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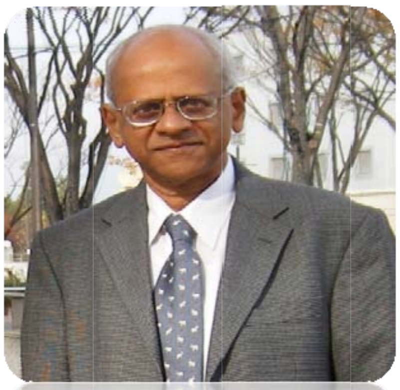
After decades of research work based on the principles laid down by Linus Pauling, supramolecular chemistry has shifted the focus to beyond the molecule. The Chemical Society speaks to one of the leading exponents of this field - Prof. Gautam R. Desiraju, about his experiences in science and beyond...



PERSONALITIES
Prof. G.R. Desiraju

...was born in Madras (now Chennai) and completed his undergraduate degree in 1972 at the University of Bombay. He was awarded his Ph.D. from the University of Illinois at Urbana-Champaign in 1976. Subsequently, he worked at the laboratories of the Eastman Kodak Company in Rochester, New York. On returning to India, he joined the faculty at the University of Hyderabad. His 1989 book *Crystal Engineering the Design of Organic Solids* and 1995 review in Angewandte Chemie defining supramolecular synthons are considered as milestones in the evolution of solid state chemistry. He is credited for having laid an emphasis on the study of hydrogen bonds and other intermolecular interactions in crystal engineering. He has also published many papers in academic journals and the research monograph *The Weak Hydrogen Bonding in Structural Chemistry and Biology*, Oxford, Oxford University Press, 1999, 2001 (in collaboration with T. Steiner). Prof. Desiraju was one of the founder members of the Crystal Engineering Communication Editorial Board and has also served on the Editorial Advisory Boards of Chemical Communications & Accounts of Chemical Research. He is a fellow of The Indian Academy of Sciences, The Indian National Science Academy, The National Academy of Sciences (India), the Third World Academy of Sciences and The Royal Society of Chemistry. He has published around 300 research papers.

• **Chemical Society (CS): You have been quite vocal about the current state of Indian science, particularly the lack of continued funding to undergraduate research labs. In this light, do you welcome the Centre's recent announcement of Rs. 1300 crores dedicated to budding scientists in the coming Five Year Plan?**

Gautam R Desiraju (GRD): Things announced in the papers are just the beginning of the story. The problem lies in the implementation. Our country has the general trend of ignoring existing centers of education and starting new ones. In stark contrast, there are century-old universities around the world! I bet you all this money announced will go into starting new universities. A critic once told me that Indian educational institutions have lifetimes of just 20-25 years. Then it becomes time to start another one! There is some element of truth in this. The interests of the whole country cannot be served by 7 IITs, 2 IISERs, etc. These have a limited capacity and that is why our existing universities need to be strengthened. What's important is how and where the 1300 crores are spent.

• **CS: You begin one of your popular articles by saying, 'I have always regarded myself as unconventional, taking roads not taken by others.' Does this out-of-the-ordinary attitude come naturally or have you developed it over a period of time to reach your goals?**

GRD: (Smiles) No, I think I was always unconventional... right from the age of 17 when I cleared the IIT entrance exam with a single digit rank and then didn't take up the seat. That was because I was already crazy about chemistry. Had I joined IIT, it would have been only one of the subjects whereas if I joined a B.Sc. in chemistry, I would be able to study chemistry most of the time! So, I guess my unconventionality started right there. If somebody did something like that today, he or she would be called insane!

• **CS: You followed your PhD with an industrial stint at Eastman Kodak Company and then immediately returned to India. What prompted you to make these two changes?**

GRD: Joining an industrial lab was the norm in the U.S. Very few researchers moved into academics without working in the industry. Even today almost 90% of the researchers graduating in the U.S. pursue industrial careers. At Eastman Kodak, I realized that chemistry is rooted in practicality and in the needs of the society. Major discoveries in chemistry have been made because of practical needs. Throughout my research work, I have tried to have a practical approach. Coming back to India was unconventional. Nobody did it then ... I guess no one does that even today. After six years in the U.S. I felt I had had enough of it. I also realized how much I loved India and decided to come back without a job in hand! Till date I don't regret that decision … the U.S. is a nice place, but it isn't meant for me.

• CS: Do you feel that most Indian scientists are unwilling to take scientific risks due to a fear of jeopardizing their future funding? Is that one of the reasons for their low scientific productivity?

GRD: No, I don't think it has anything to do with funding, per se. In most high level institutions like the IITs, IISc, Hyderabad Central University and the CSIR labs I don't think funding is a major issue. Rather, the origin of this problem is far deeper. It lies in the premium that our society places on conforming. The 'fear of the unknown' is deep seated in Indians and it comes from our educational system which encourages cramming. The rot starts in our schools.

• CS: In China, a recent law proposed by the Ministry of Science and Technology will allow scientists to report 'failures' in their research without endangering their funding prospects. What are your comments about this?

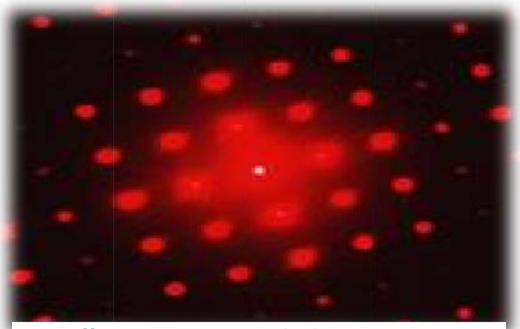
GRD: I am in favor of such a law. It is not possible for a researcher to keep succeeding in the experiments. Even a so-called 'failed' reaction gives vital information on the basis of which further experiments are designed. In chemistry, one has to have a professional attitude. It is very dangerous for a scientist to decide beforehand as to which approach would be the successful one. Such an approach is particularly destructive to chemistry – an out-and-out lab science, a living subject! Many an Indian scientist is guilty of this kind of a sin. Major discoveries have been bypassed because of this around the world. We have the famous example of Aristotle, Galileo and gravity.

• CS: With a rapidly expanding knowledge base in science, students are under increasing pressure to assimilate a lot of information in very less time. How would you advise budding scientists in this regard?

GRD: I agree it is a rather bleak situation for a young person who is interested in a scientific career. I think science shouldn't be done by anybody unless he or she likes it genuinely. The very first time I saw an experiment conducted in class IX, I loved chemistry. I am still in the same state now – that interest hasn't diminished over the last forty years. You can't enter science as a fall back option. My advice would be … don't even care about the subject you study, but look for a good teacher. My chemistry teacher in class IX was a rather interesting character who would do all sorts of crazy experiments with colors and noises – we used to find them cool. Probably, that's what triggered my interest in chemistry. Teachers play a very critical role; they have the power to influence minds. What is science finally? It is a temperament, a conviction … that there is a cause that leads to an effect … something logical, progressive and systematic.

• CS: Let us now talk a little bit about your research work. How far are we from predicting polymorphism in crystals?

GRD: We are all familiar with the example of diamond and graphite



Diffraction Pattern: unlocking structures

being allotropic forms of carbon. Allotrope is an old-fashioned word which means the same as polymorph. The carbon atoms are arranged in different ways in space giving rise to two different solid forms with profoundly different properties.

Are we close to predicting the structures of polymorphs … Yes and No. Within certain homogenous groups of compounds, one may be able to do that. But when molecules become too big or too flexible, the job becomes more difficult. Unfortunately, our computational methods do not seem to have reached the level of sophistication that these molecules seem to display when they are crystallized. I leave it to the computational chemists to solve this problem - it is a computer intensive problem. I view the problem of predicting polymorphism in crystals as one of the important and challenging ones of this century.

• CS: With changes in instrumentation, our definition of a crystal is also changing. Do you see an improvement in our understanding of what crystals are?

GRD: Crystal is a wonderful concept – it is the concept of order. What differentiates crystalline solids from other forms of condensed matter is long-range order – strict periodicity extended to infinity in three dimensions. Amorphous solids have only short range order. Earlier theories spoke of a clear demarcation between structures that were eligible to be called crystals and others. But, as our understanding improves, there is a general acceptance of intermediate degrees of order. With newer understanding, the methods of structure elucidation also need to improve. The moment long range order ceases to exist, diffraction cannot be used as an investigative tool.

• CS: There has been some controversy regarding the crystal structure of aspirin. What is your take regarding this?

GRD: (Smiles) You guys seem to have read up quite a bit about my work. Yes, there are two crystal forms of aspirin. It is the first time this has been reported for a molecular solid. In the case of aspirin, we found two different molecular arrangements in the same crystal. This is what makes aspirin unique. It challenges our definition of the word 'polymorph'. This is what happens in science – with new results existing definitions need to be re-assessed and newer ones need to be given whenever required. Even these new definitions last only for a few years. The thing that most scientists want is immortality in their research. What you do today may be undone by someone tomorrow. Only people like Newton, Einstein and Maxwell lasted for some time. Most of us don't have that immortality, we crave for it and that is one important motivating factor in science.

• CS: We also gather that, apart from chemistry, music has been one of your main interests. Tell us more about it.

GRD: (surprised!) How did you get to know?

• CS: Sources ... professor!

GRD: (smiles) I believe all human beings are receptive to music I don't believe in the term 'tone-deaf'. Music has universal appeal. I was trained up to the stage when I was performing in public, but it was only as an amateur. I realized that the practice required to excel in the field of music was more than what my academic profession would allow. In a rather cold-blooded fashion, I stopped practicing and performing, abruptly!

But music has had a profound effect on my work. I believe science to be connected to music like no other profession. The rigorous training I underwent helped me in my work. I have even modeled some of my papers on the compositions I know, though this is a trick that (I believe) only I know and can understand!! I also try and utilize the concert pattern of Carnatic music while delivering scientific lectures. I believe a lecturer should also entertain his audience in order to keep them alert throughout.