A Course in

POLYMERS, SURFACTANTS AND COLLOIDAL MATERIALS

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IN EARLY 1970, Warren K. "Doc" Lewis reminisced on the origins of the chemical engineering profession and, in turn, on the origins of chemical engineering education. His rich tale of the birth of our discipline starts with the Industrial Chemists in early-19th century England. Although engineering skill and techniques were already acknowledged as important to the development of the British chemical industry, there was effective opposition to the name "Chemical Engineer" and to the organization of a society of chemical engineering. Instead, the British Society of Chemical Industry was formed.

THE NEW CURRICULUM

Doc Lewis' long time colleague and friend, William H. Walker succeeded Lewis M. Norton as the head of the new curriculum called chemical engineering established in 1888 in MIT's Chemistry Department. Walker was strongly influenced by the instruction in physical chemistry offered by A. A. Noyes whom Doc termed "one of the Institute's greatest teachers." Walker modeled his Laboratory of Applied Chemistry after Noyes' Laboratory of Physical Chemistry emphasizing the solution of unsolved, industrially stimulated problems. Walker consolidated the first Chemical Engineering Department and focused the curriculum around the same full course requirements in organic and physical chemistry as the chemists. The engineering requirements were pared to a minimum to provide ample time to consolidate the theory and practice of chemistry.

Doc Lewis pioneered in the areas of product engineering as well as process engineering. The curriculum development at MIT including his course on "Structure-Property Relationships of Amorphous Materials" reflects the early concern for product development in the chemical engineering curriculum.

The American Institute of Chemical Engineers was formed in 1908 in response to the growing industrial interest in electrochemical processes including caustic, chlorine, carborundum, and the electro-plating of copper and nickel. As chemical engineering grew as a profession and as an engineering discipline the various engineering schools of the major state and private universities became the home for the emerging chemical engineering departments. These new departments developed more along the curriculum requirements of their parent school than in a manner consistent with the exigencies of chemical engineering. Chemistry requirements were pared to a minimum and the various engineering courses survived.

PROGRAMS IN POLYMERS LAUNCHED

In early 1967 Dr. Vivian T. Stannett, an internationally recognized polymer chemist, was successfully recruited by the chemical engineering department at North Carolina State University. He was recruited under a National Science Foundation Science Development Grant to build an effort broadly termed "polymers." His program is actually much broader and now encompasses a complete effort in applied chemistry including polymers, surface chemistry, and colloid science. Dr. Stannett's recruitment was the result of the wise and considered decision by the senior chemical engineering faculty that the strength and uniqueness of the chemical engineering research program depended upon emphasizing the "chemical" in chemical engineering. Dr. J. K. Ferrell, at that time newly appointed department head, consolidated this mandate by recruiting Vivian and acting favorably on his request that a junior faculty member be recruited as well to broaden the base of the proposed graduate teaching-research effort. Although my temples are now greying, seven years ago I was that junior recruit.

Vivian and I spent the first semester at N. C. State proposing to the government. Our overtures

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were warmly received and broad research programs in polymer science were launched. The department rubbed off on Vivian as Vivian did on the department and an AEC-sponsored research program on engineering aspects of radiation polymerization was jointly initiated by Vivian and another younger faculty member, Dr. E. P. Stahel, II.

The research effort burgeoned and then leveled in late 1969 with 12 post doctoral fellows in residence and some 20 graduate students pursuing graduate degrees based upon research in polymer science and applied chemistry.

In that building spring of 1967, a supporting graduate course titled "Structure-Property Relationships of Organic Materials" was proposed to the Parkinsonian chain of university committees. These committees had the authority to accept or reject proposed course offerings. Just as the early British Industrial Chemists were prevented from describing their new discipline accurately, the various vested interest groups on the multitude of authorizing committees approved the course curriculum without change, but made the course title into a caricature of the effects of committee compromises. My attitude was simply to see how far the committees would go and to retain the substance and flavor of the course. These rumpled men wearing serious Robert Hall suits and winged-tipped shoes, renamed my course "Applications of Structure Property Relationships of Chemical Engineering Materials". The computer, listing fall 1968 course offerings, went into cardiac arrest and sputtered out "APPLSTRPROCHENGMAT".

The course in fact, was a survey of polymer physics, surface chemistry, and colloid science. Throughout the course, applications were emphasized and the course offered a perspective of those last chapters in physical chemistry texts that are always going to be treated in the next course. They seldom are.

BENEATH THE "SURFACE"

The typical student comes to the course with a single answer to a variety of questions. When asked why water rises in a capillary tube he confidently answers: "Surface tension." When asked why the mercury level in a capillary tube is lower than the surrounding bulk fluid he, with imperceptibly diminished confidence, replies "surface tension." When asked why water wets glass and not teflon he replies: "Surface tension, surface tension." And when asked why mercury wets neither but xylene spreads on polyethylene he stutters, now with shattered confidence and a total lack of eye contact: "Surface tension, surface tension, surface tension." Then slowly he is asked what is surface tension and the graduate student in chemical engineering beams brightly: "Surface tension is the phenomenon that makes water rise in a capillary tube."

The course opens with a discussion of intermolecular bonding compared and contrasted with the nature of intramolecular or chemical bonding. The thermodynamics of surface phenomena, largely derived from the treatment of A. W. Adamson's text "Physical Chemistry of Surfaces" follow. Specific attention is devoted toward structure-property relationships of surface active solutes. In turn, wetting, detergency, capillary phenomena, and engineering applications of these phenomena are treated. The development of the Gibbs-Adsorption isotherm, the Laplace-equation and the Young-Dupre equation are focal to this treatment. The "surface phase" of the course lasts approximately 5 weeks.

The middle seven weeks of the course are devoted to structure-property relationships in polymers. Rubber elasticity, viscoelasticity, solution behavior, mechanical properties, melt phenomena,

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volatilities, and minimum reflux ratio. Analytical equations for distillation column design using assumptions such as total reflux and constant relative volatility can be introduced here as background material. (2 weeks).

7. **Separation Systems.** Separation system design is considered with emphasis on selection of a system which will perform a desired separation. Multiple column systems and combinations of extraction and distillation processes are included. During this period students are given a small design or research problem which will be due at the end of the term. Some fundamentals of distillation and extraction equipment designing is introduced here. (2 weeks).

8. **Advanced Topics.** While the students are working on their term problems, lectures are given on subjects such as unsteady state operation and control of separation systems and noneqiulibrium separations in which the MT equation is used instead of the ER equation. (2 weeks).

TEXTBOOKS

The primary text for this course has been "Notes for Staged Separations" by John Tierney. The author has a few copies which can be supplied to interested educators. Some of the texts we have used for supplementary reading assignments are listed below.

Amundson, N. R., "Mathematical Methods in Chemical Engineering, Matrices and Their Application," Prentice Hall (1966).

Hanson, D. N.; J. H. Duffin, and G. F. Sommerville, "Computation of Multistage Separation Processes," Reinhold (1962).

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thermal transitions, morphology, and processing criteria are surveyed.

The course ends with a three week introduction to the important concepts of Colloid Science. The concept of retarded gravitational settling of small particles, diffuse-double layer shielding of lyophobic colloids, and conformational rearrangements on lyophillic colloids are emphasized.

There is not sufficient faculty time to present the ideal curriculum including a three semester sequence of polymer courses and a one semester survey course in both surface chemistry and colloid science. We are fortunate, however, that the School of Textiles supplements our course with several polymer courses and the Department of Chemistry offers a course in Surface Chemistry. An advanced course in "Diffusion in Polymers" as well as Dr. Stannett's revolving Special Topics Course are offered annually in the Chemical Engineering Department.

FAVORABLE FEEDBACK

This broad, introductory course suits not only our needs but has received strong and growing subscription from students of the School of Textiles, the School of Wood and Paper Science, and the Department of Chemistry.

Our Ph.D. graduates in industry report favorably upon the utility of both the style and substance of the course. A term paper is assigned to familiarize students with the library and the English language. Both seem foreign to most students.

Applied problem solving is emphasized throughout in descriptive homework and quiz problems. A. A. Noyes emphasized this technique a century ago; Professor Alan S. Michaels following Doc Lewis and Ernest Hauser put a natural shoulder, chain smoking embellishment on this technique in the late fifties and early sixties. The technique works.

Typically the enrollment of the course, offered annually, is in excess of 25 students. More important than enrollment statistics are the welcome comments of our alumni.

Last year in a confident maneuver modeled after a Paul Hornung drawplay, I submitted a "Course Revision Request Form" to the percolating procedure of the overloaded and now remanned course and curriculum committee. The single revision was in title only. Within a week an unsealed envelope, returned through the campus mail, contained the eighteenth copy of a form reply indicating that the title of my cherished course had been changed to: "Polymers, Surfactants, and Colloidal Materials." Now the computer listing is accompanied only by the simple cough: "POL SURF COLL MAT." Applied chemistry has found a home in the Department of Chemical Engineering at North Carolina State University. □