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CHEMICAL AND BIOLOGICAL ENGINEERING DEPARTMENT SEMINAR SERIES

Nano-Engineering of Block Copolymer Vesicles

Presented by: Adi Eisenberg, Department of Chemistry, McGill University, Montreal

Time: Wednesday, March 10; 3:15 – 4:30 pm

Location: Perlstein Hall Auditorium

Abstract

Vesicles have been receiving considerable attention recently in view of a large number of potential applications. They are hollow spheres, typically 100 to 1000 nm in size, with walls of typically 20 to 30 nm, but ranging as high as 80 nm; they are thus much more stable than liposomes. It is shown that vesicles made from amphiphilic block copolymers in solution are equilibrium structures under a wide range of conditions. They are a part of a morphological continuum which includes spheres, rods, and hollow rod structures. The mechanism of curvature stabilization is shown to be preferential segregation of the longer corona chains to the outside of the vesicles while the shorter chains are segregated to the inside. The chain segregation by length is shown to be vesicle size dependent, and to be reversible in response to changes in the size of the vesicles. The sizes of the vesicles can be controlled easily over the range of 80 to 1000 nm by water content, mixed solvent composition and hydrophilic block length and block length ratio. When size changes occur in response to changes in the water content, they are primarily driven by changes in the interfacial energy between the core and the surrounding solution. The kinetics and mechanisms of size changes have been explored. The fusion mechanism involves contact and adhesion, coalescence and formation of a center wall, destabilization of that wall, asymmetric detachment of the center wall, retraction of the residue into the outer wall, and finally smoothing of the outer wall. The relaxation times for the process range from ca. 5 to 1000 seconds. Vesicle fission involves elongation, internal waist formation, narrowing of the external waist, and complete separation. It is also shown that it is possible to attach different species to the inside and outside of the vesicles in a one step preparative procedure, a factor which could be exploited in a number of applications.

Most recently, it was shown that a bi-amphiphilic triblock copolymers (PAA-b-PS-b-P4VP) yields vesicles in which the outside or inside interface can be controlled by pH. At low pH the P4VP is outside, while at high pH, the PAA is outside. The vesicles can be made to invert by a change in the ph. Finally, it is shown that drugs such as DOX can be incorporated by active loading, as has been done earlier in the liposomes, and that the release is diffusional. The result on vesicles that have been published earlier by this group are summarized in a review. (1)

References:

(1) Patrick Lim-Soo and Adi Eisenberg, J. Poly. Sci. B. Polymer Physics 72 923-938 (2004)

Biography

After graduation from the Worcester Polytechnic Institute in 1957, Eisenberg received his M.A. from Princeton University in 1959, followed by his Ph.D. in 1960. After a postdoctoral year at Princeton (with A.V. Tobolsky) and another in Basel (with W. Kuhn), he joined the faculty of UCLA in 1962, and moved to McGill in 1967. He was director of Polymer McGill 1991-1998, and

became Otto Maass Professor of Chemistry in 1992. Various sabbaticals were spent partly at the Weizman Institute of Science (Israel), Kyoto University (Japan), Imperial College (London), and LURE (Orsay, France), among others.

Eisenberg is an author or co-author of over 400 papers in refereed journals as well as ca 100 extended abstracts or short articles (in Polymer Preprints, PMSE preprints, encyclopedias, etc.). He co-authored or edited 8 books in the field. He has organized 11 major symposia or international meetings and presents numerous lectures at various universities or companies, as well as invited or plenary lectures at various scientific meetings and workshops. Honors include the Killam Research Fellowship 1987-1989, the CIC (Macromolecular Science and Engineering) Dunlop Lecture award in 1988, the Dow Distinguished Lectureship in 1996, and the EWR Steacie award in Chemistry (CSC) in 1998. Eisenberg has been elected to fellowship in the Royal Society of Canada, has received the Urgel Archambault Award of the ACFAS (Quebec), as well as the Humboldt prize of the Alexander von Humboldt foundation.

Eisenberg supervised 45 MSc. and Ph.D. thesis; 7 of his graduate students are not in Faculty Positions (5 in Canada and 1 in Korea); also, 24 of his former postdocs are now professors (7 in USA, 6 in Japan, including a former University president and a former dean, 3 in China and 2 in Israel).

Earlier work from Eisenberg's group has centered on ion-containing polymers, which has provided the conceptual framework for understanding architecture - morphology - property relations in random ionomers; his work contributed materially to the increased acceptance of ionomers in a range of commercial applications. He is now involved in the study of the micellization of ionic block copolymers, which show promise as targeted drug delivery vehicles, among others. Aggregates with a very wide range of morphologies have been produced from these materials, including spheres, rods, vesicles, tubules, and a range of unique structures, including some resembling "pincushions". Many of these are morphologically biomimetic. He is co-discoverer of the phenomenon of two-dimensional micellization in block copolymers.

Eisenberg is or was a member of the Editorial Advisory Board of the Journal of Polymer Science - Polymer Physics Edition (1977-1999), Macromolecular Reviews (1983-1990), Macromolecules (1986-88) Journal of Non-Crystalline Solids (1989), Polymers for Advanced Technologies (since 1989) and several other publications. He was on the advisory board of the Institute for Amorphous Studies, Michigan and the NSERC Grant selection Committee for Chemistry (1987-1990). He has been a consultant to a number of companies or government laboratories, including the Jet Propulsion Laboratory, Owens Illinois, Energy Conversion Devices, GTE, Raychem, Exxon and Dow Corning, among others. He is a Fellow of the CIC and the APS, and a member of the ACS. On all of these he has held official positions, such as memberships of the Executive Committee or Chairmanships.