **18**, 221 (1985).

"The Statistical Mechanical Local Composition Theory: The Balance Equations and Concentration Effects in Non-Ideal Mixtures," L. L. Lee and K. E. Starling, *Fluid Phase Equilibria*, **21**, 77 (1985).

"Fundamental Thermodynamics of Supercritical Extraction," K. E. Starling, M. A. Khan, and S. Watanasiri, *Supercritical Fluid Technology* (J. M. L. Penninger, M. Radosz, M. A. McHugh, V. J. Krukonis, Eds.), Elsevier Publications (1985).

Mixed Electrolyte Solutions

Traditionally, dilute electrolyte solutions have been treated according to the Debye-Huckel theory and concentrated ones by Pitzer's method. With existence of neutral species in mixed electrolyes (e.g., water-CO_2, NH_3 or water-methanol-NaBr), conventional theories are no longer adequate. A new theory going beyond the Debye Huckel and Pitzer methods is called for. CEMS faculty have proposed a new statistical mechanical formulation based on the local composition theory and modified distribution functions in the mean spherical approximation. Preliminary results on 23 strong electrolytes show promise.

"Prediction of Thermodynamic Properties of Electrolyte Solutions Using the Mean Spherical Approximation," S. Watansiri, M. R. Brule, and L. L. Lee, *J. Phys. Chem.*, **86**, 292 (1982).

"The Solution of the MSA for Asymmetrical Hard Ions: The Effects of the Coupling Parameter PN on the Shielding Parameter Γ and the Structure of the Electrolyte Solutions," L. L. Lee, *J. Chem. Phys.*, **78**, 3270 (1983).

Adsorption of Charged Polyatomic Molecules

The main thrust of this research is the introduction of new statistical mechanical methods into the study of electrical double layers around molecular ions. In particular, the specific objectives are: (1) to develop a new theoretical approach describing charged polyatomic ions adsorbed on electrified surfaces; (2) to test and evaluate some of the current competing theoretical hypotheses of electrical double layer; and (3) to carry out Monte Carlo or molecular dynamics simulation for adsorbed molecules.

Recently, an interaction site model (ISM) was proposed (Lee, 1984) for adsorbed polyatomics. The Born-Bogoliubov-Green-Kirkwood-Yvon (BBGKY) hierarchy in such a system was derived. It yields the pressure tensor and the site-site distribution functions that can be used to obtain information on surface structure, density and charge distributions. Particular attention will be paid to the double layer potential, solvation forces, steric packing order, counterion screening, charge oscillations and/or coordination saturation effects. The causes and ranges of parameters that induce such behavior will be determined.

"The Lennard-Jones 9:3 Adsorptive System I: The Percus-Yevick and Hypernetted Chain Theories and Their Modifications," L. L. Lee and L. S. Smith, *J. of Chem. Phys.*, **71**, 4085 (1979).

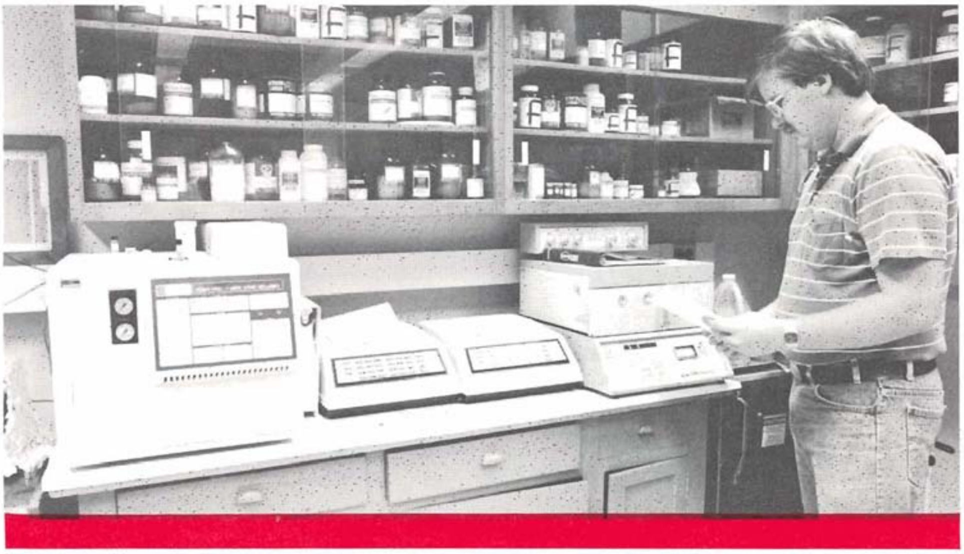
"The Lennard-Jones Adsorptive System II: Prediction of the Liquid Density Profiles by Perturbation Theory," L. L. Lee, *J. Chem. Phys.*, **73**, 4050 (1980).

Highly Accurate Natural Gas Compressibility Factors

OU maintains its world-class position in petroleum industry education and research as host of the International School of Hydrocarbon Measurement, believed to be the oldest petroleum industry school in the Free World that is devoted to fluid measurement and control. In an annual meeting in short-course format the school offers classes in measurement and handling of petroleum gas and liquids—including natural gas liquids, tars and slurries—to a large number of representatives of equipment manufacturers, the natural gas and petroleum industries, governmental agencies and others from all over the world directly interested in the measurement and control of hydrocarbons. CEMS Professor Ken Starling is chairman of the executive committee of the school.

To meet gas industry needs for accurate volumetric flow-rate measurement procedures, Starling's project for the development of a new, highly accurate equation of state for the prediction of the supercompressibility factor and other properties of natural gases has been sponsored by the Gas Research Institute, following many related projects sponsored by GRI and the Department of Energy, on occasion in collaboration with Rex Ellington, Lloyd Lee and Richard Mallinson.

Equation-of-state development work from 1981 through 1984 targeted pipeline-quality natural gases and gases with large amounts of carbon dioxide and nitrogen. Presently, this work is being extended to include accurate prediction capabilities for industry use. The American Gas Association Transmission Measurement Committee Report No. 8 presents the detailed information for computations of compressibility factors and supercompressibility factors for natural gas and other hydrocarbon gases.



The gas chromatograph used by research assistant Jeff Marnix provides composition analyses of fuel samples from high boiling materials to non-condensable gases.

"New Developments in the Determination of Compressibility and Supercompressibility: Status of Natural Gas Supercompressibility Factor and Thermodynamic Properties Correlation," K. E. Starling, J. L. Savidge, R. T. Ellington, T. Reid, and S. Shankar, *Proceedings of the American Gas Association Transmission Conference*, 86-DT-48, 753–763 (1986).

"New Developments in the Determination of Compressibility and Supercompressibility: Status of Natural Gas Supercompressibility Factor and Thermodynamic Properties Correlation Research," K. E. Starling, J. L. Savidge, R. T. Ellington, R. Reid, and S. Shankar, *Proc. of the Oper. Sec. of the Amer. Gas Assoc.*, 753–763 (1986).

"Wet and Sour Natural Gas Compressibility Factors and Supercompressibility Factor Prediction Method for Custody Transfer Needs," K. E. Starling and J. L. Savidge, *Proc. of the 1986 Int. Gas Res. Conf.* (1986).

"Gas Flow Measurement Improvement by Accurate Thermodynamic Properties Correlation," K. E. Starling, J. L. Savidge, S. Shankar, and T. Reid, *Proc. of the Int. Symp. on Fluid Flow Meas.*, 681–692 (1986).

"Equation of State Composition Dependence," K. E. Starling, M. A. Khan, M. H. Li, and L. L. Lee, *Fluid Phase Equilibria*, 37, 141–151 (1987).

"PVT Data Base Evaluation Methodology for Highly Accurate Equation of State Development," K. E. Starling, J. L. Savidge, and K. H. Kumar, *Fluid Phase Equilibria*, 27, 203–219 (1986).

Synthetic Fuel and Heavy Oil Characterization for Thermodynamic Property Estimation

The determination of the chemical structures present in heavy fuel fluids are being estimated with FTIR, NMR and other techniques using a chemical structural model. Determination of the minimal data and assumptions needed for the estimation of particular thermodynamic properties is also made. A novel combination of FTIR and gel permeation chromatography is being developed to improve the characterizations while minimizing cost. Thermodynamic property estimations are made using an established, reliable equation-of-state-based framework.

"The Characterization Requirements for an Equation-of-State-Based Correlation Framework for Predicting the Calorimetric Properties of Coal Fluids," R. D. Hulvey, M. W. Peters, M-H. Li, R. G. Mallinson, and K. E. Starling, 42nd Annual Calorimetry Conference, University of Colorado, Boulder, July 1987.

"A Combined Group Contribution and Equation-of-State Methodology for Calculating Calorimetric Properties of Coal Fluids," R. D. Hulvey, M. W. Peters, M-H. Li, R. G. Mallinson, and K. E. Starling, AIChE meeting, New York, N.Y., November 1987.

Ph.D. candidate Mohamed Tahiri uses a high-temperature, high-pressure micro-batch reactor system for coal and oilshale conversion studies.

CERAMICS, POLYMERS AND MATERIALS

Two CEMS faculty have innovative research programs in novel areas of polymers science. We think both areas have exciting possibilities for future advances in technology.

The Melt-Blowing Process and Fibers Products

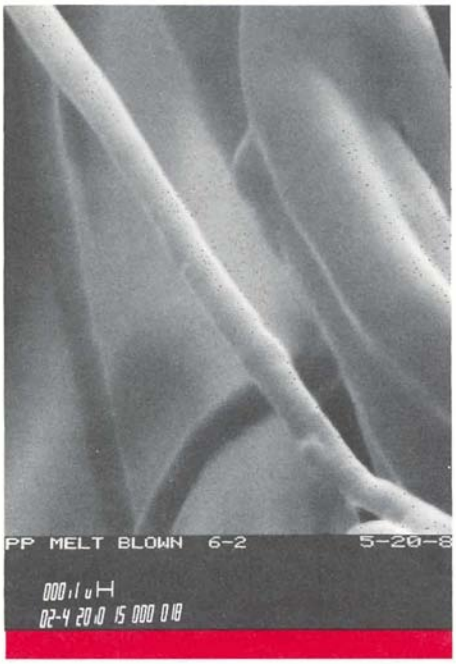
Robert Shambaugh's research in melt blowing has grown rapidly since his arrival at OU three years ago. At the urging of several industrial sponsors, the melt-blown effort has become a formal program in the newly formed Center for Polymer and Fiber Research (CPFR). CPFR, like IASR, is an industrial-academic consortium. The melt-blowing program within CPFR is limited to eight industrial sponsors. Along with other advantages, royalty-free licenses on all patents are offered to all consortium members. Thus far, six Fortune 500 companies are committed to joining this program. In the future, other programs of CPFR will be developed involving other areas of materials research.

Shambaugh and his research team have spent two years and thousands of hours in design and construction of unique equipment to make melt-blown fibers, among the smallest organic fibers ever made. Diameters of 0.1 micron are possible (a human hair is about 100 microns in diameter).

In the melt-blowing process, a near-supersonic gas stream impacts upon a molten polymer as the polymer is extruded from a small capillary. The force of the gas rapidly accelerates the filament and attentuates the fiber diameter. In less than 50 microseconds, the filament speed increases from 0.01 m/sec to over 500 m/sec, and the fiber diameter decreases from 500 microns to as little as 0.1 micron (a 2,500,000X reduction in cross sectional area). Theoretically, fibers made with this unusual process could be up to 25X as strong as steel wire.

Because of the fineness of melt-blown fibers, they make excellent filters, thermal insulation and absorbent materials. Sales of melt-blown fibers have enjoyed a 21.6 percent growth rate over the last five years, and this high rate will undoubtedly continue.

CEMS's initial research efforts involve developing the optimum operating conditions for the melt blowing of polypropylene, the most common melt-blown material. With polypropylene as a base case, Shambaugh's research group is demonstrating the optimum operating conditions for a wide variety of thermoplastics such as polyesters and polyethyl-



Magnified 20,000 times by the scanning electron microscope, the fiber in the foreground is invisible to the unaided human eye. The fiber is actually about half the width of the average wavelength of visible light.

ene sulfide. Dow, Phillips, Eastman and Fina have supplied CEMS with a number of polymer formulations, many of which are not available commercially.

Unique fibers with unique properties of fineness and strength could well result from the fibers work. Their approach to process optimization is fundamental—mathematical modeling and fiber characterization are inextricably related to this optimization process.

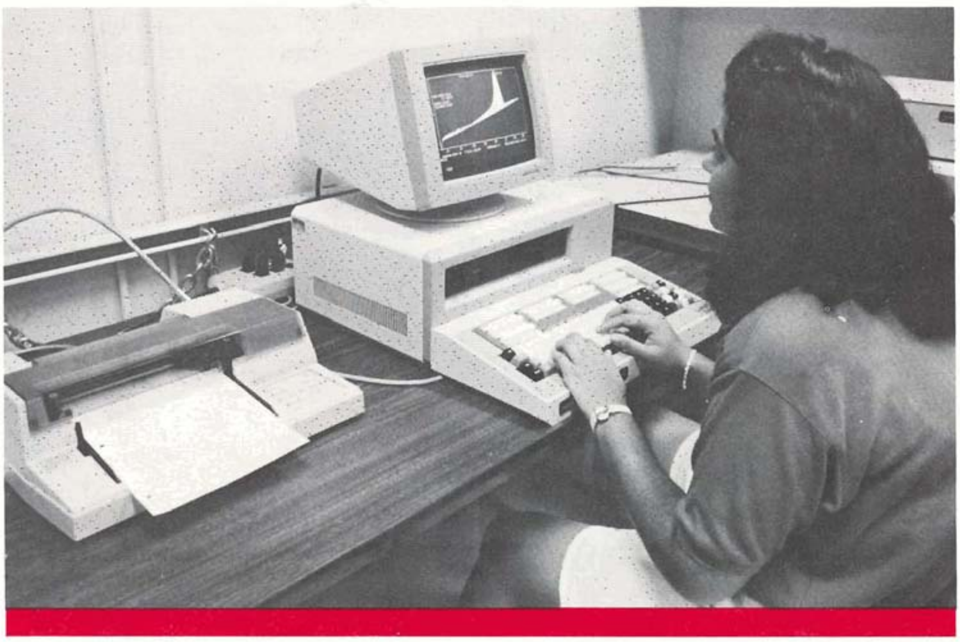
Shambaugh and his research team also are developing a mathematical model to predict and optimize melt blowing. A good model will allow prediction of fiber attentuation (final diameter), gas consumption and perhaps even the fiber strength. The model will save experimental time by suggesting optimum operating regions and/or polymer formulations and optimum die-head modifications for the melt-blowing process.

The research group has found that melt blowing has three regions. Region 1, the low gas-rate region, produces continuous fibers of relatively large diameters (greater than 10 microns). In region 2, higher gas rates cause the fibers to break up and form short-fiber segments and undesireable particle globs, or "shot" (greater than 3,000 microns diameter). Finally, the very high gas rates of region 3 cause both the production of extremely fine fibers (as small as 0.1 microns diameter) and the elimination of undesirable shot.

The group is presently modeling region 1 with a complex, interactive computer program that simultaneously solves the coupled momentum and heat transfer equations. Extensions to regions 2 and 3 are planned. Regions 2 and 3 are particularly difficult to model because of the fracturing of the filaments and because of the wildly whipping, almost random motion of the fiber segments at speeds which often exeed Mach 1.

Additionally, techniques to characterize melt-blown fibers are being developed in Shambaugh's fibers labs. These techniques include fiber-size distribution by optical microscopy, scan-

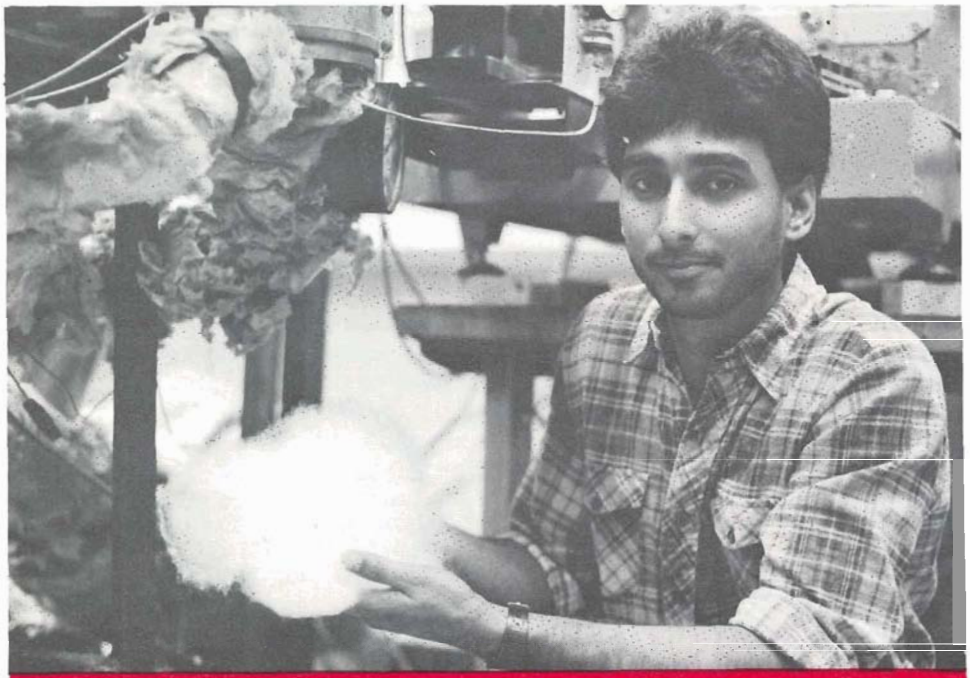
A high-speed strobe enables Prof. Robert Shambaugh and research assistants to photograph fibers during production to monitor variations in results of the melt-blowing process. Variations of orifice design and gas pressure produce corresponding differences in fiber shape, size and crystalline structure.



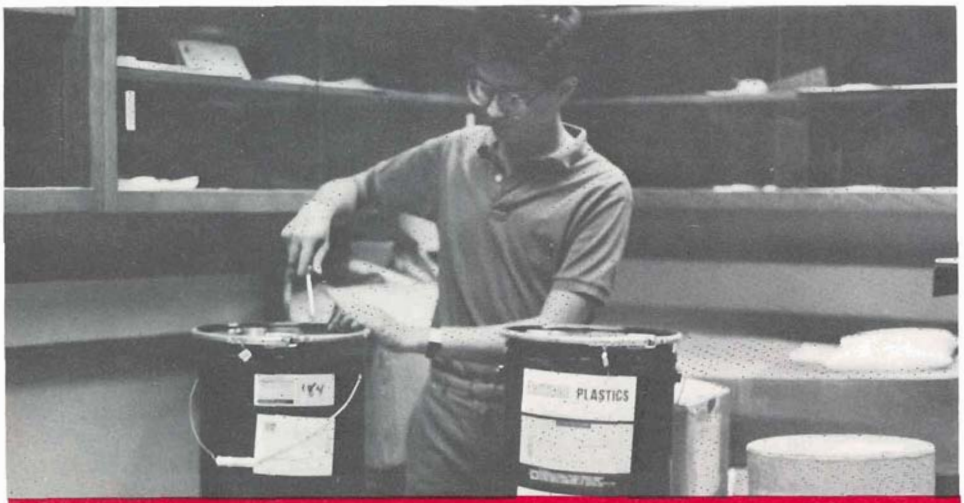
Research assistant Seema Vad uses a differential scanning calorimeter to analyze crystallinity, melting point, glass transition temperature and other characteristics of polymer samples.

ning electron microscopy (SEM) and computer techniques; fiber crystallinity and other thermodynamic parameters by differential scanning calorimetery (DSC); fiber-strength tests involving both single fibers and collections of fibers; fiber crystallinity and orientation, measured by wide-angle X-ray scans (WAXS); fiber crystallinity and voids determination by density measurements; degradation (molecular weight reduction) by intrinsic viscosity measurements; and fiber microstructure by SEM. Other possible techniques are fourier transform infrared spectroscopy (FTIR), small-angle X-ray scans (SAXS) and nuclear magnetic resonance (NMR).

These techniques will serve as independent, off-line measures of the properties of melt-blown fibers. Preliminary results have shown that unique crystal structures are present in melt-blown fibers.



Research assistant K. Narasimhan displays a cloud of melt-blow fibers such as may in the near future find use in insulation, composite materials and other products.



Polymers, such as these being opened by graduate research assistant Tien Wu, have been supplied for use in the CEMS melt-blowing process by supporting corporations including American Petrofina, Dow Chemical, Eastman Kodak and Phillips Petroleum.

A viscometer is used in calculation of the molecular weight of polymer samples and thermal degradation of melt-blown fibers.

"The Melt Blowing of Polyolefins," R. L. Shambaugh, K. M. Narasimhan, and S. Vad, *Proceedings of the Society of Rheology 59th Annual Meeting*, Atlanta, Ga., October 1987.

"The Process of Melt Blowing," R. L. Shambaugh and K. M. Narasimhan, *Proceedings of INDA-TEC 1987*, Hilton Head, S.C., May 1987.

"Fiber/Gas Interaction During Melt Blowing," R. L. Shambaugh and K. M. Narasimhan, *Proceedings of Society of Rhelogy Annual Meeting*, Tulsa, Okla., October 1986.

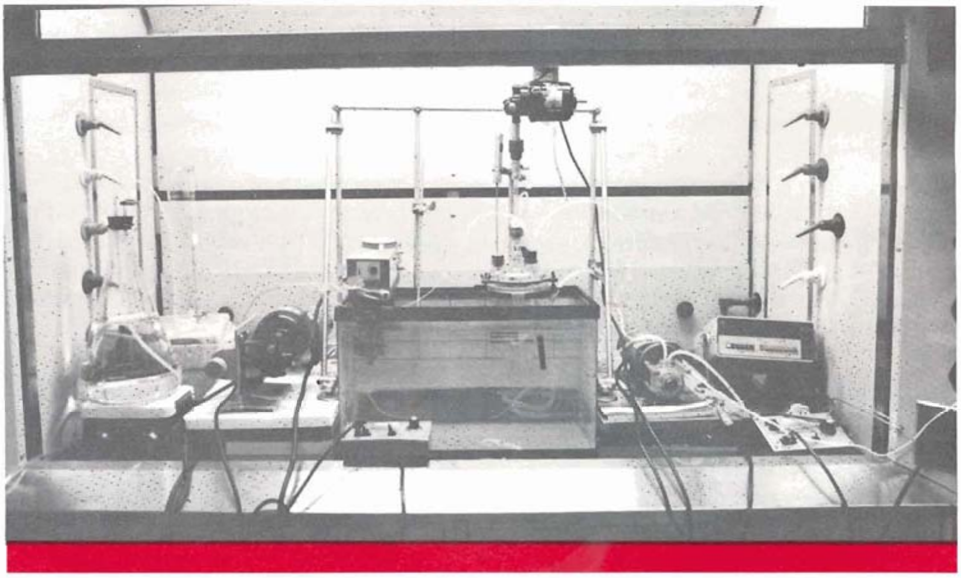
Polymerization

Richard Mallinson's current polymerization research involves the emulsion polymerization of vinyl acetate. This method of polymerization is widely used to produce latexes for the coatings industry and bulk addition polymers. He is seeking to understand the mechanisms involved in this complex heterogeneous polymerization technique with focuses on the molecular weights of the polymers and the effects of the surfactant emulsifiers on the molecular weights, particle sizes and conversions. Experiments are carried out in a continuous stirred tank reactor with on-line conversion determination and off-line use of laser light scattering and gel permeation chromatography for determination of particle size and molecular weight, respectively.

"Modeling of Molecular Weight Variation in Continuous Stirred Tank Vinyl Acetate Emulsion Polymerization," R. G. Mallinson and C. H. Lee, presented at the 60th Colloid and Surface Science Symposium, Atlanta, Ga., 1986. (Submitted for publication, *AIChE J.*, October 1987).

"The Molecular Weight Distribution in Continuous Stirred Tank Vinyl Acetate Emulsion Polymerization," R. G. Mallinson and C. H. Lee, In Press.

"A Sensitivity Analysis of the Oscillatory Behavior of Continuous Stirred Tank Emulsion Polymerization of Vinyl Acetate," R. G. Mallinson, presented at the AIChE Annual Meeting, Miami Beach, Fla., November 1986, In Press.



The continuous emulsion polymerization reactor system in Prof. Richard Mallinson's lab facilitates analysis of mechanisms involved in complex heterogeneous polymerization techniques.

Stress Corrosion Cracking in Steel

Stress corrosion cracking is the name given to the process of fracture of metals under the combined effects of an applied tensile stress and a corrosive environment. Problems of environmentally assisted cracking are limiting factors in a number of industrial processes and military systems.

Raymond D. Daniels' studies for the Air Force on failure problems in aircraft systems components have been funded annually since 1978. Recent studies have been concerned with failures of steel breech chambers in cartridge-ignition aircraft engine starters. The failures are associated with the corrosion produced by the residues from the burned solid propellent cartridges.

Conventional stress corrosion cracking experiments are carried out using a static loading device with the specimen surrounded by the corrosive environment. Time to failure is determined as a function of the stress level and environmental factors.

Another method of stress corrosion testing, the slow strain-rate tensile test, has gained recognition as a valuable tool in studying susceptibility to stress corrosion cracking. This technique requires a tension test machine of an adequate load capacity and is capable of providing constant but extremely slow crosshead speeds (10^{-6} to 10^{-9} m/s). The optimum strain rate for testing is determined by the crack propagation rate for a particular metal-environment system.

In this test, stress-corrosion-cracking susceptibility is determined from the comparative tensile stress-strain curves of a sample tested in the corrosive environment and a sample tested in an inert environment. The fracture surfaces are also examined to compare the crystallographic modes of fracture. Testing at various crosshead speeds can give information on the cracking mechanism and has been used to distinguish cathodic hydrogen assisted cracking processes from anodic-dissolution-assisted cracking processes.

Other recent research under contract has been concerned with the property changes that occur in electroless nickel coatings when they are heated above their normal operating temperature. Nickel-phosphorus coatings are being evaluated over a range of phosphorus contents from 1 to 12 percent. X-ray diffraction techniques are being used to study structural changes in the coatings, including precipitation phenomena and the development of preferred crystal orientations.

Also involved with Daniels in Department of Defense aircraft component failure analysis, as well as separate, related DOD-sponsored research, Bob Block has been recognized by various national companies as a consulting expert in the area of failure analysis. The continuing thread of Block's research interests is concern with the basic mechanisms by which plastic deformation and failure occur in metals. This research has involved studies of the dislocation arrangements in the surface and near-surface layers of deformed single crystals and the interactions between the surface and substrate material. He is currently setting up a testing program for a leading Oklahoma company to evaluate wood-metal adhesives for use in the construction industry. Block's background in failure analysis is utilized by the University of Oklahoma law school where he is regularly called upon to participate in their seminar on products liability.

"Stress Corrosion Cracking of 4340 Steel in Aircraft Ignition Starter Residues," R. D. Daniels, *Corrosion Cracking* (V.S. Goel, ed.), American Society for Metals (1986).

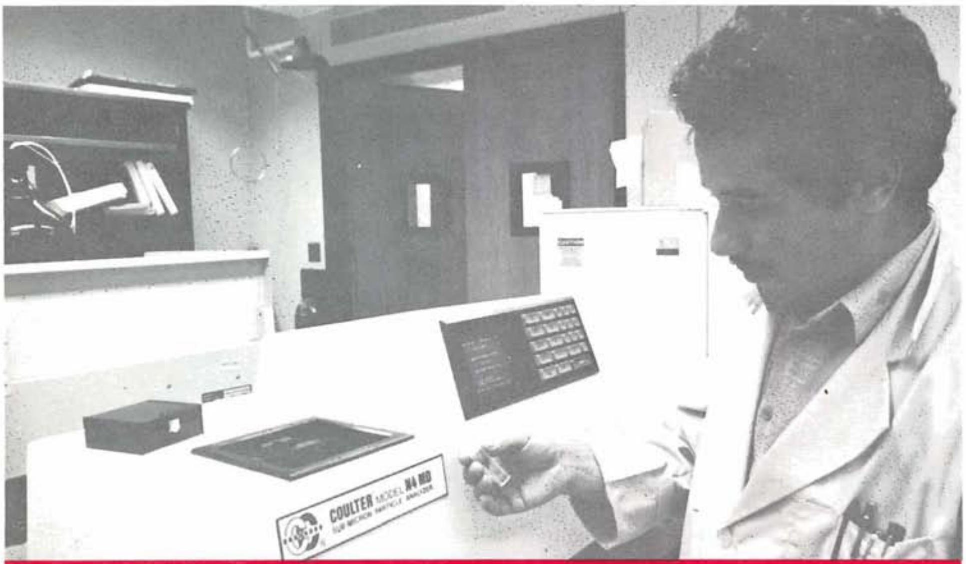
"Stress Corrosion Cracking of 4340 Steel in Aircraft Ignition Starter Residues," R. D. Daniels and K. J. Kennelley, *Journal of Materials Engineering* (June 1987).

"Failure Analyses of Steel Breech Chambers Used with Aircraft Cartridge Ignition Starters," R. D. Daniels, *Analyzing Failures* (V. S. Goel, ed.), American Society for Metals (1986).

"Hydrogen Induced Dislocation Motion," J. A. King, *Scripta Met.*, 19, March (1985).

Refractory Powders

Ceramics have the highly desirable properties of strength, temperature resistance and resistance to chemical attack. Because of these features, industrial demand is increasing for ceramics for a wide variety of applications, and CEMS incorporates a response to this demand with the development of research in this area through new faculty member Lance Lobban's efforts. Chemical manufacture of refractory powders (from which ceramics may be formed) generally involves very exothermic reactions.



Emulsion particle sizes are determined from dynamic laser-light scattering. Data such as those obtained here by research assistant Mohamed Tahiri will contribute further understanding of the effects of surfactant emulsifiers on particle size.

Chechian Ko, graduate research assistant, analyzes gel permeation data on the Water's Maxima data system.

Control of product purity and size distribution is important, but can be difficult. Reaction mechanisms are determined by combining mathematical modelling with experimentation. Knowledge of the mechanisms will aid in the design of process control and in improvement of the manufacturing process. The new research group now being formed by Lobban will apply principles of chemical reaction engineering and modem control theory to the optimization of product parameters.

BIOMEDICAL AND BIOLOGICAL ENGINEERING

The chemical engineer's strong grounding in fundamental phsyics, chemistry and mathematics makes him or her a valuable resource to demanding new technologies involving living systems. CEMS has a growing interest in these areas and has already made significant contributions to important developing areas.

This September, CEMS welcomed new Assistant Professor Lance L. Lobban (BSChE '81, University of Kansas; Ph.D. '87, University of Houston). His research interests include catalytic reaction rate mechanisms and modeling, partial oxidation of hydrocarbons and synthesis of refractory powders.

Blood Substitutes

Blood substitutes are a useful alternative to whole blood in medical applications. They can be used for transfusions when human blood is not available or cannot be administered for religious reasons. They also have novel and promising applications, including perfusion of myocardial and cerebral ischemia (local anemia of tissues) to whole organs, preoperative treatment of severely anemic patients, treatment of myocardial and cerebral ischemia (local anemia of tissues) to improve oxygen supply, and combined chemotherapy or radiation therapy to enhance the effect of some anticancer drugs. Perfluorochemical (PFC) emulsions and stroma-free hemoglobin are the two most successful categories of blood substitutes. A novel possible application of these compounds being examined in one current project is their use to oxygenate high-density cell cultures for fermentation technology. E. A. O'Rear leads CEMS's research in this area.

PFCs are fluorinated organic compounds. They are chemically inert, non-toxic and good carriers of oxygen.

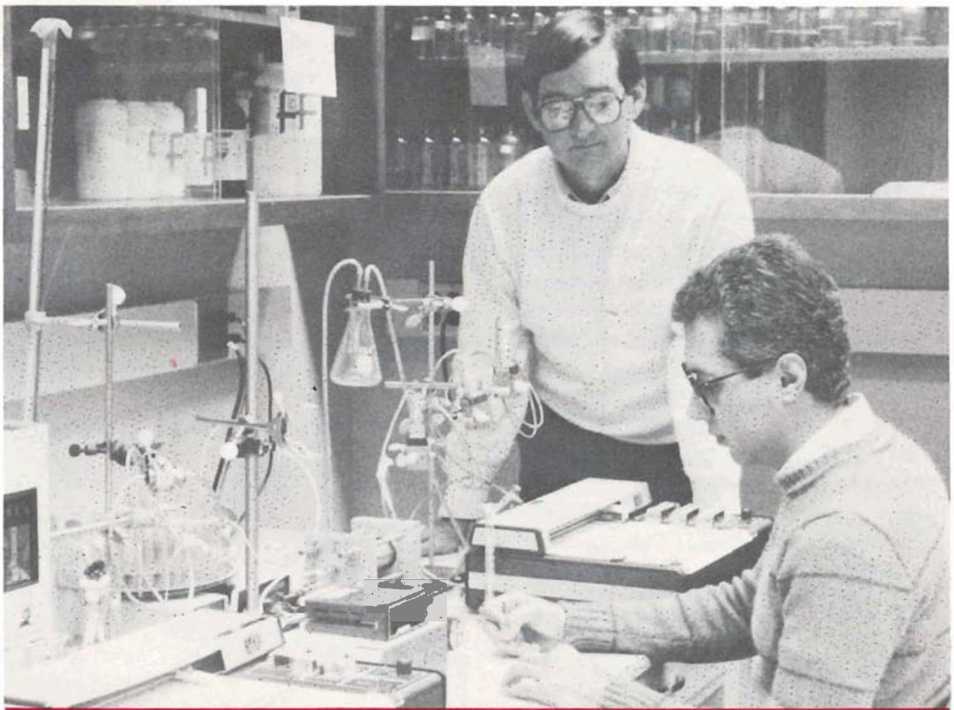
aqueous system, which causes two immiscible phases to form, but which are both predominantly water. The same thermodynamic forces that cause the solution to form the two phases provide the driving force necessary to cause a distribution of biological molecules between these phases in unequal quantities. Although this phenomenon has been known and utilized for some time, there is still no fundamental basis for designing such separations, and the understanding of the thermodynamic behavior is only now beginning to be studied. Our approach is to carry out experiments to determine the behavior of specific biological molecules, proteins and enzymes and to relate their behavior to their measureable chemical physical properties in such a way that a predictive capability may be developed. This would minimize the amount of testing and "intuition" that are now currently needed to accomplish these separations. Richard Mallinson heads CEMS research efforts in this area.

ENERGY

Some people think that the energy crisis is over. Chemical engineers know better. When the next "energy crisis" comes, CEMS plans to be among the leaders in energy-related research by maintaining an active program today.

Depolymerization of Crosslinked Macromolecular Networks (with Applications to Coal Liquefaction)

Modern composite materials consist of a crosslinked polymeric matrix surrounding reinforcing particles and/or fibers. Many factors are important in producing the strength of the composites, including the integrity of the matrix. Coals have also been represented by crosslinked macromolecular networks, the degradation of which provides the basis for conversion to liquid fuels. In this research, a crosslinked polymeric network has been synthesized that can represent an ideal "model" for coal. This network is thoroughly characterized and then thermally degraded under coal liquefaction conditions. The breakup of the network is followed by analysis of the insoluble and soluble materials that result. The experiments allow the development of a theoretical model for the random degradation of such networks, whether coal or composite matrices, which may be used to predict the behavior of less well characterized systems under similar degradation conditions.



Prof. Jeffrey Harwell, standing, confers with graduate research assistant Ali Arshad, who is monitoring pressure through a core simulating an oil reservoir to check effectiveness of surfactant quasiface plug formation and duration. Data accumulated from experiments with surfactant mixtures tested through a range of expected reservoir conditions will help to create an index for selection of efficient mixtures to suit particular reservoir profiles.

Enhanced Oil Recovery

Surfactant-Enhanced Waterflooding

Despite the utility of waterflooding technology in oil production, the process generally leaves some 65 percent of the original oil in a formation unproduced. A major problem is the development of water channels between the injection and production wells. Surfactant-enhanced waterflooding, a process developed in CEMS, is a novel way of increasing sweep efficiency by diverting injected water into the oil-rich portions of the reservoir. The basic idea of the new process is to use separately injected solutions of two different surfactants. One of the surfactants has a greater chromatographic velocity in the formation. When the two surfactants mix in the reservoir, they undergo a spontaneous phase separation. By this mechanism, fluid flow through the most permeable region of the reservoir is reduced, while high injectivity is maintained.

Surfactant Flooding

After oil cannot be produced economically by waterflooding, one EOR option is surfactant flooding. In surfactant flooding, a detergent solution is introduced into the reservoir through an injection well from which it flows toward a production well. The surfactant reduces the interfacial tension between the flowing water and oil trapped in pores in the rock by capillary forces. This oil is freed, permitting it to form an oil bank that can be produced.

Research in CEMS is focused on solving some of the problems that have prevented surfactant-flooding technology from being economical. The major goal is to understand the fundamental processes of interest and to apply that knowledge to find solutions to specific problems. In surfactant flooding, detergent is lost by adsorption on minerals, precipitation or phase trapping into residual oil. By judicious use of surfactant mixtures, these mechanisms of loss can be reduced, lowering surfactant requirements of a flood and decreasing raw materials costs. For example, addition of nonionic surfactant to an anionic surfactant reduces the tendency to precipitate. Addition of anionic surfactant to nonionic surfactant reduces the tendency to partition into the residual oil phase. Mixtures of anionic surfactants or mixtures of anionic and nonionic surfactants can exhibit lower adsorption than the pure surfactants involved.

"Enhanced Oil Recovery by Surfactant-Enhanced Volumetric Sweep Efficiency," A. Arshad and J. H. Harwell, *SPE #14921.*

"Thermodynamics of Microemulsion Formation by Mixtures of Anionic and Nonionic Surfactants," O. Haque and J. F. Scamehorn, *J. Dispersion Sci. Technol.*, 7, 129 (1986).

"Surfactant Chromatographic Movement: An Experimental Study," J. H. Harwell, R. S. Schechter, and W. H. Wade *AIChE Journal*, **31**, 415 (1985).

"Thermodynamics of Adsorption of Surfactant Mixtures on Minerals," J. H. Harwell, B. L. Roberts, and J. F. Scamehorn, In Press.

Heterogenous Catalysis

Heterogeneous catalysts are used in numerous industrial reaction processes, and tremendous incentive exists for improvements of catalysts and catalyst utilization, areas of special interest to CEMS's newest faculty member, Lance Lobban. Partial oxidation of olefins and other hydrocarbons are particularly important for the production of liquid fuels and chemical feedstocks from simpler hydrocarbons. Currently, there is much interest in deriving novel techniques for synthesizing conventional chemicals from unconventional feedstocks or by unconventional processing. Experimental techniques to obtain local and average properties, and mathematical tools to analyze the data, can help discriminate between possible reaction mechanisms by identifying elementary steps in the reaction process. These studies can identify factors limiting the catalyst performance, which can lead to improved process yields and selectivities.

A major area of effort is in the development of catalysts that are both more active and more selective. Another possible alternative for enhanced chemical reaction is in the presence of an electric field. In collaboration with Richard Mallinson, Cedomir "Cheddy" Sliepcevich has demonstrated that the partial oxidation of hydrocarbons can be accomplished in an electric field at essentially ambient temperatures and pressures to obtain alcohols and aldehydes in yields comparable to catalytic systems operating at elevated temperatures and pressures.

"Kinetics and Mechanism of Moroccan Oil Shale Solubilization in Supercritical Toluene," M. Tahiri, C. M. Sliepcevich, and R. G. Mallinson, *Energy and Fuels* (Accepted for publication October 1987).

"Methane Partial Oxidation in Alternating Electric Fields," R. G. Mallinson, C. M. Sliepcevich, and S. Rusek, Am. Chem. Soc. Nat. Meeting, New Orleans, La., August 1997.

"The Depolymerization of a Coal Model Polymer," I. Lee, C. M. Sliepcevich, and R. G. Mallinson, Am. Chem. Soc. Nat. Meeting, New Orleans, La., August 1987.

"Reaction Kinetics for Donor-Solvent Coal Liquefaction," R. G. Mallinson, R. A. Greenkorn, and K. C. Chao, AIChE Annual Meeting, New York, N.Y., November 1986.

"Structural Characterization/Correlation of Calorimetric Properties of Coal Fluids," K. E. Starling and R. G. Mallinson, *Proc. U.S. D.O.E. Univ. Coal Prog. Contractors' Conf.*, Pittsburgh, Pa., July 14–16, 1986.

Flame Dynamics

The ability to predict hazardous zones for releases of flammable and/or toxic materials into the atmosphere under variable weather conditions and geographical terrains continues to perplex those responsible for the design of accident response systems and for the safety of the populace. For the past 25 years, C. M. Sliepcevich and his associates have delved into various facets of this problem. Although currently there are several sophisticated mathematical models that in combination with reasonable engineering judgments are adequate for most practical situations, the incentive to develop even more precise models is to obtain a better fundamental understanding of the dispersion process itself. Currently Sliepcevich is collaborating with Faruk Civan in the petroleum engineering school in this work.

Water is separated from triethylene glycol in a climbing film evaporator in the ChE Design Laboratory. Design lab course work provides realistic process design experience for seniors such as Mark Richards (foreground) and Monty Dolph.

A bench-scale micellar-enhanced ultrafiltration cell operated by graduate research assistants Lori Brant (left) and Nancy Gullickson removes organics and metals from aqueous streams using single-species surfactants and surfactant mixtures. Results obtained from bench- and pilot-scale units promise extremely efficient low-energy surfactant-based separation techniques for wide industrial application.

For the past 30 years, the Flame Dynamics Laboratory under Sliepcevich's direction has completed numerous projects related to fire research, including some 30 doctoral dissertations and a comparable number of master's theses. One subject area that is of particular, current interest is the unification of ignition criteria with the burning rates and surface-flame spread rates for solids. Most of the experimental data has been accumulated already. The problem now is to develop mathematical models to describe the physical and chemical processes involved. The problem is unusual in that three-dimensional, chemical kinetic parameters are involved.

"Differential Quadrature for Multi-dimensional Problems," C. M. Sliepcevich and F. Civan, *J. of Math. Anal. and Applic.*, **101**, No. 2, 423–443 (1984).

"Efficient Numerical Solution for Enthalpy Formulation of Conduction Heat Transfer with Phase Change—Technical Note," C. M. Sliepcevich and F. Civan, *Int. J. Heat Mass Transfer*, **27**, No. 8, 1428–1430 (1984).

"On the Solution of the Thomas-Fermi Equation by Differential Quadrature—Technical Note," C. M. Sliepcevich and F. Civan, *J. of Computational Phys.*, **56**, No. 2, 343–348 (1984).

"Convenient Formulations for Convection/Diffusion Transport," C. M. Sliepcevich and F. Civan, *Chem. Engr. Sci.*, **40**, No. 10, 1973–1974 (1985).

"Application of Differential Quadrature to Solution of Pool Boiling in Cavities," C. M. Sliepcevich and F. Civan, *Proc. of the Okla. Acad. of Sci.*, **65**, 73–78 (1985).

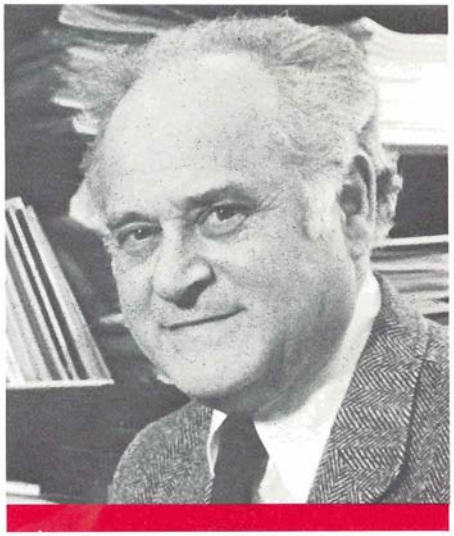
Distinguished European Presents 13th Annual Harry G. Fair Lecture

Eli Ruckenstein, distinguished professor of chemical engineering at the State University of New York at Buffalo, presented the 1987 Harry G. Fair Lecture in April. The topic of Ruckenstein's presentation was "The Chemical Engineering of Surfactant Solutions."

Ruckenstein received his master's degrees in chemical engineering in 1949 and his doctorate in 1967 from the Polytechnic Institute of Bucharest, Romania, and was a professor there until 1969. While in Romania, Ruckenstein focused his scientific efforts in the area of heat and mass transfer.

Ruckenstein came to the United States when he was invited by the National Science Foundation to serve as senior scientist at Clarkson College of Technology. He served as professor at the University of Delaware Department of Chemical Engineering from 1970 to 1973 before he joined the faculty at Buffalo, where he was promoted to his current position in 1981. Since coming to the United States, he has focused his research in the areas of catalysis, surface phenomena, colloids, emulsions and biocompatible surfaces.

For his research, Ruckenstein received three Romanian national awards as well as the Alpha Chi Sigma award for research in chemical engineering from the American Institute of Chemical Engineers in 1977 and the Kendall Award of the American Society in 1986 for his research in colloids and surfaces.



Eli Ruckenstein

CEMS Master's Candidate Awarded Kodak Fellowship

Raymond H. Floyd II, a May 1988 candidate for a master's degree in chemical engineering, has been selected by the Texas Eastman Co. as an Eastman Kodak Graduate Scholar in Chemical Engineering for 1987–88. The fellowship, awarded on the basis of academic merit, provides a $12,000 grant to Floyd for completion of his project involving recovery of surfactant and solute from solubilized surfactant solutions.

Floyd, who received his bachelor's degree in chemical engineering from OU in 1986, received bachelor's degrees in both biochemistry and chemistry in 1969 at California Polytechnic State University at San Luis Obispo.

Before coming to OU to study chemical engineering, Floyd worked three years for Mobil Corp. in Los Angeles as a quality-control chemist, first-line supervisor and foreman.

In 1975, Floyd bought a service station, which he operated for the next seven years. As a successful business operator, Floyd was able to pursue a pilot's license and bought a Cessna 210. He and his wife, Karen, and their three children toured the United States by motor home before moving to Oklahoma so Floyd could pursue degrees in chemical engineering.

Floyd and his wife, a teacher at Willowview Hospital in Oklahoma City, have many family ties to southeastern Oklahoma and returned to the area because of an appreciation of the pace and lifestyle the state offers. Floyd would like to remain in the area after completion of his graduate education, he said.

Polly Dvorak, tabbed "Secretary Emeritus" by Prof. Ed O'Rear, retired in August to travel and enjoy her family. At a reception in her honor, faculty, staff and students presented her with a set of luggage in appreciation of the service she gave through the years. Bon voyage, Polly!

Seminar Series 1986–87

The CEMs seminar series and special lectures presented in 1986–87 brought professional insight into various aspects of careers open to chemical engineers.

Seminars included "Rheological Behavior of Polymeric Liquid Crystals by Arthur Metzner, University of Delaware; "Film Thickness Distribution for Gas-Liquid Annular Flow in a Horizontal Pipe" by Paul Jepson, Heriot-Watt University; "Knudsen Region Molecular Flow Through Porous Media of Finite Thickness" by Timothy Faley, University of Notre Dame; "Spatially Nonuniform States of Catalytically Reacting Systems" by Lance Lobban, University of Houston; "Equations of State of Polar Fluids" by Kwang-Chu Chao, Purdue University; "In Situ Capacitance Studies of Thin Polymer Films During Compressed Fluid Extractions" by David Ziger, AT&T Engineering Center at Princeton, N.J.; and "Miscibility and Properties of Blends of Poly(Styrene-B-Ethylene-Co-Butylene-B-Styrene) Copolymers with Dissimilar Homopolymers" by Pamela Tucker, University of Texas at Austin.

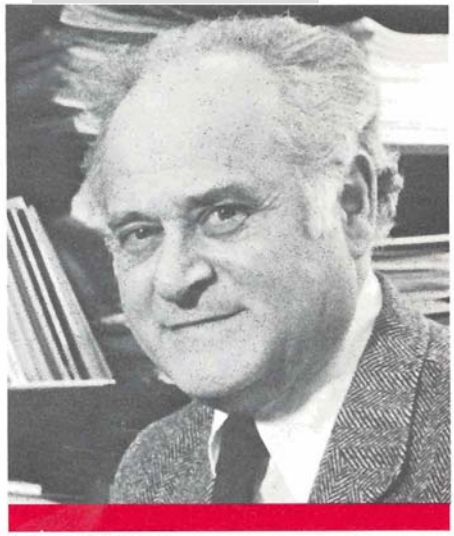
Distinguished European Presents 13th Annual Harry G. Fair Lecture

Eli Ruckenstein, distinguished professor of chemical engineering at the State University of New York at Buffalo, presented the 1987 Harry G. Fair Lecture in April. The topic of Ruckenstein's presentation was "The Chemical Engineering of Surfactant Solutions."

Ruckenstein received his master's degrees in chemical engineering in 1949 and his doctorate in 1967 from the Polytechnic Institute of Bucharest, Romania, and was a professor there until 1969. While in Romania, Ruckenstein focused his scientific efforts in the area of heat and mass transfer.

Ruckenstein came to the United States when he was invited by the National Science Foundation to serve as senior scientist at Clarkson College of Technology. He served as professor at the University of Delaware Department of Chemical Engineering from 1970 to 1973 before he joined the faculty at Buffalo, where he was promoted to his current position in 1981. Since coming to the United States, he has focused his research in the areas of catalysis, surface phenomena, colloids, emulsions and biocompatible surfaces.

For his research, Ruckenstein received three Romanian national awards as well as the Alpha Chi Sigma award for research in chemical engineering from the American Institute of Chemical Engineers in 1977 and the Kendall Award of the American Society in 1986 for his research in colloids and surfaces.



Eli Ruckenstein

CEMS Master's Candidate Awarded Kodak Fellowship

Raymond H. Floyd II, a May 1988 candidate for a master's degree in chemical engineering, has been selected by the Texas Eastman Co. as an Eastman Kodak Graduate Scholar in Chemical Engineering for 1987–88. The fellowship, awarded on the basis of academic merit, provides a $12,000 grant to Floyd for completion of his project involving recovery of surfactant and solute from solubilized surfactant solutions.

Floyd, who received his bachelor's degree in chemical engineering from OU in 1986, received bachelor's degrees in both biochemistry and chemistry in 1969 at California Polytechnic State University at San Luis Obispo.

Before coming to OU to study chemical engineering, Floyd worked three years for Mobil Corp. in Los Angeles as a quality-control chemist, first-line supervisor and foreman.

In 1975, Floyd bought a service station, which he operated for the next seven years. As a successful business operator, Floyd was able to pursue a pilot's license and bought a Cessna 210. He and his wife, Karen, and their three children toured the United States by motor home before moving to Oklahoma so Floyd could pursue degrees in chemical engineering.

Floyd and his wife, a teacher at Willowview Hospital in Oklahoma City, have many family ties to southeastern Oklahoma and returned to the area because of an appreciation of the pace and lifestyle the state offers. Floyd would like to remain in the area after completion of his graduate education, he said.

Polly Dvorak, tabbed "Secretary Emeritus" by Prof. Ed O'Rear, retired in August to travel and enjoy her family. At a reception in her honor, faculty, staff and students presented her with a set of luggage in appreciation of the service she gave through the years. Bon voyage, Polly!

Seminar Series 1986–87

The CEMs seminar series and special lectures presented in 1986–87 brought professional insight into various aspects of careers open to chemical engineers.

Seminars included "Rheological Behavior of Polymeric Liquid Crystals by Arthur Metzner, University of Delaware; "Film Thickness Distribution for Gas-Liquid Annular Flow in a Horizontal Pipe" by Paul Jepson, Heriot-Watt University; "Knudsen Region Molecular Flow Through Porous Media of Finite Thickness" by Timothy Faley, University of Notre Dame; "Spatially Nonuniform States of Catalytically Reacting Systems" by Lance Lobban, University of Houston; "Equations of State of Polar Fluids" by Kwang-Chu Chao, Purdue University; "In Situ Capacitance Studies of Thin Polymer Films During Compressed Fluid Extractions" by David Ziger, AT&T Engineering Center at Princeton, N.J.; and "Miscibility and Properties of Blends of Poly(Styrene-B-Ethylene-Co-Butylene-B-Styrene) Copolymers with Dissimilar Homopolymers" by Pamela Tucker, University of Texas at Austin.

Program of Excellence Scholarships and Achievement Awards 1987–88

CEMS continues to maintain a large number of superior students receiving scholarships and academic achievement awards. These chemical engineering scholars are frequently supported by competitive college, universitywide and private foundation programs as well as by CEMS's own Program of Excellence. The 1987–88 Program of Excellence class is populated with students with 4.0 GPAs and composite ACT scores averaging in the 30s.

The school and sponsoring companies recognize superior achievement in the challenging chemical engineering curriculum through awards given each academic year. In spring 1987, senior achievement award recipients were Barry Penney, who received two awards, the Phillips Award for outstanding senior and the Robert Vaughn Award for outstanding undergraduate research; Brad Harris, who received the American Institute of Chemists Award; and Astrid Bottomley, who won the Pamela Pesek Johnson Award for outstanding senior in process design. Astrid also received the $800 F. Mark Townsend Scholarship for 1986–87 for outstanding academic achievement and involvement in extracurricular activities.

Marilyn Grass received the Dow Outstanding Junior Award, and Edward Jones, the American Institute of Chemical Engineers Award to an outstanding junior. Maurice Lampl received the CEMS Outstanding Sophomore Award.

CEMS continues to offer valuable practical research experience and additional scholarship support to undergraduate students through its program of research scholarships. Susan Howard was selected for a summer 1986 scholarship. Students participating during fall 1986 were Stephen Heimbach, Edward Jones, Tim Melton and Mark Richards. Spring 1987 research scholarships were awarded to Hans Christain, Edward Jones, Burt Lampl, Barry Penney and Steven Shimoda.

Bethany senior Marilyn Grass is the recipient of the $1,000 Outstanding Junior Chemical Engineering Award provided by Dow Chemical U.S.A. Presenting the award to Grass is L. J. "Larry" Burmeier (right), manager of training and development for Dow Chemical, Freeport, Texas, and CEMS Director Raymond Daniels. Grass more recently received a $1,000 Society of Women Engineers scholarship for 1987–88, sponsored by United Technologies.

Support for Program of Excellence scholars is made possible by contributions from Atlantic Richfield Co., Celanese Chemical Co., Cities Services Co., Chevron, Conoco, Inc., Dow Chemical Co., Mobil Oil, Phillips Petroleum Co., Procter & Gamble, Shell Oil and the OkChE Alumni Support Group.

Program of Excellence Scholars for 1987–898 are:

Atlantic Richfield
Jana Armstrong

Celanese Chemical
Katricia Louthan

Cities Services
Brett Baker
Holly Battersby

Chevron
Terry Kendrick
Kevin J. McKeown
Laymon Moates

Conoco
Christopher Canfield
Hans Christain

Dow Chemical
Marilyn Grass

Mobil Oil
Cynthia Estep
Maurice Lampl
Vanessa Ong
Mark Porter

Monsanto Chemical
Cheveil Bush
Tracy Byford

Phillips Petroleum
Tom Burghart
Khoa Dao
Leslie Davidson
Mark Dawkins
James Hickey
Paul Pfeffer

Procter and Gamble
Lance Gibson
Derek Gregory
Jill Hall
Murray Hamilton
Rebecca Holland
Steven Shimoda

Shell Oil
Matthew Roberts

OkChE Alumni
Michelle Frazier
Nora Melton
Jason Proctor
Kristy Sells
Julie Sheffield

Outstanding Paper Presentation Recognized by AOCS

CEMS Professor John F. Scamehorn and recent OU graduate Kevin L. Stellner (Ph.D. '87) have been given the 1987 Award of the American Oil Chemists Society for Outstanding Paper Presentation for the paper, "Precipitation of Anionic/Cationic Surfactant Mixtures," which was recently presented at the society's annual meeting in New Orleans. Stellner has since been employed at Lever Brothers in Edgewater, N.J.

The award not only honors the co-authors for the content of the paper, AOCS Executive Director James Lyon said, "But more important, it is a recognition of superior presentation and the importance of *effective* scientific communication."

New Alumni 1986–87

BACHELOR OF SCIENCE
IN CHEMICAL ENGINEERING

Astrid Bottomley
Lori Walker Brant
Randall Busky
Jerry Chenoweth
Carl Ellett
Michael Essien
James Ferguson
Darin Fields
Adam Ganz
David Gieber
Bradley Harris
Ronda Huffines
Joe Jayroe
Billy Jones
Bradley Lowery
David McIver
Susan Millsap
Scott Nesbit
Barry Penney
Bita Rakhshanfar
Thomas Richardson
Sun Sasongko
Iyad Shanaa
Gary Simmons
David Sowards
Steven Statham
Ahmadali Tabatabai
Jon Warzel

BACHELOR OF SCIENCE
IN METALLURGICAL
ENGINEERING

Douglas McClure
Samuel Okorozo
Tesilimi Sanusi

MASTER OF SCIENCE
IN CHEMICAL ENGINEERING

David Baugh
Geoffrey Chappell
Robert Dunn, Jr.
Chris Grout
K. M. Narasimhan
James Rathman
Thomas Reid, Jr.
Sadasivan Shankar
Kevin Stellner
Kalyanaraman Subramanian
Sumner Tison

MASTER OF SCIENCE
IN METALLURGICAL
ENGINEERING

Haresh Harpalani
Aneesh Sadarangani

DOCTOR OF PHILOSOPHY
IN CHEMICAL ENGINEERING

Su Lin
Kiran Sheth
Kevin Stellner

Alumni Notes

John M. Campbell (PhD '51), former chair of OU's School of Petroleum Engineering, has been named the 1987 recipient of the Gas Processor's Association Hanlon Award for service and contributions to the industry. It is the highest honor conferred by the Tulsa-based group. Now retired, he pioneered the development of commercial glycol hydration systems.

William A. Kennedy (BSChE '66), president of Oklahoma City-based Corken International, a specialty manufacturer of pumps and compressors for the liquefied petroleum gas industry, must be proud of the company, which went public in March. Corken has posted profits every quarter since 1945, making it one of Oklahoma's most successful firms.

At the spring AIChE meeting in Houston, **Norman Carnahan** (PhD '71) co-chaired a session in honor of the late Tom Leland. Also participating was **Ali Mansoori** (PhD '69), a professor at the University of Illinois at Chicago Circle, who presented a paper.

John R. Hallman (PhD '71) has been appointed vice-president and academic dean of Spring Garden College in Philadelphia after serving as both associate and acting academic dean. Hallman has published more than 30 technical papers and articles and has achieved international recognition by virtue of his unique work on surface reflectance and absorptance characteristics of materials. Last summer, he and his wife, Florence, flew to England and visited museums, colleges, Herrod's, the Tower of London and Westminster Abbey, among other sites. One stop included two days at Gilwell Scout Camp to teach 800 Cub Scouts about American Indian history and dances.

Mao Sup Han (PhD '72) recently moved to C.E. Lummus in Houston. He attended the Gas Processors Association annual convention in March along with other OU alums **Ed Lindenberg** (BSME '48), **Charles Perry** (BSChE '51), **Allen Blancett** (BSChE '61, MSChE '62, PhD '66) and **Bill Woodard** (BSChE '67, MSChE '71, PhD '73) and OkChE board member **David P. Kurtz**.

Mike Smith (BSChE '79) is finishing a residency in orthopedic surgery at the University of Michigan. He completed the pre-med undergraduate program in Norman and then attended medical school at the OU Health Science Center.

Ngoc Chau Thai (BSChE '79) has joined Con Edison in New York as a system analyst. He operates a nuclear reactor simulator that utilizes her engineering and programming skills.

Lester Landis (BSChE '82 MSChE '84, PhD '85) and his wife, **Debra Wotring Landis** (BA '82, JD '85), have moved into a new home in the Rice Medical Center area of Houston. Lester works at Exxon Production Research while Debra, a former UOSA president, is employed with a prestigious law firm.

Alumnus **Lowry Blakeburn** (BSChE '83, MSChE '85) of Conoco's Ponca City refinery attended the spring national meeting of the American Chemical Society in Denver. He presented a paper on surfactant-enhanced carbon regeneration, which was the basis of his thesis work at OU.

Now in Merrimack Valley in North Andover, Mass., **Sharon Potter** (BSChE '83) conducts failure mode analysis on hybrid integrated circuits with AT&T. She has taken up snow skiing in New Hampshire and has bought a 200-year-old colonial house, which she is fixing up with a friend.

Both **Kevin Clary** (BSChE '85) and **Warren Becraft** (BSChE '85) are attending graduate school at the University of Queensland in Australia. Each made trips home from the summer "down under" for Christmas.

Stig Peitersen (BSChE '85) and his wife, Cristina, celebrated the birth of a baby daughter, Annika Anne, in December. After finishing the pre-med program in chemical engineering, Stig entered medical school at OUHSC where he is continuing his studies.

Alumni **Danell Wright** (BSChE '85) and **Kevin Sneed** (BSChE '85) were married last November in Tulsa. The newlyweds live in Houston where Kevin is studying for his MBA at the University of Houston and Danell is employed with Conoco. Classmate **Dru Ann Preston McElreath** (BSChE '85), a member of the wedding party, is continuing her education as she works toward a PhD in biology at the University of Dallas.