

## In this issue

### Plants as communicators

It was many decades ago that J. C. Bose attempted to frustratingly educate the reluctant biologists and in particular the conservative botanists about the ways in which plants could feel, respond and even communicate. What he earned to begin with, was mostly ridicule. Gradually, however, the reluctance gave way to curiosity, and the ridicule was replaced by sympathy if not apology. The conservative view that plants are different from animals did erode and they were viewed just as a continuum in the spectra of living things created and shaped by the Darwinian forces of natural and sexual selection. There are a lot more botanists today who are willing to accept plant ethology as a field with strong conceptual basis and without the stigma of anthropocentric views; it has been realized that these sessile organisms could in fact feel, respond and communicate in their own way. For instance, plants attacked by the defoliating insects are known to emit volatile chemicals which induce other plants in the neighbourhood to synthesize the antifeedants in order to deter the defoliators – a kind of warning process where the potential victims are signalled against the impending dangers of defoliation.

Interestingly, certain defoliating insects themselves seem aware of such strategies of the plants much more than some botanists are willing to accept that plants could indeed do so. It has been shown that certain cucurbits when attacked by the defoliating insects send the signal from the parts that are fed upon (leaves) to other parts of the plants from where the antifeedants are synthesized and translocated to the part of infestation (leaf) such that further damage by the pest is minimized. However some defoliators are known to first girdle the petiole of the leaf before they start feeding such that the antifeedants from other parts of the plant do not reach the target leaf. Consequently, the insect could de-

vour the whole leaf without any defence by the plant.

One interesting question that obviously emerges is how fast and how does the plant feel the defoliation by the insect and how is the signal transferred to other parts of the plant. Sashidhar and his colleagues at the University of Agricultural Sciences, Bangalore and Sinha and his group at Indian Agricultural Research Institute, New Delhi (Sinha is now in the Water Technology Centre, IARI) have been investigating exactly such details of signal transfer within the plants in a different context – they are studying the mechanism of signal transfer under conditions of drought stress to the plants. Sashidhar's group is evaluating the possibility of abscisic acid (ABA) as a signal emerging from roots subjected to moisture stress while Sinha's group is tracking the electric pulses as potential signals between stressed roots and leaves above ground.

Consider a plant experiencing the moisture stress. It is very essential that the plant shifts its physiology from a highly metabolic state towards a state that conserves its water while maintaining the minimal life processes. This shift requires that the stress experienced by the roots below the ground is conveyed to the leaves above the ground. These signals help the leaves close their stomata to minimize the transpiration through which much of the water loss occurs in leaves. Such message transfer has to occur as rapidly as possible such that not only could the plants minimize their metabolic activity following the moisture stress, but also resume their normal physiological activity following water loss. Further the signal transferred should also carry the information regarding the extent of the moisture stress in order that the response of the leaves is in proportion to the severity of the stress. Rekha and others from the Sashidhar group at University of Agricultural Sciences, Bangalore, review (page 284) the merits and constraints associated with the ABA and electric pulses as

signals in such processes. They narrate the difficulties of creating the moisture stress as a single signal-emitting process in such studies. It is not unlikely that the groups might look for other stresses such as defoliation of leaves in species such as cucurbits where probably the induction of signals could be much more sharp. In any case their study is one step further towards viewing plants not different from animals in their skills of communication and behaviour.

K. N. Ganeshiah

### Solvent effects

Most chemical reactions are carried out in solution, with solid state and gas phase reactions being practised by only a small population of chemists. While considerable attention is usually paid to the structures and stabilities of reactants and products, the subtleties of the solvent medium are usually conveniently ignored. At times clever manipulation of solvents can result in dramatic enhancements of reaction rates and product yields.

A notable example is the use of aqueous solutions to carry out Diels–Alder reactions. In water, salt effects can be striking. For example in the synthesis of the natural product cantharidin ultra high pressures (16–18 kbar) were found to be necessary. The use of lithium perchlorate in diethyl ether results in efficient synthesis at atmospheric pressure. Can such solvent effects be rationalized? Anil Kumar (page 289) reviews studies that suggest that 'internal pressure' of a salt–solvent system can serve as a measure of the electrostriction effect. Taken together with activation volumes for reactions, this quantity affords insights into the causes of the observed rate accelerations. The author extends these ideas to an apparently unrelated, but interesting problem – the thermal stabilities of DNA

duplexes. Spectacular changes in melting temperatures of double helical DNA occur in the presence of salts. The treatment of these solvent effects discussed in the article by Anil Kumar departs significantly from conventional wisdom. Rational 'solvent engineering' to control reaction rates, stereoselectivities and thermal stabilities may indeed be possible in the not-too-distant future.

P. Balaram

### Visibly spectacular pressure-induced transitions in copper metagermanate

Copper metagermanate ( $\text{CuGeO}_3$ ) is a very soft layer-type material like mica with a light blue colour and crystallizes in the orthorhombic space group  $\text{Pbmm}$  ( $\text{C}_{2h}^5$ ). The discovery of spin-Peierls transition below 14 K at ambient pressure by Hase, Terasaki and Uchinokura (*Phys. Rev. Lett.*, 1993, 70, 3651) has generated considerable interest in this system. It is of interest to note that  $\text{CuGeO}_3$  is the first inorganic system to exhibit the exotic spin-Peierls transition when cooled to low temperatures.

Recent high pressure investigations by Jayaraman and co-workers at the University of Hawaii (*Phys. Rev. Lett.*, 1995, 75, 2356; page 306, this issue) have shown that this system exhibits several pressure-induced phase transitions. The novel aspect of the high pressure behaviour is the spectacular colour changes associated with these phase transitions. These authors have carried out extensive high-pressure investigations on this system using Laser Raman Spectroscopy and optical microscopy as diagnostic tools in the conventional diamond anvil pressure apparatus. Three distinct high pressure phases are observed in the

7–9 GPa (70–90 kbar) region when the normal orthorhombic phase (phase I) of  $\text{CuGeO}_3$  is compressed. However, the type of phase obtained depends sensitively on the hydrostaticity of the pressure transmitter employed in the studies. Thus when a gas like helium or a liquid like 4:1 methanol/ethanol mixture is used as a pressure transmitter (which ensures a near hydrostatic pressure environment for the sample), the sample as observed by an optical microscope contracts abruptly by nearly 15% in the  $b$ -direction near 7 GPa. This new high pressure phase labelled phase II with a striking contraction in the  $b$ -axis direction has a pale green colour and a Raman spectrum different from that observed in phase I. The reverse phase transition occurs near 5.6 GPa on pressure release. It is to be emphasized that helium has been established to be a perfect hydrostatic medium up to 11.8 GPa at room temperature and methanol (which freezes just a little above 7 GPa) provides a similar environment for the sample.

The usage of argon which freezes at a relatively low pressure of 1.2 GPa at room temperature leads to a rather complex behaviour. The normal orthorhombic phase (phase I) on pressurization turns blue near 7.5 GPa (designated as phase III). Even as this transition is progressing, these authors deserved yet another phase transition (phase IV) accompanied by a colour change from blue to green. It may be remarked that each of these phases has a characteristic Raman spectrum. The green phase (phase IV) which is stable up to 15 GPa reverts to the blue phase (phase III) near 5 GPa on pressure release and further can be quenched to ambient pressure. The quenched phase transforms to the original orthorhombic phase only on heating to 600°C.

These visibly spectacular pressure-induced phase transitions with a

rich variety of phases in a non-hydrostatic pressure environment pose several interesting possibilities. The authors point out that the structure of copper metagermanate is closely related to the pyroxene family minerals but with an important difference. The backbone structures consisting of corner shared  $\text{GeO}_4$  tetrahedra in this system lie on the same side of the chain while they lie on either side in a pyroxene chain. The stability of this chain is rather low because of the strong repulsion of the highly charged  $\text{Ge}^{4+}$  ions. This consideration has prompted the authors to propose that this delicately balanced chain structure transforms to the stable pyroxene type of structure at high pressures. Although the structures of these high pressure phases have not yet been determined, the blue phase is speculated to have the pyroxene type of chain structure. Since the blue phase can be pressure quenched, structural work on these samples would confirm or otherwise this conjecture.

The observation of the pale green phase (phase II) in truly hydrostatic media is perhaps the most interesting aspect of this work. Raman spectra of this phase seem to confirm that the chain structure is preserved during the phase transition. The abrupt decrease in the  $b$ -axis accompanying the transition is possibly related to a rotation of the chain in the structure without breaking any bonds. The transition from phase I to phase II is observed only when the sample is unconstrained (true hydrostatic medium) while the transition proceeds in a complex way when the sample is constrained in the non-hydrostatic pressure medium. The authors speculate that the phase II is a ferroelectric-ferroelastic phase. Further work on this system should throw more light on these fascinating possibilities.

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