Professor Palit's Memorial Lecture

Anti-biofouling -How a polymer brush repels proteins and our novel integrated design

by

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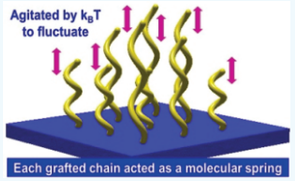
Abstract

Grafting a layer of chains on a surface to form a polymer brush has been considered as an effective approach to make it anti-biofouling (less protein adsorption). The anti-biofouling property has been qualitatively attributed to the hydration of such a polymer brush with a layer of immobile water molecules and the steric effect; namely, the adsorption decreases monotonically as the polymer grafting density (s) increases. However, there is no quantitative and satisfactory explanation why the adsorption starts to increase when s is sufficiently high and why polyethylene glycol (PEG) still remains as one of the best to repel proteins. We have looked the captioned question from another angle: the entropic elasticity instead of the protein-surface interaction, i.e., the enthalpy change.

Considering that each grafted chain is confined inside a cylindrical "pore/tube" made of its neighboring chains, as shown in the right figure, we found its optimal length by minimizing its free energy (*A*) that contains the exclude volume interaction and the chain elasticity (both of them have an entropic nature) [1, 2]; estimated how *A* depends on s and the chain length (*L*); and calculated its thermal energy-agitated chain conformation fluctuation that slows down the adsorption kinetically. After comparing *A* with the thermal energy, we are able to predict how both *L* and s affect the protein repelling and explain why PEG performs better than others. Our predictions are surprisingly and *quantitatively* comparable with those literature results [3, 4].

We will also illustrate how to develop some novel anti-biofouling coatings for shipyard/marine applications by using an integrated design that combines different existing strategies; namely, the self-polishing, the self-structure and the self-generated soft and dynamic surface [5, 6].



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About the speaker

Wei Lun Professor of Chemistry and Honorary Professor of Physics in the Chinese University of Hong Kong; In 1982, he graduated from Chemical Physics in the University of Science and Technology of China. After obtaining his Ph.D. in 1987 and then remaining as a postdoctoral both under the supervision of Professor Benjamin Chu in the State University of New York at Stony Brook, he moved to BASF (Ludwigshafen, Germany) in 1989: first as an Alexander von Humboldt Fellow for one year to cooperate with Dr. Wolfgang Schrof under the supervision of Dr. Dieter Horn; and then as a permanently hired staff to supervise the laser light-scattering laboratory in the Dispersion Group, the Department of Solid Stat and Polymer Physics. In 1992, he resigned from BASF to join the Department of Chemistry in the Chinese University of Hong Kong as a Lecturer (British System); underwent a double promotion to Reader in 1996; became a Professor of Chemistry in 1999 and an Honorary Professor of Physics in 2003; and was further appointed as a Wei Lun Professor of Chemistry in 2010. **For his significant contributions in prefund understanding of conformation, dynamics and phase transition of polymer chains in solution**, Professor Chi Wu was elected as a Fellow of the American Physical Society and a Member of Chinese Academy of Sciences in 1999 and 2003, respectively. His research mainly combines synthetic chemistry, polymer physics and molecular biology to design and execute decisive experiments to address certain important problems in biology, macromolecules and polymer colloids, including the development of non-viral vectors for gene and molecular medicines; the nucleation of protein-protein aggregation in neuron-degenerative diseases; the stress-induced stem cell differentiation and its biomedical applications; the design, synthesis and self-assembly of functional macromolecules; and molecular characteristic properties of intractable and special polymers. His current research interest mainly moves to biological problems, especially molecular medicines and chemical biology. For details: http://chiwu.chem.cuhk.edu.hk

About Prof. S.R. Palit

Prof. Santi Ranjan Palit was born in Calcutta on the 24th March, 1912. In 1931 he came out First in First Class in the B. Sc. examination and the same performance was repeated in the M Sc. examination in Pure Chemistry of the Calcutta University. The next two years after passing the M Sc. examination was a period of agony of joblessness to him, since his mother (a follower of Mahatma Gandhi) opposed to allowing his son joining any Government service under the then British Government. At long last it was through the intermediary of Dr. Shyama Prasad Mukherjee that he got a research fellowship at the Department of Pure Chemistry of Calcutta University under Prof. J. N. Mukherjee, (a renowned colloidal chemist) and published his first paper in 1933 on cataphoretic speed of colloid particles. But he left it after one year to join the Vidyasagar College as lecturer where he spent two years and then wrote a book on Elementary Physical Chemistry. In 1938 he joined the Lac Research Institute, Ranchi as a Research Assistant under Dr. H. K. Sen where he got exposed to the fascinating world of paints, varnishes, lacquers etc. The first paper on Cosolveney came out from there in 1940 and subsequently he received P. R. S and D. Sc degree of Calcutta University. Prof. Mc-Bain of the University of Stanford, California invited him to search solvents for soaps and in early 1945 he joined in McBain's laboratory working as a Bristol-Meyer Research Associate. Prof. McBain had a great admiration to him quoting "Palit has a special ability to look at a familiar thing from an unfamiliar angle". After that he started to work with Prof. Herman Mark at the Polymer Institute at Brooklyn as a part-time researcher after a full time service at the research laboratory of E. F. Drew & Company, a leading manufacturer of oil derivatives. He then started the work on cosolvency of high polymers and made vast experience on the rapidly developing branch of Polymer Science. On the basis of work done there he was given the P.R.J.C award. Mention may be made of two very successful co-workers of him at that time, who was Bruno Zimm, famous for Zimm plot and Turner Alfrey.

In 1947 amidst the climax of dawning independence, he came back to India. At that time Prof. Meghnad Saha, the then President of the Indian Association for the Cultivation of Science (IACS) was organizing the Association in a new and promising manner befitting a leading research centre with emphasis on high polymers. Immediately he appointed S. R Palit first as a planning officer and then as a Professor of Chernisty. Thus started the Physical Chemistry Department of the I.A.C.S. housed in a single room and a verandah of the then dilapidated premises at 210 Bowbazar Street, Calcutta. At 1950 IACS shifted to Jadavpur where he made a good school of polymer and physical chemistry. Regarding the Professor's activities on polymers, it will not be irrelevant to quote Prof. Herman Mark:" ..... during his (Palit's) activities at his institute in Calcutta he (Palit) developed into the leading polymer scientist in India and in fact, the most prominent representative of this discipline in the far East. His numerous publications and his successful and convincing delivery of many lectures at International Conferences continued to increase his reputation and made him to become a recognized member of the small group of leading polymer scientists in the entire world". He worked as a Guest Professor in Berlin 1965-66 and in 1966 he was a visiting Professor at the University of Florida, USA. He became a fellow of the Indian National Science Academy (F. N. A) and a fellow of the Indian Academy of Sciences (F. A. Sc.). Number of successful doctoral students guided by Prof. Palit till 1975 was 80, but he stayed at IACS as emeritus professor till 1981 and guided about another 20 students His last three students were awarded the degree in 1980-1981. He published more than300 papers, monographs etc and his most important contributions are particularly polymerization kinetics including chain transfer and dye partition techniques for detection of polymer end groups, (ii) Anomalous (non-Faradaic) electrolysis, nonaqueous titration etc. He died on 14 th August 1981 at calcutta after his coming back immediate from London delivering /demonstrating a talk on non-Farady electrolysis at Royal Society keeping a group of eminent polymer scientists working both in academic and industry in the country.

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Dr. S.R. Palit Memorial Lecture 2017:
Professor Sadhan C. Jana, University of Akron, Akron, Ohio, USA