Modern Superabsorbent Polymer Technology

edited by

Fredric L. Buchholz

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PREFACE

The essential idea of using a superabsorbent polymer as a liquid storage medium in personal care products is a relatively old idea, dating back to 1966. Successful commercialization of superabsorbent polymers, however, occurred in about 1980. As a result of commercialization of superabsorbent polymer in disposable infant diapers, the technical literature describing the synthesis and properties of superabsorbent materials has exploded in the past 15 years. The literature includes dozens of patents in addition to journal articles and conference proceedings. It has been a daunting task to stay abreast of the developments in this field and to sort through the myriad of synthetic chemistry and analytical techniques to better understand the new technology as it develops.

In view of this problem, it seems appropriate to find a common context of technology and science in which to place the inventions and discoveries so that we may achieve a better understanding of what superabsorbent polymers are, how they are made, and why they are relevant to modern life. In this volume, we hope to provide such a context. We provide a rational thread based in polymer science that will stitch together the various technologies into a unified whole. This rational thread is that the material properties of superabsorbent polymers define their usefulness in personal care items and in the other applications and that these properties result directly from the synthetic techniques used to make the polymers. We hope to show how these basic ideas may be linked into a useful model of superabsorbent polymers.

In this volume, we focus primarily on descriptive chemistry and physics and on industrial practices to show the practical side of these materials. To a large extent, we leave derivations of important mathematical relationships as exercises for students and other interested parties, but use the results to show the interrelationships between the structures, properties, and uses of superabsorbent polymers.

In Chapter 1, the concepts of absorbency and superabsorbency are defined, compared, and contrasted. Even though the mathematics used to describe absorbency and superabsorbency are very similar, the underlying mechanisms of the processes are entirely different. An understanding of these mechanisms and how they coexist in modern absorbent products is vital to new product development.

In Chapter 2, the synthetic chemistry of superabsorbent polymer is described in

detail. Superabsorbent polymers are crosslinked polymer networks, but real polymer networks are vastly different from the idealized "three-dimensional fisherman's net" that is easy to imagine. An understanding of how the conditions of synthesis affect the structure helps us create improved superabsorbent polymer. Preparative examples are given, and the effects of impurities are described. The polymerization kinetics are discussed in detail, as they apply specifically to superabsorbents. Some new methods to measure and study the kinetics of the polymerization are described and discussed.

In Chapter 3, the process chemistry is described. It may appear that there are as many processes for making superabsorbent polymers as there are manufacturers. However, there are many similarities between the technologies because the principal application is in personal care, and the dominant chemistry is the free-radical polymerization of acrylic acid. The similarities and differences between the major classes of processes, solution and suspension polymerization, and those between the individual manufacturers are detailed. The processes are broken into the component unit operations, and the effects of these operations on the polymer properties are detailed.

In Chapter 4, the analytical chemistry of superabsorbent polymers and the raw materials are surveyed. Numerous techniques for evaluation of the properties and behavior of superabsorbent polymer have been developed. We describe different methods and show how the methods relate to the properties and polymer science of superabsorbent polymer. Methods include spectroscopic methods used to probe the molecular structure of the polymers and methods used to qualitatively and quantitatively measure the absorbency and mechanical properties. A number of these methods are critically reviewed and compared according to their foundations in polymer science.

In Chapter 5, the structure and property relationships of crosslinked superabsorbent polymer are described. The relationship between the structure of the polymer network, the conditions of synthesis, and the properties, such as the swelling capacity and the elastic modulus of the gel, are developed, with a focus on the principal role of superabsorbent polymer as an absorbent in disposable goods. A model of the absorbency under load is developed, and the dependence of this measurement on the numerous parameters of the polymer system is described.

In Chapter 6, new superabsorbent polymers and forms are surveyed. As the role of superabsorbent polymer in absorbent cores expands, new materials are being developed to meet the expanding needs. Absorbent fibers and foams are described and contrasted with the granular polymers that are widely available at the present time. The potential drawbacks and benefits of biodegradable superabsorbent polymers are also discussed.

In Chapter 7, applications of superabsorbent polymers are described. Although the bulk of the research and development effort has been placed on disposable absorbent products, numerous other applications have been developed, and some of them have achieved commercial success. A detailed look is taken at the use of superabsorbent polymers in personal care products, and some of the interesting,

emerging applications are described, including horticultural uses, controlled release, and construction materials.

In the end, we hope you understand superabsorbent polymers and their applications better. As a result of creating this book, we know that we do.

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Few works of this kind are individual efforts, and this book about superabsorbent polymers is certainly no exception. Of course we wish to thank the principal contributors of the chapters. Tom Staples has been involved with superabsorbent polymer research at The Dow Chemical Co. since the early 1980s and was instrumental in developing our first manufacturing process. David Henton, in contrast, spent much less time in the superabsorbent polymer R&D group, but left us with some valuable new techniques for analysis. Larry Wilson divides his time between synthesis and physical chemistry of superabsorbent polymer, which is an effective combination of interests. Sergio Cutié, Pat Smith, and Bob Reim spend countless hours each year solving our most difficult problems in analytical chemistry of superabsorbent polymer. David Allan helps us take our thinking and products in new and different directions. This book would not have been written without their efforts.

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