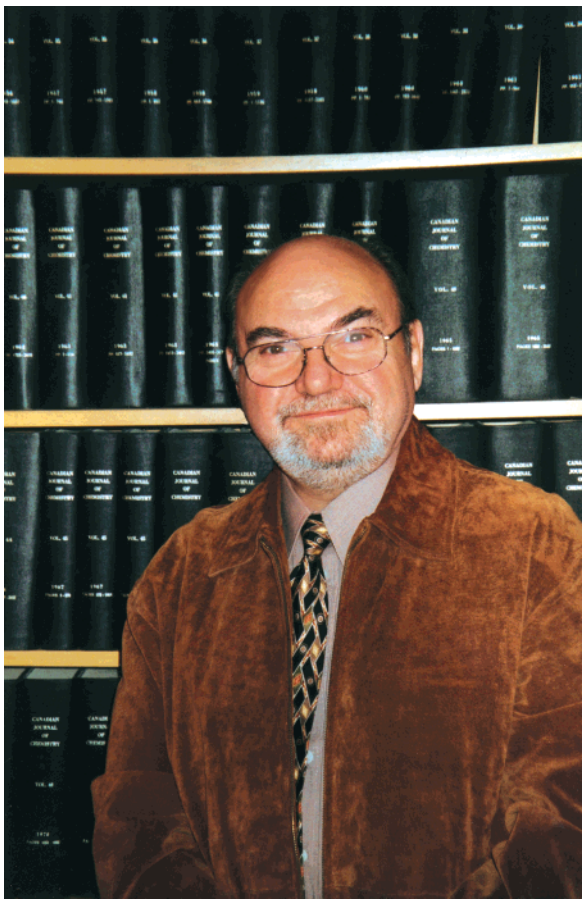
Macromolecules

Volume 33, Number 21 October 17, 2000

Adi Eisenberg



On February 18, 2000, Adi Eisenberg, Otto Maas Professor of Chemistry at McGill University in Montreal, Canada, celebrated his 65th birthday with his family, friends, students, and colleagues.

Adi Eisenberg is recognized internationally as one of the greatest physical polymer chemists and a pioneer in the important field of ion-containing polymers. His ingenious approach has provided insightful knowledge to various aspects of polymer science, in particular to the morphology and mechanical properties of ionomers of various architectures and polymer blends with ionomers. His book *Ion-Containing Polymers—Physical Properties and Structure* (coauthored with M. King, 1977)[1] is widely read by many polymer scientists. In the past 10 years, he has shifted his main research focus from physicochemical properties of bulk materials to the fascinating world of ion-containing polymer colloids. The intriguing and beautiful self-assemblies in solutions and at the air−liquid interface have raised tremendous interest in the polymer community. Have you ever seen "crew-cut" micelles? Have you heard of "hollow bagel" structure? At the age of 65, Adi Eisenberg is having a lot of fun in his "morphological wonderland"[2] and sharing his catching enthusiasm with students and colleagues.

Adi Eisenberg was born in Breslau, Germany (now Wroclaw, Poland). He lost most of his family during the Second World War. He immigrated to the US in 1951. Although due to the war he had not received formal education until the age of 13, he finished high school in 1953 and then graduated from Worcester Polytechnic Institute in 1957. He pursued his graduate study at Princeton University, receiving an M.Sc. in 1959 and a Ph.D. in 1960, under the direction of A. V. Tobolsky. His graduate research at Princeton was mainly related to thermodynamics of polymerization. Adi Eisenberg spent one year as a Research Associate at Princeton to explore a new area of mechanical properties of inorganic materials. Subsequently, he joined Werner Kuhn's laboratory at the University of Basel as a NATO fellow to work on polyelectrolytes. In 1962, as an assistant professor, Adi Eisenberg established his laboratory at the University of California, Los Angeles, where he worked on various ionic polymer systems, including polyphosphates. While at UCLA, he also made a significant contribution to the understanding of glass transition phenomenon in polymers. In 1967, Adi Eisenberg moved to McGill University in Montreal, Canada, as an associate professor in chemistry. He was promoted to full professor in 1975 and currently holds the positions of Otto Maas Professor of Chemistry and director of "Polymer McGill" at McGill University.

Adi Eisenberg's work ranges from detailed experimental investigation to pure theoretical modeling, with a clear focus on ion-containing polymers. His interest and contributions are documented in his over 300 refereed publications, approximately 70 extended abstracts, mostly Polymer and PMSE Preprints, and eight books. *Macromolecules* is certainly his favorite journal; his publications also appear in *Journal of Polymer*

10.1021/ma0009799 CCC: $19.00
Published on Web 09/22/2000

Science, Journal of American Chemical Society, Science, Physical Review Letters, and others.

Adi Eisenberg has always put emphasis on the importance of modeling complex polymeric systems. In 1970, he published the first theoretical paper on ionomers, where he described the well-known multiplet-cluster model.[3] In this model, he proposed that ion pairs in ionomers form multiplets, and with increasing ion content, the multiplets further rearrange to form clusters. Twenty years later, when more detailed mechanical and small-angle X-ray scattering (SAXS) data became available, it was clear that the multiplet/cluster model had to be extended to explain some new observations. Adi Eisenberg, together with B. Hird and R. B. Moore, proposed an upgraded model, the Eisenberg−Hird−Moore model.[4] In the new model, it is assumed that the mobility of the segments surrounding the multiplets is reduced relative to the other segments in the bulk material. When the multiplets group together to form a cluster, the volume where the chain mobility is significantly reduced is large enough to lead to a separate glass transition temperature. NMR and other techniques later confirmed the concept of reduced mobility. This model is currently used to explain many physical phenomena in ionomers.

The research of Adi Eisenberg has opened up many new applications for ionomers. He was the first to conduct a systematic study of perfluorinated ionomers such as Nafion,[5] generating tremendous interest in these now very important industrial materials. He was also the first to take advantage of the ionic interactions to improve the compatibility of polymer blends.[6] He demonstrated that a wide range of polymer pairs, such as polystyrene with polyacrylates, polyurethanes, and polyamides, could be made compatible by use of ionic interactions.

The systematic studies of random ionomers by Adi Eisenberg over the past 30-some years have become the building blocks of modern ionomer chemistry. The relationship between ionomer structure and a wide range of physical properties, including mechanical and rheological properties, has been established. As he indicated in his latest book on this subject (coauthored with J. S. Kim), "*...our understanding of the field has also advanced, to the point at which the outcome of many experiments can be predicted, at least semi-quantitatively. The ability to anticipate some experimental results is fortunate, because the field of ionomers is huge, given that many nonionic polymers can be converted into ionomers using a range of pendent ionic groups...*".[7]

The research interest of Adi Eisenberg shifted from bulk properties of ionomers to colloidal and interface science in the early 1990s, when he observed a two-dimensional micellization phenomenon at the air−water interface,[8] together with J. Zhu and R. B. Lennox. Subsequently, ribbonlike and lamellar micelles were also prepared on the water surface by using block copolymers with definite relative block lengths. The most novel discovery in this area came when ionic "crew-cut" micelles were observed in his laboratory.[9] These micelles were prepared by a very imaginative method. Some of the "crew-cut" morphologies were completely new, such as compartmented vesicles, pincushions, and hollow tubes with diameters of approximately 100 nm.[10]

The most recent endeavors of Adi Eisenberg include the understanding of the thermodynamics and kinetics of the micellization and morphological transitions of amphiphilic block copolymers. A substantial amount of effort was also devoted to explore the potential applications of these novel micelles in medical science and in the electronic industry. One day, these "crew-cut" micelles might serve as new drug delivery vehicles, and the nanotubes might be used in new electronic devices.

Adi Eisenberg is a very enthusiastic teacher with a great sense of humor. His students will always remember his friendly encouragement, enthusiasm, advice, as well as his interest in their career development as scientists. He has trained almost 100 graduate students and postdocs who are now working in industries and in academia worldwide. He refers to the present and former students and associates as members of his extended family. Adi Eisenberg also collaborates extensively with many scientists around the world, including A. V. Kabanov, V. A. Kabanov, R. B. Lennox, M. Pineri, M. H. Rafailovich, M. Rutkowska, H. P. Schreiber, J. Sokolov, C. Williams, and many others.

Adi Eisenberg plays an active role in the polymer community. He has organized many symposia and conferences, including the first Gordon Conference on Ion-Containing Polymers in 1979, which is continuing on a biennial basis. He has served on the editorial boards of many scientific journals, including *Macromolecules*. His accomplishments have brought him many honors such as the Macromolecular Science and Engineering Award (Dunlop) from the Chemical Institute of Canada in 1988, a Killam Research Fellowship in 1987−1989, and the E. W. R. Steacie Award in Chemistry from the Chemical Society of Canada in 1998. He is also a Fellow of the Chemical Institute of Canada and the American Physical Society.

On this special occasion and key milestone, those of us who have been inspired by Adi want to congratulate him on his outstanding achievement and wish him all the best for the future. With his current momentum, we fully expect that Adi Eisenberg will continue to serve the polymer community for many years to come.

References and Notes

(1) Eisenberg, A.; King, M. *Ion-Containing Polymers—Physical Properties and Structure*; Academic Press: New York, 1977.
(2) Cameron, N. S.; Corbierre, M. K.; Eisenberg, A. *Can. J. Chem.* **1999**, *77*, 1311−1326.
(3) Eisenberg, A. *Macromolecules* **1970**, *3*, 147−154.
(4) Eisenberg, A.; Hird, B.; Moore, R. B. *Macromolecules* **1990**, *23*, 4098−4108.
(5) Yeo, S. C.; Eisenberg, A. *J. Appl. Polym. Sci.* **1977**, *21*, 875−898.
(6) Smith, P.; Eisenberg, A. *J. Polym. Sci., Polym. Lett., Ed.* **1983**, *21*, 223−230.
(7) Eisenberg, A.; Kim, J.-S. *Introduction to Ionomers*; John Wiley & Sons: New York, 1998.
(8) Zhu, J.; Eisenberg, A.; Lennox, R. B. *J. Am. Chem. Soc.* **1991**, *113*, 5583−5588.
(9) Gao, Z.; Varshney, S. K.; Wong, S.; Eisenberg, A. *Macromolecules* **1994**, *27*, 7923−7927.
(10) Zhang, L.; Eisenberg, A. *Science* **1995**, *268*, 727−731.

Z. Jason Gao*

ExxonMobil Research and Engineering Company, Paulsboro Technical Center, 600 Billingsport Road, Paulsboro, New Jersey 08066

Diep Nguyen

PPG Industries Inc., R&D Center, 4325 Rosanna Drive, Allison Park, Pennsylvania 15101

Claudine E. Williams

Physique de la Matière Condensée, Collège de France, 11 Place Marcelin-Berthelot, 75005 Paris, France

MA0009799