

Guest Editorial

Staudinger's concept on *Polymer Science* and the Impact of Ziegler-Natta Catalyst on *Polymer Technology*

In Commemoration of Diamond Jubilee Events: Noble Prize to Staudinger and Discovery of Ziegler-Natta Catalyst

In good olden days, like all of us, scientists had to handle simple problems of life style but with change in life style, the demand of present human society has increased manifold over the years. Those were the days when demands of life style were not that complex; solutions could generally be realized with simple available items; and scientists generally gave attention to simple molecules and phenomena to seek solutions for earthy problems. But today's situation is quite different when human society is trying to harness Nature to its comfort zone and looking for habitation in the space. Nature may look to be simple but actually it has to process host of functions meticulously through numerous complex material processes 24x7. Thus, in order to meet the demands of modern lifestyle, materials science cannot remain satisfied with mere handling of only simple molecules. Necessity is the mother of invention; and that is how the concept of macromolecules crept into the cradle of Chemical Science for this Physical World. In fact, one of the most important classes of material science emerged in modern times is the macromolecular science or polymer science. The field of Polymer science has networked virtually with all branches of natural science including bioscience and technology to help carry forward the cause of human endeavor for betterment of life.

Polymer products were known for engineering applications even before the Roman Civilization but the actual science of polymer or macromolecule established much later due primarily to the German Scientist Hermann Staudinger whom many believed the father of polymer science. History says that Staudinger placed the subject of polymer on the wheel of Science. Since then the scientific journey of polymer science started with ever increasing vigor and momentum; and now we are passing through the period of Diamond jubilee time to commemorate two great landmark events associated with Polymer Science and Technology - one is the event of Nobel Prize recognition to Staudinger; and the other is due to the discovery of Ziegler-Natta catalyst. As a matter of fact, after a prolonged effort, at long last precisely on December 11, 1953, Staudinger received the Nobel award in recognition of his concept of polymer molecules which ultimately established the science of large molecules. This recognition is considered as the 1st Nobel recognition to polymer science as a subject under Chemistry. It is now accepted that Staudinger's concept established essentially the *Science of Polymer*. Interestingly, in the same year in 1953 the magnum opus, *Principles of Polymer Chemistry* authored by PJ Flory was published by Cornell University Press.

On the other hand, the first impact of technology on polymerization caused a paradigm shift in the *Technology of polymer* with the discovery of a very specific kind of catalyst system to carry out stereo-specific polymerization for the first time in the period between 1953 and 1954 – thanks to the German scientist Karl Ziegler who once joined in the *Defence forces*, discovered the catalyst based on the combination of titanium and organoaluminum compounds in the year 1953 for the production of stereo-regular polyethylene without applying high pressure and temperature as otherwise being practiced. Such stereo-regular polyethylene are characteristically very specific and special in terms of its molecular order and conformational regularity, thus producing very ordered, very long, straight-chain molecules. And incidentally, within a short gap of time since Ziegler's work, the Italian scientist Giulio Natta also independently discovered not only similar kind of catalyst in the year 1954 but it actually outflanked Ziegler in making stereo-regular polypropylene and a wide variety of polymers particularly the stereo-regular *cis* polyisoprene synthetic rubber. More importantly, such synthetic rubber was molecularly identical with Natural rubber; and it opened up a new scope of technology to tailor the microstructure of the polymer molecule in a most precise manner such that the process could even imitate the Natural polymer in molecular terms and tacticity. As a result of such ground breaking technological innovation, they jointly got Nobel Prize for their contribution in the field of Polymer Science & Technology; and such unique catalyst class is known by the name Ziegler-Natta catalyst.

In this eventful time of diamond jubilee of discovery of Ziegler-Natta Catalyst and the 1st Nobel recognition on the subject of polymer science came to Staudinger's work for establishing the cardinal concept of macromolecule or polymer; Defence Science Journal (DSJ) for the fitness of things has timely arranged to publish this special issue on Polymer Science and Technology (S&T) in earnest to remind these landmark events of polymer S&T among the researchers of materials science and particularly among the polymer communities such that many of them may get inspired from such marvels of S&T events.

Although the fundamental contributions of Staudinger, Ziegler and Natta are relatively more recognized to us but the role of other stalwarts like Herman Mark, W. Carothers, PJ Flory, or even Frederick Sanger and host of polymer personalities cannot be ignored. Flory was particularly known for his prodigious volume of work in the field of polymers.

Through such countless contributors, the subject of Polymer S&T has reached to such a great height. Polymers have become so versatile that they are often known by the name *magic material* as no other class of materials can match such versatility as polymeric materials enjoy. Amenability of architectures of polymer molecules enable them to offer a wide spectrum of properties from stiff to soft, rigid to rubbery; elastic to plastic; transparent to translucent or opaque; for that matter their popularity and familiarity can be felt everywhere, whether it is furniture or fabrics or foam. More importantly, polymers are relatively inexpensive and easy to process to arrive at the article level.

Defence Science Journal is a multidisciplinary journal whose functional role is similar to the *heart-beat* of our life process. Human heart draws fresh air from the atmosphere and then pumps out the oxygenated-blood to the entire human body. Analogically, DSJ essentially draws research inputs from across the globe; then it disseminates documented knowledge to the researchers of the entire globe. This special issue of DSJ is truly special in the sense that it includes the topics of diverse disciplines but within the framework of Polymer Science and Technology. It is a montage of papers from host of distinguished scholars, academic experts, scientists and professionals of the field from different nationalities, far and wide from Brazil to New Zealand, associated with various academic institutions, industrial research center, national research laboratories and universities as can be sensed from their spectacular contribution in the important areas of polymer science and technology or engineering of contemporary interest.

It will be a satisfaction, if the effort for this special issue can be of any use for the researchers to cross-fertilize research thinking to emanate fresh idea or information for further progress. Clearly the contributions made by the authors and coauthors include variety of subjects related not only with hi-tech areas of polymer material research but also has articles of interest to highlight the topics of global concern on the S&T issues as could be understood from the array of topics broadly in relation to such themes as environmental friendly renewable resources, biodegradable polymers and green composites, protein based polymeric products for removal of toxic pollutant, biomaterial based gels and their rheological aspects for medical cause, polymer based organic-inorganic hybrid materials, new attempts of innovation in engineering fabrics in combination with shear thickening fluid or fluorination of fabrics, CNT filled polymer nano-composites materials, e-beam processing technology for polymer system, ion beam sputtering (IBS) technique for magnetic nanocomposite materials besides analytical approach for understanding cross-linking as well as conformation aspects of thermosets and thermoplastics respectively.

I sincerely express my heartfelt gratitude to all the contributors for their benign help and all round cooperation during reviewing and revision process and particularly for their courtesy in accepting the invitation for making this special issue successful. I am thankful to Dr A.L. Moorthy, former Director for showing confidence on me to act as Guest Editor

for the special issue of *Defence Science Journal* on the topic of Polymer Science and Technology. I am grateful to Dr K.D. Nayak, Distinguished Scientist, the then Chief Controller (R&D) and present Director General of DRDO for reaffirming faith on me for the responsibility of this special issue. I am also thankful to Shri S.K. Jindal, Director DESIDOC for giving this lab a new environment and extending the support to access the fine facilities and infrastructure of the lab. I would also like to thank the team of -S-S-S-S-S-.... (as if, symbolizing a polymer) comprising *Sudhanshu, Sinha, Sharad, Sarika, Sanjay, et al.* for their sincere support for timely bringing out this special issue of DSJ. With all such support only it has been possible to publish this polymer special issue in appropriate time when entire polymer community is commemorating the diamond jubilee events associated with the names of Natta, Ziegler and Staudinger !

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Special issue on Polymer Science & Technology,
Defence Science Journal



Dr G.S. Mukherjee, MTech, PhD (Calcutta University, 1985) started career at NTH, Calcutta; later joined DMSRDE, Kanpur and acquired long experience in active R&D work on Polymer Science & Engineering primarily in the area of toughened resins, syntactic foam, Kevlar reinforced ballistic composites, sandwich structures for attenuation of blast, photopolymerization, kinetic parameters, thermodynamic compatibility, blends, IPN, polymer additives and modifications of resins, NLO materials and magnetic nanocomposites; received the DRDO award in recognition of valuable contribution in developing optically stable extrudable polymer film intended for Windshield for LCA; then deputed to G-FAST, New Delhi think tank of DRDO (2008-2010) dealt primarily with the futuristic issues of R&D program; later he led the new initiative of DRDO Knowledge Management System to process and protect DRDO Knowledge assets and identity; visited institutes of Singapore and USA as DRDO delegate; conducted specialized courses in all the Military commands across the country; delivered lectures as keynote speaker, guest speaker, invited talk, plenary lecture, chaired technical sessions of National and International conferences; besides research papers, contributed Book reviews, Opinion, Editorial highlights; He has about 140 papers; since 1992, giving honorary services as book critic, reviewer for more than a dozen of Journals including the Journals of Royal Society of Chemistry. He is/ has been in the editorial responsibilities for seven scientific journals; He is a recipient of INSA visiting Fellowship, Fellow of Institution of Chemists (FIC); Fellow of Institution of Engineers (FIE); member of ACS, AAAS. He held honorary positions of President (Engg. Sciences Section) of 97th Indian Science Congress and other scientific societies; name listed in who's who publications. His current research interests primarily include polymer materials, nanocomposites.