means that the maximum mole fraction for CH_3OH is 0.14, not 4×10^{-5}.

Thus, catalysts can modify practical thermodynamic equilibrium by dictating that equilibrium for each reaction be considered separately. Catalysts do not change *equilibrium constants,* but the properly chosen catalyst allows us to ignore many of the reactions in equilibrium calculations because their rates are low. As pointed out by Hamilton and Greenwald[7]

> *Of all the compounds that might theoretically form, it is well known that it is necessary to have thermodynamic information on only CO, H_2, and CH_3OH to calculate equilibrium concentrations and yields in such a selectively catalyzed system.*

We ignore an entire class of reactions when we calculate the equilibrium yield for methanol without also considering the equilibrium for paraffins formation, even though $\Delta G > 0$ for methanol formation, and $\Delta G < 0$ for methane and higher paraffin formation. All the higher alcohols and all the paraffins are more thermodynamically favored than methanol,[9] but they are formed in very low concentrations over the typical ZnO/Cr_2O_3 catalyst.

In summary, catalysts affect practical equilibrium conversions because conversions much higher than those calculated from equilibrium can be obtained in catalytic reactors.

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ChE **book review**

INTRODUCTION TO MACROMOLECULAR SCIENCE

by Peter Munk

John Wiley and Sons, Inc., New York; 522 pages, $44.95 (1989)

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As a research field, polymer science has flourished within chemical engineering more than in any other traditional academic discipline and, while I have not surveyed this quantitatively, I feel confident in asserting that many more courses on aspects of polymer science and technology are taught in chemical engineering than in any other kind of department. That fact alone makes the appearance of a new textbook on polymer science a noteworthy event for chemical engineering. On top of that, there is the fact that polymer science has become so broad a topic that there are many ways to approach its presentation and concomitant, there is a general dissatisfaction with the books available for instruction during the last five years. It was precisely this feeling that led Professor Munk to write this book, as he explains in the Preface; for this, I salute him, since complaining is certainly easier and more immediately gratifying than bookwriting.

The book is intended for a first course in polymer science but is at a level that would be appropriate for introducing the subject to either seniors or graduate students. It comprises five chapters, the first four of them quite large and broad in themselves: Structure of Macromolecules, Techniques for Synthesis of Polymers, Macromolecules in Solution, and Bulk Polymers. These are solid, information-rich chapters. The fifth chapter, Technology of Polymeric Materials, is but ten pages long and is not really up to the job announced by its title.

The flow of topics, beginning with a detailed discussion of the ways that macromolecules can be put together, followed by a second detailed chapter on synthetic methods is, in my view, exactly appropriate for an introductory book. Connections made between uncharged, synthetic polymers, which are the main subject of the book, and important related topics, such as polyelectrolytes, micelles, proteins, and polynucleotides, are very well done and useful. Particular care has gone into placing polymer science in a proper context, which is both educational for the reader and likely to stimulate student interest by helping them see connections.

The third chapter on polymers in solution is also filled with important and useful information on the basic physical chemistry of mixture of polymers with solvents. I begin to find divergence between the author's point of view and mine in the heart of this chapter. The presentation of experimental methods, when viewed from the perspective of current practice, overemphasizes membrane osmometry and ultracentrifugation and underemphasizes scattering of light and, particularly, of neutrons. Neutron scattering goes unmentioned in this chapter on solutions and only makes a brief appearance in the fourth chapter on bulk polymers. The section on equation-of-state solution theories misses a great opportunity to highlight the work of Professor Munk's colleague in chemical engineering, Isaac Sanchez who, with Bob Lacombe, showed (in the late seventies) how the Flory-Huggins lattice model could be extended in a simple but powerful way to comprehend PVT effects in the phase behavior of polymer mixtures. Nonetheless, this is a perfectly usable chapter by any instructor of polymer science, no matter what his or her personal prejudice might be.

Up to this point, this book ranks, in my estimation, with Paul Flory's first book, *Principles of Polymer Chemistry,* in terms of the sequence and balance of coverage. (I should add, so that you can calibrate me and my judgment, that I insist that any new graduate student working with me become completely conversant with the entirety of Flory.)

The gap of Professor Munk's divergence from my ideal path widens in Chapter 4 on bulk polymers. I suspect that this is related to a divergence from Professor Munk's own interests, as he is a widely respected physical chemist with interests in polymer solutions. Chapter 4 still contains considerable useful information, and most of what is in it is important. However, it is the omissions to which I object. Perhaps the single most important development in bulk polymers during the eighties has been the elaboration of the concept of reptation. This word is mentioned exactly once in this book. Rubber elasticity, classical viscoelasticity of polymers, and mechanical properties of semicrystalline polymers are all well covered in this book, making it very suitable for a course that deals significantly with physical properties of polymers. On the other hand, modern polymer melt rheology is essentially absent.

Another point of omission in this book (with which I disagree, but which is done explicitly and intentionally by the author) is the absence of primary references. No references are given in the text (except for figure captions); references, to other books exclusively, are given in lists for all chapters at the end of the book. I don't mind the collection of all references at the end, or even the lack of references inserted in the text—but I think it is a mistake not to tell students where the primary literature is. They miss seeing the origins of textbook facts, complete with all the experimental considerations, errors, etc. Without that exposure, some students develop either an unwarranted reverence, or an insufficient appreciation, for the achievement behind what they read in their textbooks.

On balance, this is a very good, solid, usable textbook for many variations on polymer science and engineering courses likely to be taught in chemical engineering departments. I have used it for the last year to introduce new graduate students to the research field. As mentioned earlier, complaining about books is a favorite pastime among instructors of polymer science. Professor Munk's book should diminish the complaints and raise the standard for those who would aspire to do better. ❐