

DARSHAN RANGANATHAN

(04 June 1941 – 04 June 2001)

Biog. Mem. Fell. INSA, New Delhi **34** 85-98 (2008)





Darshan K. Gupta



DARSHAN RANGANATHAN

(1941-2001)

(Elected Fellow 1996)

"A bright light has been switched off from your life for ever"

– Professor G Mehta

DARSHAN RANGANATHAN was born on June 4, 1941 and passed away from metastasis of cancer on June 4, 2001, exactly at the age of sixty.

Darshan! I Often said, "You are a star"!

She was more than a star. She was a comet in the chemical horizon, shedding brilliance at prodigious costs of energy and vanishing at the apex of her career!

Darshan was born as the third child of Vidyavati and Shantiswarup Markan of Karol Bagh New Delhi. After completing her early education, in Aryasamaj Girl's Primary School, Delhi (1946-51) and Indraprastha Higher Secondary School (1951-1958), Delhi, where Miss. SVL Ratan greatly influenced her to pursue chemistry, which, fortunately she did in Delhi University. Even at a young age she was full of life, and was fond of music, dancing and drawing, excesses of which many times, won her rebukes from teachers! She was a brilliant scholar, always standing first and completed her Ph.D. under the guidance of the legendary, Professor TR Seshadri, even while teaching Chemistry at Miranda College. As a coveted awardee of The Senior Research Scholarship of the Royal Commission for the Exhibition of 1851, she carried out outstanding postdoctoral work in the group of Professor DHR Barton. She returned to India in 1969.

Everything about Darshan is memorable. Soon after her return from UK in 1969, we met, for the very first time, at a symposium for a few seconds. Months later, I proposed to her and to my good fortune she accepted. We were married on June 4, 1970. In 1972, we were blessed by Anand, who happily has evolved as an excellent scientist.

On June 16, 1970 Darshan joined our laboratory at IITK, with no scholarship at that time, but was perfectly happy to have a laboratory. She loved to work with her own hands and worked for long hours cheerfully with unparalleled skills. It seems that I had read Darshan's profile correctly. I told her that from the very first day, we would share my resources as an Assistant Professor of the Department, by way of students, equipments, chemicals, project funds and that we will work in different domains of research. With all the trials, tribulations and various types of prejudices,



she did exceedingly well on her own, published independently and was already a Member of the Indian Academy of Sciences by the time she got her first real job at Regional Research Laboratory, Trivandrum in 1992. There she set up a laboratory for Bioorganic Research. Her rise there had been truly meteoric. As Professor Surolia stated Darshan had more publications in the *Journal of the American Chemical Society* in her last years than I ever had in this journal in my whole career! The peer system in India is really good; thus who earlier looked at Darshan with doubt, now became her ardent well wishers and promoters, a phase in her life she enjoyed, though late. In 1998 at the invitation of Dr. Raghavan, Director, Indian Institute of Chemical Technology, we moved to Hyderabad, a wonderful city, with wonderful people and incredible facilities. Darshan flourished under such most benign environment, received many awards including Fellowship of the Indian Academy of Sciences (1991), The Indian National Science Academy (1996), AV Rama Rao Foundation Award (JNCASR), Jawaharlal Nehru Birth Centenary Visiting Fellowship (INSA, 2000), Third world Academy of Sciences award (TWAS) in Chemistry (1999) and Sukh Dev Endowment Lecture (NCL).

A German Scientist at a Symposium succinctly stated what made Darshan unique: "Madam, you look like an Indian Goddess!" With her captivating smile, impeccable globular bindi and gorgeous Kancheepuram sarees, her gentleness, dignity, her overcoming cheerfully the frosted glass ceiling which the establishment offered throughout her stay at IITK, with malice to none, courtesy to all, ready to share with me what little I had by way of chemicals, equipments and grants to pursue her own research, with or without scholarship and cheerfully riding on the back of my bicycle for twenty years, surely she had been qualified her for that remark!

Her contribution to chemical education was monumental. She co-authored several books and a generation of young organic chemists grew up with a monthly analysis of current literature, "Current Organic chemistry highlights", edited by Darshan and myself (those days, I typed on a stencil and she drew the structures beautifully), made available at negligible cost!

Darshan's genius gave me immense joy. At the time of her passing away, she was the most prolific organic chemist in India, having, in the last five years, a dozen publications in *The Journal of The American Chemical Society*, six in the *Journal of Organic Chemistry* and dozens in others. Her monumental contributions to the Accounts of Chemical Research was published, as well as many other papers, posthumously. All these achievements assume special significance, particularly for young aspiring women scientists in India. When she came to Kanpur, where I was a member of the faculty, the rules that exist even today, did not permit her to be offered a position. Therefore, throughout her long stay in Kanpur, she had to hop from fellowship to fellowship and for some periods none at all! We counted on small



mercies and I am truly grateful to IITK and the Chemistry Department for permitting her to do research. I knew from the beginning that she was better than me and was proud to share my funds and students with her so that she could work on her own problems and published on her own. That is all she wanted, brushing away all other irritants and she gradually blossomed into an organic chemist who won international peer recognition, even before she accepted an independent position at RRL, Trivandrum in 1992 and subsequently moved to IICT, Hyderabad in 1998. I dwelt on this theme for long because what Darshan faced at Kanpur to pursue her research would continue for a long time and it can be won only with strong determination. As a small tribute to Darshan's fierce profile, The Indian National Science Academy kindly agreed to institute a biennial lecture in her memory to an outstanding woman scientist regardless of the domain of research. This is a first for the Academy to offer encouragement to women scientists, which is long overdue. A very useful strategy for aspiring women scientists in India, is to adopt the path taken by Darshan, who had realized that women scientists would face additional impediments and had planned her career taking note of that rather than worrying about it. She set an example to be emulated. Till the very end of her life she worked very hard. Her courage and will to fight with no acrimony and with a smile and verve made all those who came into contact to literally love her.

I dwelt on her personality at first, rather than her science since hers is an ideal profile to emulate.

Summarizing Darshan's genius is even more difficult. At the time of her passing away, she was the most prolific organic chemist in India.

Her perceptions of problems were truly uncanny. They were brilliant in perception, exquisite in design and perfect in execution. She brought in a fresh wave to organic chemistry, with most problems having their roots in the manifestations of Nature. She ventured into domains that others feared to tread and succeeded brilliantly. She simulated in the laboratory the ATP-imidazole cycle, where Nature creates a daughter imidazole from a parent imidazole in a cyclic operation and she put this concept to practice by creating an imidazole-producing machine! Hans Krebs was awarded the Nobel Prize in medicine for unraveling the process of excretion of urea, an operation critical to sustenance of life. The operation called "Krebs's cycle", where ornithine, as a carrier molecule, in a cyclic operation results in ejection of urea! Darshan demonstrated in the laboratory the salient features of his process, a magnificent achievement. Most of the hormones that regulate your life are small proteins arising from specific fragmentation of larger, genetically coded proteins. The genesis of pituitary hormones makes fascinating chemistry, and Darshan simulated this process in the laboratory. She discovered several specific DNA cleaving agents. Her closer and closer liaison with Nature made her realize how important biomolecules are simply made by aggrandization of smaller units.



ushered her to perhaps the most productive phase of her life, supramolecular chemistry. Name any example of biomolecular architecture, such as, membranes, ion channels, ionophores, nanotubes, cyclic and hybrid peptides, all these she designed, assembled in the laboratory, in most cases had their structure established by X-ray crystallography and their properties studied and compared with that of natural systems. She collaborated extensively and all were happy to be associated with her. She became a wizard in conjuring supramolecules that are hairpins, double helices, Janus shaped two helix bundles, parallel sheets, figure of eight shapes, channel formers, bangle stands and nanotubes. She played on molecules like an instrumentalist and created divine melodies with the minimum tones.

Darshan's memoir would not be complete, without Dr. Isabella Karle, who is with the Naval Research Laboratory, Washington. They have never met. All the wonderful X-ray figures are a creation of Isabella, crystals in oil, crystals so thin and crystals one could hardly see, she solved them all!

Towards the later stages, Darshan's output was so prodigious that I was not able to assess their impact. I believe that there is a latent running thread that serve as link in the evolution novel ideas. After Darshan's passing away, I looked for this running thread by analysis of her papers and sure enough was able to perceive the evolution of her thoughts in the design of macromolecules by self-assembly. I edited the quintessence of her work named *Patterns for Supramolecular Design*, authored by Darshan Ranganathan and Isabella Karle, which was published by New Age International Publishers, New Delhi in 2002.

On her passing away in 2001, I carry a heavy burden of guilt! During 1995-1996, I had a severe attack of brain TB. Darshan literally saved my life, at her own cost! She had detected early a small growth in her right breast, but did not tell any one, for fear that it may upset my fragile equilibrium. By the time she eventually told me this growth was large! Mastectomy was performed soon, and we will always be indebted to CNR, Indu, Balu and Shakti for their concern and help, Unfortunately metastasis was detected in mid-2000 and in spite of all that we could do, she passed away under the most tragic circumstances, Although I knew that she was suffering immensely, she worked hard to the very end, Dr. Raghavan could not believe that seeing her ever cheerful demeanor.

For such a wonderful human being, the end should come so early and so painfully is indeed a cruel twist of destiny. She fought her long suffering just as bravely. Cancer is a disease of such pervasiveness that it leaves a guilt in those responsible for the treatment, because in retrospect, one could count many things I ought to have done differently. One is led to wonder if there is something uncanny about the date and time of her passing away: the very day she was born sixty years ago and to the very day and timed to the minute that she married me thirty golden years that went by, a dream never to return.



It would be a befitting tribute to Dr. Darshan, to pictorially present some of her marvelous designs as given below.

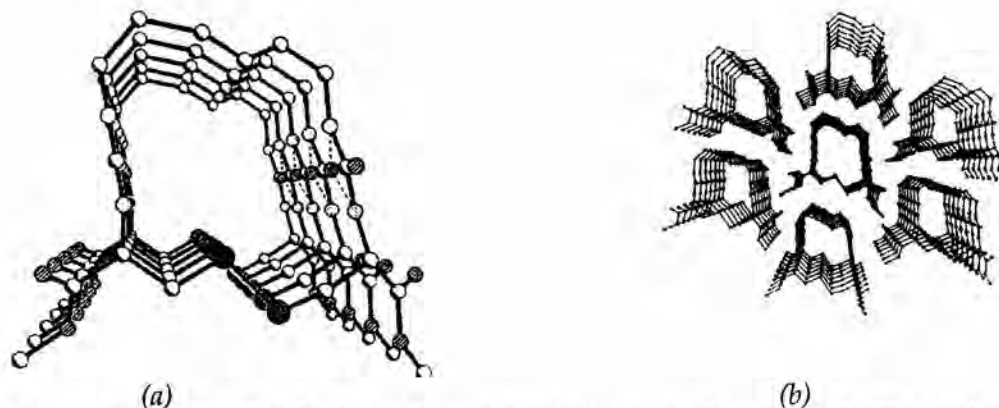


Fig. 1: Nano tubes from $(\text{CH}_2)_6 (\text{N}=\text{C}=\text{O})_2$ and urea! (a) A view into the cavity. (b) The perfect alignment of the nano tubes in the crystal.

JACS, 1999, 121, 6103

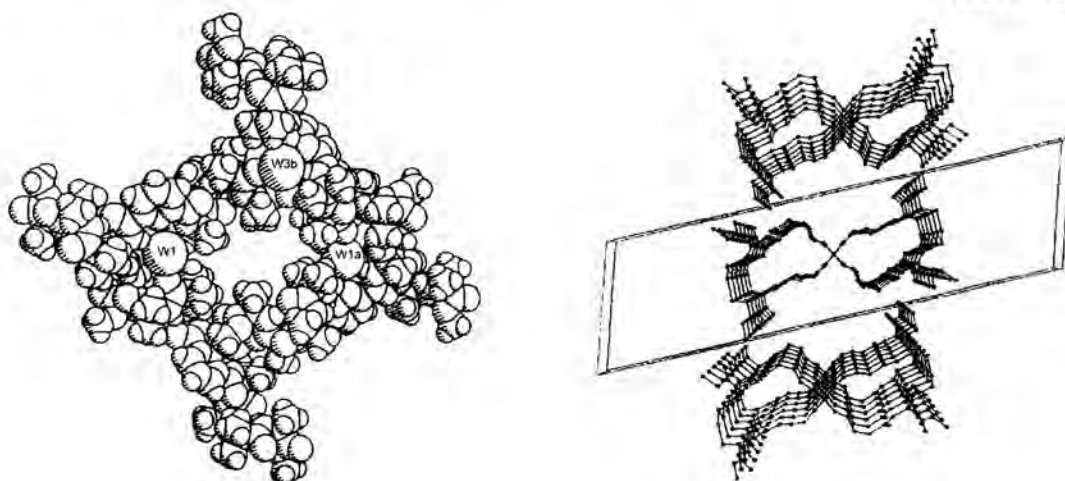


Fig. 2: A crystalline tetrameric channel from Py (Aib)₄ that really works! Strategically placed water molecules hold the crystal together into one cohesive unit. The cavity is quite large and can accommodate guests.

J. Peptide Res., 2000, 56, 416

Fig. 3: Double barreled nano tubes! Cystine capped penta-erythritols crystallize to form bis nano tubes, the units in full register!

JACS, 2001, 123, 5619

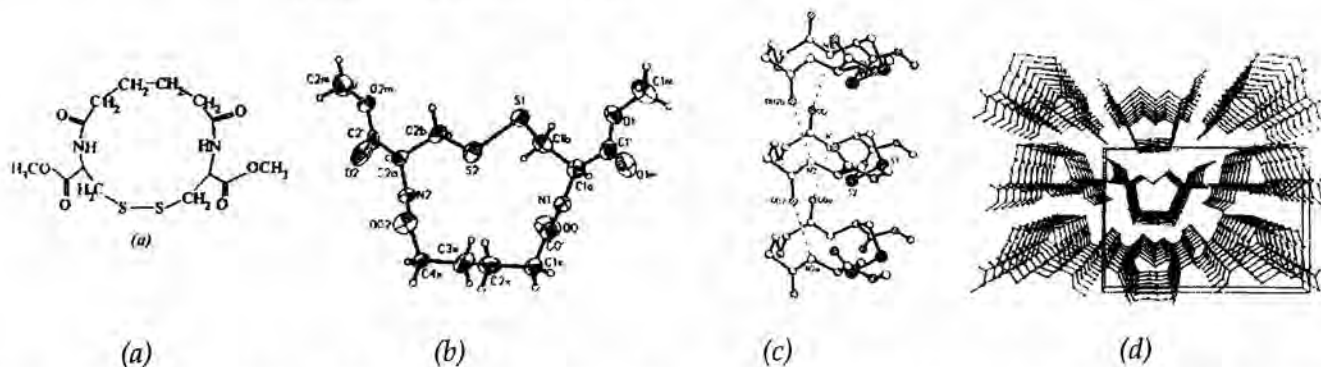


Fig. 4: It is hard to believe! But crystals of cyclic adipate of Cystine. (a,b) Form vertical stacking by hydrogen bonding (c) Assembling side by side in perfect register (d) The hollow open ended tubes are held together only by hydrophobic forces.

J. Org. Chem., 1999, 64



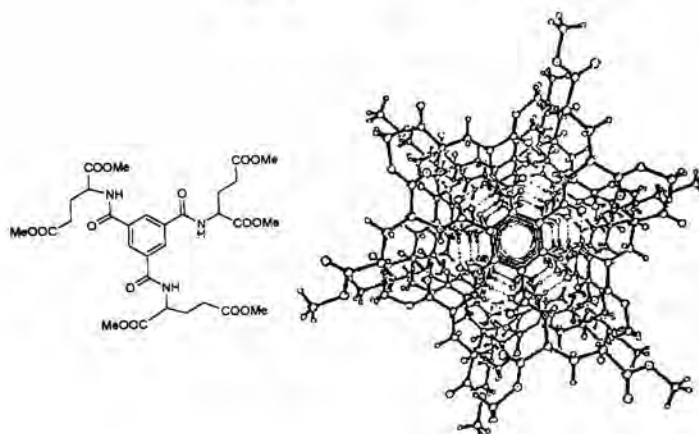


Fig. 5: One of the finest designs of Darshan, the crystals of the simple glutamate a have the exquisite structure b stabilized by vertical π - π Stacking, delightfully augmented by vertical NH...O=C hydrogen bonding, with each sub-unit participating in three intermolecular hydrogen bonding, related by three fold rotation symmetry.

Biopolymers, 2000, 54, 289

S RANGANATHAN, FNA
Discovery Laboratory, Organic III
Indian Institute of Chemical Technology
Uppal Road, Hyderabad-500607 (AP)
Tel: 040-27191234; E-mail: ranga@iict.res.in

BIBLIOGRAPHY

- 1965 (With MUKHERJEE SK and SESHADRI TR) Constitution of Latifolin (F) *Tetrahedron* **21** 149.
- 1966 (With MUKHERJEE SK and SESHADRI TR) Synthesis (\pm) Latifolin Dimethyl Ester (C) *Curr Sci* **34** 690.
- (With MUKHERJEE SK and SESHADRI TR) The Absolute Configuration of Latifolin (C) *Tetrahedron Lett* 3767.
- (With MUKHERJEE SK and SESHADRI TR) 4-Phenyl Coumarins as Precursors of Neo-Flavanoids (C) *Curr Sci* **35** 477.
- (With MUKHERJEE SK and SESHADRI TR) Epoxide Formation as a Side Reaction on Silver Nitrate/ Alumia Column (C) *Curr Sci* **36** 387.
- (With MUKHERJEE SK and SESHADRI TR) Pro-Anthocyanins of Bassia-Butyracea Roxb (C) *Curr Sci* **35** 223.
- (With MUKHERJEE SK and SESHADRI TR) Some Novel Ionic Displacements in Latifolin System (C) *Ind J Chem* **4** 479.
- (With MUKHERJEE SK and SESHADRI TR) Synthesis (\pm) Latifolin Dimethyl Ether (F) *Tetrahedron* **22** 3491.
- 1967 (With MUKHERJEE SK) A Novel Photo-rearrangement of Latifolin *Tetrahedron Lett* 4169.
- (With MUKHERJEE SK and SESHADRI TR) A Novel Rearrangement of Latifolin *Tetrahedron Lett* 1153.
- 1968 (With BARTON DHR, WELZEL P, DANKS LJ and MCGHIE JF) The Synthesis of Cyclooctenol (C) *J Chem Soc Chem Comm* 643.



- 1968 (With MUKHERJEE SK and SESHADRI TR) Steric Influence of o-Tosyloxy group in Styryl Conjugation (C) *Ind J Chem* 5 27.
- 1969 (With BARTON DHR, WELZEL P, DANKS LJ and McGHIE JF) Photochemical Transformations: The Synthesis of Cycloartenol (F) *J Chem Soc* 332.
- 1970 (With BARTON DHR) Photochemische Umwandlungen XXVII Neue Partial Synthese von 4-Desmethyl und 4-Bisdesmethyl Triterpenoiden (F) *Ann* 737 108.
- 1973 (With RANGANATHAN S and SIDHU RS) (2,3) vs (3, 3): The Novel Sigmatropic Rearrangement of Oxime-O-Allyl Ethers (C) *Tetrahedron Lett* 3577.
- (With RANGANATHAN S and MEHROTRA AK) The Hassner-Ritter Reaction in Iodine Azide Additions of Pinenes with Solvent participation (C) *Tetrahedron Lett* 2265.
- 1973 (With RANGANATHAN S and MEHROTRA AK) A Novel Route to 1-(Azidoalkyl) Tetrazoles by Hassner-Ritter Reaction (C) *Synthesis* 356.
- 1974 (With RANGANATHAN S and MEHROTRA AK) Nitroethylene as a versatile Ketene Equivalent Novel One step Preparation of Prostaglandin Intermediates by Reduction and Abnormal Nef Reaction (C) *J Am Chem Soc* 96 5261.
- 1975 (With RANGANATHAN S and MEHROTRA AK) An Un-anticipated Facile Regiospecific and Stereospecific A→F Prostanoid Transformation (C) *Tetrahedron Lett* 1215.
- 1976 (With RANGANATHAN S and IYENGAR R) A Simple and Convenient Route to 11-Desoxy Prostaglandins (F) *Tetrahedron* 32 961.
- 1976 (With RANGANATHAN S and MEHROTRA AK) Synthesis of 3,5-Dioxo-2-oxatricyclo [4.2.1.0^{4,8}] nonane (2,4-Dioxo-5-oxa brendane) (C) *Synthesis* 620.
- 1977 (With RANGANATHAN S and MEHROTRA AK) A Novel Facet of Halolactonization Reaction (F) *Tetrahedron* 33 809.
- (With RANGANATHAN S and MEHROTRA AK) Ketene Equivalents (F) *Synthesis* 289.
- (With RANGANATHAN S and MEHROTRA MM) A Biogenetic Type Synthesis of a Naturally Occurring Furanoid Fatty Acid (C) *Synthesis* 838.
- 1978 (With RANGANATHAN S and MEHROTRA MM) Synthesis of 9,11-Ethno PGH₁ and Homo 9,11-Ethno PGH₁ (C) *Tetrahedron Lett* 1851.
- 1979 (With RAO CB and RANGANATHAN S) Nitroethylene: Synthesis of Novel 2-Nitroethylphosphonates (C) *J Chem Soc Chem Commun* 975.
- 1980 (With RANGANATHAN S, RAO CB, MEHROTRA AK and IYENGAR R) Nitroethylene: A Stable Clean and Reactive Agent for Organic Synthesis (F) *J Org Chem* 1185.
- (With RANGANATHAN S, RAO CB and KESAVAN K) Nitroethylene: A Novel Synthon for N-(2-Nitroethyl) Amino Compounds (C) *Synthesis* 884.
- (With RANGANATHAN S and MEHROTRA MM) The Synthesis of PGF_{1α} by Restructuring of Castor Oil (F) *Tetrahedron* 36 1869.
- 1981 (With RANGANATHAN S and RAO CB) The Preparation and Transformation of N-Benzoyl-2-Aza-3-oxabicyclo (2.2.1) hept-5-ene and N-Benzoyl-2-Aza-3-oxabicyclo (2.2.1) heptane (F) *Tetrahedron* 37 637.
- (With RANGANATHAN S, RAO CB and RAMAN K) The Preparation and Transformations of 2-Aza-3-oxabicyclo (2.2.1) heptane Hydrochloride (F) *Tetrahedron* 37 629.



- 1981 (With RANGANATHAN S, RAMACHANDRAN PV, MAHANTY MK and BAMEZAI S) A Chemical and Thermochemical Study of Non-observed Symmetry Allowed Reactions (F) *Tetrahedron* **37** 4171.
- (With RANGANATHAN S) Self-Organizing Systems: Evolution of the Genetic Apparatus (F) *Trans Bose Res (Pub 1983)* 1st **44** 109.
- 1982 (With RANGANATHAN S and BAMEZAI S) Nitroethylene: Nitroethylation of Amines (C) *Tetrahedron Lett* 2789.
- 1983 (With BAMEZAI S) A Novel Proline Derived Meso-ionic Synthon (C) *Tetrahedron Lett* 1067.
- 1983 (With RANGANATHAN S, BAMEZAI S, MEHROTRA S and RAMACHANDRAN PV) 2-Nitroethyl Phenyl Sulfoxide: A Novel Reagent for Facile Nitroethylene Transfer (C) *J Chem Res (S)* 78.
- 1984 (With FAROOQUI F) Synthesis on Templates: Regio-specific Synthesis of Imidazoles (C) *Tetrahedron Lett* 5701.
- (With RANGANATHAN S and RAMACHANDRAN PV) Iodoxybenzene: A Remarkably Close Ozone Equivalent (F) *Tetrahedron* **40** 3145.
- (With RANGANATHAN S) Evolution of the Genetic Code: Chemical Studies on the Genesis of Coded -Amino acids (F) *Proc Indian Acad Sci (Chem Sci) Golden Jubilee Special Issue* **93** 687.
- 1985 (With BAMEZAI S, HENG HC and CLARDY JON) A Novel and Unusual Intramolecular Redox Reaction: The Transformation of L-Proline to N-Amino-2-Pyrrolidones via Meso-ionic systems (C) *Tetrahedron Lett* 5739.
- (With FAROOQUI F and BHATTACHARYYA D) Synthesis on Templates II: Directed Synthesis of Imidazoles from Adenine (C) *Tetrahedron Lett* 2905.
- (With BARNEZAI S and RAMACHANDRAN PV) A Study of the Preparation and Reactions of the Unusually Labile 5-Methyl (1, 2, 4) Oxadiazolo (2, 3-c) Quinazoline-2-one (F) *Heterocycles* **23** 623.
- (With BAMEZAI S) A Novel and Practical One-step Synthesis of 5, 6-Dihydro-3-Phenyl-4H-Pyrrolo (1, 2-b) Pyrazole (Withasomnine) (C) *Synthetic Comm* 259.
- (With RANGANATHAN S and SINGH SK) 4-^tButyl Iodoxybenzene: An Effective Ozone Equivalent (C) *Tetrahedron Lett* 4955.
- 1986 (With RATHI R, KESAVAN K and SINGH WP) The Demonstration of Novel O→N Claisen Rearrangement in Purines (F) *Tetrahedron* **42** 4873.
- (With FAROOQUI F, BHATTACHARYYA D, MEHROTRA S and KESAVAN K) The Chemical Simulation of ATP-Imidazole Cycle (F) *Tetrahedron* **42** 4481.
- (With RATHI R) Imidazole Synthesis on a Solid Support (C) *Tetrahedron Lett* 2491.
- (With FAROOQUI F, MEHROTRA S and KESAVAN K) The Reaction of 4-Quinazolones with Organo-metallic Agents - A Persistent Preference for Ring Rupture over Cyclization (F) *Heterocycles* **24** 2493.
- 1987 (With RANGANATHAN S, SINGH SK and BHATTACHARYYA D) Oxidative Transformation of Coded Aromatic Amino Acids with 4-^tButyl Iodoxybenzene (C) *J Chem Soc Chem Commun* 3111.



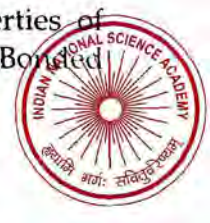
- 1987 (With RANGANATHAN S, BHATTACHARYYA D, SHANTHY S and SINGH GP) L-Methionine Oxidation: Novel and Unanticipated Transformations with 4-Butyl iodoxybenzene (F) *Tetrahedron* 5363.
- (With RANGANATHAN S and SINGH SK) A Practical and Convenient Synthesis of the Nitroethylene Transfer Reagent 2-Nitroethyl Phenyl Sulfoxide (C) *Tetrahedron Lett* 2893.
- (With RANGANATHAN S and BHATTACHARYYA D) The Transformation of Tryptophan to Aspartic Acid in Peptides (C) *J Chem Soc Chem Commun* 1085.
- 1988 (With RANGANATHAN S and SINGH WP) Spontaneous Cyclization of a Chain Shortened Lysine Analog (C) *Tetrahedron Lett* 3111.
- 1989 (With SINGH GP and RANGANATHAN S) Peptide Bond Formation at the Micellar Interface (C) *J Am Chem Soc* **111** 1144.
- 1990 (With RATHI R and SHARMA S) Repetitive Imidazole Synthesis Using An Immobilized Imidazole Template (F) *J Org Chem* **55** 4006-4010.
- (With RATHI R) Urea Cycle: Chemical Simulation of Arginine Biosynthesis (F) *Org Chem* **55** 2351-2354.
- (With SINGH GP) The Demonstration of Selective Peptide Bond Formation in Clear Aqueous Solution (C) *J Chem Soc Chem Commun* 142.
- 1990 (With RANGANATHAN S, BAMEZAI S, SINGH WP, BHATTACHARYYA D, SINGH GP, RATHI RK, JAYARAMAN N and PATEL BK) Chemical Approaches to Re-structuring of Proteins (C) *Pure and Applied Chem* **62** 1437.
- 1991 (With SAINI SUJATA) Transformation of C-terminal Serine and Threonine Extended Precursors into C-terminal α -Amidated Peptides: A Possible Chemical Model for the α -Amidating Action of Pituitary Enzymes (C) *J Am Chem Soc* **113** 1042-44.
- (With RANGANATHAN S and BHATTACHARYYA D) The Transformation of Histidine Side Chain to Non-coded Asparagines (C) *Tetrahedron Lett* **32** 5616.
- (With BAMEZAI S and SAINI S) A Serendipitous Finding of L-Proline as a Precursor of Novel Mesoionic Synthon: Delineation of New Transformations (F) *Indian J Chem* **30B** 169.
- 1992 (With SHAH K and VAISH N) An Exceptionally Mild and Efficient Route to Dehydroalanine peptides (C) *J Chem Soc Chem Commun* 1145.
- (With FAROOQUI F, RATHI R, SAINI S, VAISH N and GEORGE S) Enzyme Action: The Delineation of Novel Strategies Based on Reaction Mechanism and Transition States (F) *Ind J Chem* **31B** 934.
- (With FAROOQUI F, RATHI R, SAINI S, VAISH N and GEORGE S) Enzyme Action: The Delineation of Novel Strategies Based on Reaction Mechanism and Transition States (F) *Pure and Applied Chemistry* **64** 1147.
- 1993 (With PATEL BK and MISHRA RK) Design of a Chemical Nuclease Model with (LyS)₂Cu as the Core Motif (C) *J Chem Soc Chem Commun* 337.
- (With VAISH NK, SHAH K, ROY R and MADHUSUDANAN KP) Oxalo peptides as Core Motifs for Protein Design (C) *J Chem Soc Chem Commun* 92.
- (With RANGANATHAN S, SINGH GP and PATEL BK) Demonstration of Exclusive α -peptidation at the Micellar interface (C) *Tetrahedron Lett* 525.



- 1994 (With VAISH NK and SHAH K) Protein Backbone Modification by Novel C α -C Side-Chain Scission (F) *J Am Chem Soc* **116** 6545-6557.
- (With KARLE IL, SHAH K and VAISH NK) Conformation of the Oxalamide Group in Retro-bispeptides (F) *Int J Peptide Protein Res* **43** 160.
- (With PATEL BK and MISHRA RK) Design of a Simple and Flexible Dimeric Peptide Model for DNA Recognition and Scission (C) *J Chem Soc Chem Commun* 107.
- (With LUTHRA M, RANGANATHAN S and BALASUBRAMANIAN D) Protein Associated Pigments that Accumulate in the Brunscent Eye Lens: Identification of a Quinoline Derivative (F) *FEBS Letters* **349** 39-44.
- 1994 (With LUTHRA M, RANGANATHAN S and BALASUBRAMANIAN D) Racemization of Tyrosine in the Insoluble Protein Fraction of Brunscent Aging Human Lenses (F) *J Biol Chem* **269** 22678.
- 1995 (With VAISH NK, CHANDRAMOULI GVR, VARGHESE B, MUTHUKUMARAN RB and MANOHARAN PT) Crystal Structure of [Aib-COCO-Aib]Cu₂: A Unique Example of Modular Self-Assembly (C) *J Am Chem Soc* **117** 1634.
- (With KARLE IL) Methanol Mediated Modular Self-Assembly of Antiparallel β -Dimers: Crystal Structure of C α Backbone Modified Tripeptide Bz-Aib-NH-CO-CO-Aib-OMe (F) *Int J Peptide Protein Res* **46** 65-68.
- 1995 (With KARLE IL) The Delineation of Hydrogen-Bonding Patterns in Supramolecular Self-Assembly of Several Core Oxalo Retro-Peptides and Crystal Structure of MeO-Ser-Leu-COCO-Leu-Ser-OMe (F) *Int J Peptide Protein Res* **46** 18-23.
- (With KARLE IL) Polymethylene Spacer Linked Bis (Ala) Peptides form β -Sheet Structures: Crystal Structure of and Self-Assembly Pattern of Adipoyl and Suberoyl Analogues (F) *Int J Peptide Protein Res* **46** 24-29.
- (With KARLE IL) Core Directed Self-Assemblies in the Solid State of Retro Aib Bis-peptide Dicarboxylic Acids: A Design Strategy for Control of Molecular Orientation in Peptides (F) *Biopolymers* **36** 323-331.
- 1996 (With KARLE IL and HARIDAS V) Crystal Structure of Cyclo(Adm-Cyst)₃: Example of a Topologically Defined Double-Helical Cystine Cyclic Peptide (C) *J Am Chem Soc* **118** 10916-10917.
- (With KARLE IL and HARIDAS V) A Persistent Preference for Layer Motifs in Self-Assemblies of Squarates and Hydrogen squarates by Hydrogen bonding [X-H...O; X=N, O or C]: A Crystallographic Study of five Organic Salts (F) *J Am Chem Soc* **118** 7128-7133.
- (With HARIDAS V, MADHUSUDANAN KP, ROY R, NAGARAJ R, JOHN GB and SUKHASWAMI MB) Design synthesis an Ion Transport Properties of a Novel Family of Cyclic Adamantane Containing Peptides (C) *Angew Chem Int Ed Engl* **35** 1105.
- Design and Synthesis of Self-Assembling Peptides (F) *Pure and Appl Chem* **68** 671.
- 1997 (With KURUR S, MADHUSUDANAN KP and KARLE IL) Self-assembling Urea Peptidomimetics: A Simple One-step Synthesis and Crystal Structure of Core β -Alanyl Ureylene Retro-bispeptides (MeO-Aaa-[NH-CO-NH]-CH₂-CH₂-CO-NH-Aaa-OMe; Aaa = amino acid A) (C) *Tetrahedron Lett* **38** 4659-4662.



- 1997 (With KARLE IL and HARIDAS V) Molecular Recognition: The Demonstration of 1,3-Bis-[(Pyrid-2-yl)amino] Carbonyl Adamantane as an Exceptionally Versatile Assembler of One-Dimensional Motifs (F) *J Am Chem Soc* **119** 2777-2783.
- (With KURUR S) Synthesis of Totally Chiral Multiple Armed Poly-Glu and Poly-Asp Scaffoldings on Bifunctional Adamantane Core (C) *Tetrahedron Lett* **38** 1265-1268.
- (With HARIDAS V, MADHUSUDANAN KP, ROY R, NAGARAJ R and JOHN GB) Serine-Based Cyclodepsipeptides on an Adamantane Building Block: Design Synthesis and Characterization of a Novel Family of Macrocyclic Membrane Ion-Transporting Depsipeptides (F) *J Am Chem Soc* **119** 11578-11584.
- 1998 (With HARIDAS V, GILARDI R and KARLE IL) Self-Assembling Aromatic-Bridged Serine-Based Cyclodepsipeptides (Serinophanes): A Demonstration of Tubular Structures Formed through Aromatic π - π Interactions (F) *J Am Chem Soc* **120** 10795-10800.
- (With HARIDAS V, KURUR S, THOMAS A, MADHUSUDANAN KP, NAGARAJ R, KUNWAR AC, SARMA AVS and KARLE ISABELLA L) Demonstration of endo-cis-(2S, 3R)-Bicyclo [2.2.1] hept-5-en-2, 3-dicarbonyl Unit as a Reverse-Turn Scaffold and Nucleator of Two-Stranded Parallel β -Sheets: Design Synthesis Crystal Structure and Self-Assembling Properties of Norborneno Peptide Analogues (F) *J Am Chem Soc* **120** 8448-8460.
- (With KARLE IL and HARIDAS V) Adamantane-Constrained Novel Cyclodepsipeptides: Crystal Structure and Self-Assembling Properties of Cyclo (Adm-Ser)₂ and Cyclo(Adm-Ser-Xaa)₂, Xaa = Val/Ser (F) *J Am Chem Soc* **120** 6903-6908.
- 1998 (With HARIDAS V and KARLE IL) Cystinophanes a Novel Family of Aromatic-Bridged Cystine Cyclic Peptides: Synthesis Crystal Structure Molecular Recognition and Conformational Studies (F) *J Am Chem Soc* **120** 2695-2702.
- (With KURUR S, MADHUSUDANAN KP, ROY R and KARLE IL) Self-assembling bis-dendritic peptides: design synthesis and characterization of oxalyl-linked bis-glutamyl peptides [Glu_n(CO₂Me)_{n+1}-CO-]₂; n = 1, 3, 7] (F) *J Peptide Res* **51** 297-302.
- (With HARIDAS V, VAISH NK, MADHUSUDANAN KP, ROY R, BALASUBRAMANIAN D and SRINIVAS V) The Demonstration of spontaneous self-assembly of Novel Fluorescent Proflavin Lipids (F) *J Ind Chem Soc* **75** 598.
- 1999 (With KARLE IL and KURUR S) A Unique Example of a Self-Assembled Hydrogen-bonded Polynuclear Sheet in the Solid-State Structure of a Retrobispeptide-Copper (II) Complex (C) *J Am Chem Soc* **121** 7156-7157.
- (With LAKSHMI C and KARLE IL) Hydrogen-Bonded Self-Assembled Peptide Nanotubes from Cystine-based Macrocyclic Bisureas (F) *J Am Chem Soc* **121** 6103-6107.
- (With THOMAS A, HARIDAS V, KURUR S, MADHUSUDANAN KP, ROY RAJA, KUNWAR AC, SARMA AVS, VAIRAMANI M and SARMA KD) Design Synthesis and Characterization of Tyrosinophanes a Novel Family of Aromatic-bridged Tyrosine-based cyclodepsipeptides (F) *J Org Chem* **64** 3620-3629.
- (With HARIDAS V, SUNDARI CS, BALASUBRAMANIAN D, MADHUSUDANAN KP, ROY R and KARLE IL) Design Synthesis Crystal Structure and Host-Guest Properties of Polymethylene-Bridged Cystine Based Cyclobisamides: A Facile entry into Hydrogen-Bonded Peptide Nanotubes (F) *J Org Chem* **64** 9230-9240.



- 1999 (With HARIDAS V and KARLE IL) Diamond Crowns: Design Synthesis and X-ray Crystallographic Studies of a Novel Family of Adamantane-Containing Crown Ethers (F) *Tetrahedron* **55** 6643-6656.
- (With VAISH NK) Chemical Nucleases Crafted From Core Oxalo Retro-bispeptides Res Chem Intermed (F) **25** 609-614.
- 2000 (With HARIDAS V, KURUR S, NAGARAJ R, BIKSHAPATHY E, KUNWAR AC, SARMA AVS and VAIRAMANI M) Norbornene-Constrained Cyclic Peptides with Hairpin Architecture: Design Synthesis Conformation and Membrane ion Transport (F) *J Org Chem* **65** 365-374.
- (With HARIDAS V, NAGARAJ R and KARLE IL) Double-Helical Cyclic Peptides: Design Synthesis and Crystal Structure of Figure-eight Mirror Image Conformers of Adamantane-Constrained Cystine-Containing Cyclic peptide Cyclo(Adm-Cyst)₃ *J Org Chem* **65** 4415-4422.
- (With LAKSHMI C, HARIDAS V and GOPIKUMAR M) Designer cyclopeptides for self-assembled tubular structures *Pure Appl Chem* **72** 355-362.
- (With KURUR S and KARLE IL) Design Synthesis and Crystal Structure of Self-assembling Norbornene (NBE)-Supported Two-helix Bundles: A Unique Example of Janus-Helicity in the Solid-State Structure of NBE(Aib)₅)₂ *Biopolymers* **54** 249-261.
- (With KURUR S, GILARDI R and KARLE ISABELLA L) Design and Synthesis of AB₃-Type (A = 1,3,5-Benzenetricarbonyl unit; B = Glu-diOMe or Glu7 OctaOMe) Peptide Dendrimers: Crystal Structure of the First Generation *Biopolymers* **54** 289-295.
- 2000 (With KURUR S, KUNWAR AC, SARMA AVS, VAIRAMANI M and KARLE IL) Channel-forming Self assembling Bishelical Amphiphilic Peptides: Design Synthesis and Crystal Structure of Py(Aibn)₂, n = 2, 3, 4, *J Peptide Research* **56** 416.
- 2001 Designer Hybrid Cyclopeptides for membrane ion Transport and Tubular Structures *Acc Chem Res* **34** 919-930.
- (With KARLE IL and LAKSHMI C) Demonstration of a Cystine Unit as a Promising Turn Scaffold for the design of a Parallel U-Shaped Two-Helix Bundle Motif: Crystal Structure of the Homodimer Cys (Aib_n)₂ (n= 3,4) (F) *Biopolymers* **59** 301-304.
- (With LAKSHMI C) Cystine-Based Cyclic Oligoureases: A New Class of Hydrogen-Bonding Electroneutral Anion Receptors (F) *Chem Comm* 1250.
- (With GOPI KUMAR M and KARLE IL) A hybrid cyclic proline designed to adopt a β-fold: Crystal Structure of cyclo (ProNHCH₂CH₂NH-Pro-COCH₂CH₂CO-) (F) *Chem Commun* 271-272.
- (With GOPI KUMAR M, KISHORE RS and KARLE IL) A unique example of core modified bis proline peptide self-assembling into an infinite hydrogen-bonded ribbon: Crystal structure of Z-Pro-NH(CH₂)₂NH-Pro-Z (F) *Chem Commun* 273-274.
- (With SAMANT MP and KARLE IL) Self-assembling Cytine-derived, Fused Nanotubes based on Spirane Architecture: Design, Synthesis and Crystal Structure of Cystinospiranes (F). *J Amerchem Soc* **123** 5619-5624.
- 2002 (With SAMANT MP, NAGARAJ R and BIKSHAPATHY E) Design synthesis and membrane ion transport properties of Cystine- and serine based cyclo-oxaheptane-1, 7 bisamides (F) *Tetrahedon Lett* **43** 5145-5147.
- 2005 (With KARLE IL) An asymmetric conformation of 1, 3, 5-benzene tricarboxyl [Aib₄OMe]₃ (F) *J Peptide Res* **65** 65-70.
- 2008 (With KARLE IL, GOPI KUMAR M and NAGARAJ R) Design synthesis conformational and membrane ion transport studies of proline-adamantane hybrid cyclic depsipeptides (pN₃) (F) *Biopolymers* **89** 471-478.

