

# Professor M. Santappa Award Lecture

## Design and Development of Ultra-Low Permeable Moisture Barrier Materials for Organic Device Encapsulation

by

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Bangalore

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Organized by:



### Abstract

The biggest opportunity for organic electronics like organic displays and organic photovoltaic devices are when these devices can be flexible, lightweight and can be fabricated in large areas compared to conventional inorganic materials. However, many of the materials used in organic devices are sensitive to the environment that limits their lifetime. The active device components degrade due to moisture and by photo oxidation due to molecular oxygen in the presence of moisture. Conventional polymer materials exhibit moisture permeabilities 106 times higher than the requirement posed by the barrier materials for protecting these organic devices. Therefore, my work is on the design and synthesis of various functional materials that can be used as encapsulant which exhibit ultralow water vapor barrier properties. Furthermore, measurement of ultra low moisture permeability is another challenge in the development of these barrier materials. Hence, we worked on the development, standardization and application of a measurement technique based on cavity ring down spectroscopy for determining ultra low water vapour permeabilities through these barrier films. Therefore, the thesis discusses on the development and characterization of various moisture barrier materials such as polymer nanocomposites, organic layered architectures, reactive barriers, etc. These barrier materials were finally used for encapsulating organic photovoltaic devices and were subjected to accelerated aging studies to evaluate their efficacies of as encapsulants.

### About award winner

Giridhar Madras received his chemical engineering degree from Indian Institute of Technology at Madras in 1990. He obtained his Ph.D. degree in chemical engineering from Texas A&M University, USA, in 1994. Subsequently, he worked in the University of California at Davis, USA. He returned to India as an Assistant Professor of chemical engineering at the Indian Institute of Science, Bangalore in 1998. Since 2007, he has been a Full Professor at the Chemical Engineering Department. He is also an associate faculty in Solid State and Structural Chemistry and a chairman in the Interdisciplinary Center for Energy Research.



His research interests are in the area of reaction engineering applied to polymers, supercritical fluids, and catalysis. His research group focuses on reaction kinetics, as applied to various systems and processes. The research group's approach is to develop several new materials that are used as catalysts for known reactions. He proposes new reaction pathways/mechanisms providing the research community with a method to develop new materials with superior properties. In this regard, his research group has synthesized new materials that work as photocatalysts for the degradation of a wide variety of dyes and organics that are common pollutants in waste water. He has also developed new catalysts for the three way catalysis for the NO+CO reaction and CO and hydrocarbon oxidation and proposed new mechanisms governing these reactions. His work on polymer degradation wherein the polymers are converted to useful products such as the monomers or fuel oils has been well received.

Prof. Giridhar Madras also collaborates extensively with colleagues in Indian Institute of Science. His collaboration has resulted in varied research in the interdisciplinary field of chemistry and materials. Specifically, his collaborations have resulted in the work on new biomaterials based on polymers for drug delivery and tissue engineering; development of new polymers as encapsulants for solar cells; preparation of novel polymers for membranes and electromagnetic shielding; catalysts for specific selective reactions and several other projects.

He has successfully executed various projects worth several crores from various governmental agencies such as DST, DBT etc. and numerous industries such as BHEL, FMC, GAIL etc. In recognition of his early work, he received the Scopus Young Scientist Award from Elsevier for being the most cited young author in engineering. Based on his overall work, he was awarded the Presidential Swarnajayanthi fellowship by the Department of Science and Technology, India, in 2006 and the S.S. Bhatnagar prize from CSIR, India in 2009 from the prime minister of India and the J.C. Bose National fellowship in 2014. This are the country's highest awards given for scientists below the age of 40, 45 and 60, respectively. He has been elected fellow of all the science and engineering academies of India and was recently given the IISc excellence award in teaching and research.

He has published more than 450 international journal articles, which have more than 12000 citations and is among the most cited engineering scientists in India. He is listed by Web of Science as among the top 1% of all scientists in the world. He is currently the associate editor of several journals with various publishers including RSC advances (RSC), Advanced powder technology (Elsevier), Bulletin of Material Science (Springer), Current Science (Indian Academy) and International journal of polymer science (Hindawi).

In addition to scientific research, he writes a popular blog and maintains a website that answers questions for prospective faculty who want to return to India. In his free time (which he has plenty), he reads, translates Sanskrit literature and writes on Hindu philosophy.

### About Professor M.Santappa

Mushi Santappa born on October 2, 1923, obtained his BA (Chemistry) in 1943 from the University of Madras. He did his MSc (Chemistry) in 1946 from Banaras Hindu University. He obtained PhD (Organic Chemistry) in 1949 from University of London under the guidance of R.W. West followed by a second PhD (1951) in 'physical chemistry of high polymers' from Manchester University. Upon his return to India he joined the University of Madras (1952) as a Reader in Physical Chemistry and became a Professor in 1958. He served as Director, Central Leather Research Institute (CSIR-CLRI) from 1972-78. Subsequently he served as Vice-Chancellor of SV University, Tirupathi (1979-81) as well as the University of Madras (1981-84). He was conferred honorary DSc from Andhra, Madras, Sri Krishna Devaraya and Madurai Kamaraj Universities and honorary DLitt from Gulbarga University.

Professor Santappa published over 350 papers in peer-reviewed



journals and guided 59 PhD students. He was awarded the S.S. Bhatnagar Prize for Chemical Sciences (1967), the Sir JC Ghosh Memorial Medal of Indian Chemical Society (1982), and the FICCI Award for Science and Technology (1985). He was elected Fellow of the Indian Academy of Sciences, Bangalore, National Academy of Sciences (India), Allahabad and the Indian National Science Academy, New Delhi.

Professor Santappa was initiated into the study of kinetics of vinyl polymerization as a PhD student working with Professor Meredith G. Evans, FRS (1904-1952) at the University of Manchester in the years between 1948 and 1951. Professor Evans, an early pioneer in the study of chemical kinetics, turned to the study of electron transfer reactions involving ferrous ions and hydrogen peroxide (Fenton reagent) and their ability to polymerize methyl methacrylate in aqueous emulsions Professor Evans elucidated the kinetics and mechanism of this reaction and further proposed that UV and visible light can promote internal electron transfer and, thus, vinyl monomers can be polymerized under the influence of light (photo polymerization). Professor Santappa's PhD work concerned photo-initiated free radical polymerization of vinyl monomers. Upon his return to India Professor Santappa built an active school of research on the study of kinetics of vinyl polymerization. Beginning in 1955 he published a series of over 150 papers on kinetics and mechanism of vinyl polymerization and determination of initiation rates and chain transfer constants for a host of initiators and vinyl monomers. Along with Professor Santi R. Palit at the Indian Association for the Cultivation of Science, Professor Santappa, established the first rigorous school for polymer science research in India and trained a whole generation of polymer chemists who went on to practice the discipline with great distinction. Professor Santappa brought great visibility to Indian polymer research for about three decades. In 1983, he organized India's first ever IUPAC sponsored International Symposium on Polymers at Madras (Chennai). In 1996 he authored a book which comprehensively reviewed the status of polymer science in India

### About Professor M. Santappa Award

The Award was instituted by the Society for Polymer Science, India, in 1988 to honour Professor Mushi Santappa, a distinguished physical chemist and a pioneer in polymer science research in India. Professor Santappa was the founder of the Department of Physical Chemistry, University of Madras. Under his dynamic leadership and erudite scholarship, the Department became of hub of polymer science research in the period 1952-1970.

The award is given biennially by the Society to distinguished scientists for outstanding research contributions made in India during the ten years preceding the year of the award in the field of Polymer Science.