

rheumatism and a number of skin diseases. The bark of this tree finds use as an astringent in internal haemorrhage.

Besides the Indian laurel, there are 3 species of *Calophyllum* in south India, viz. *apetallum*, *polyanthum* and *austrorindicum*. The first and the third species are restricted to southwestern India and Sri Lanka. *C. polyanthum* is widespread in the Western Ghats, Sri Lanka and Southeast Asia. This species of magnificent tree (grows to over 30 m in height) was much exploited by the British for making ship masts and railway sleepers till about independence. This species continues to be one much sought-after by timber industries and as a result very few large trees are found in south

India. During a study of vegetation in the Uttara Kannada district (where the species is most common in south India), the estimated population of *C. polyanthum* was 200 plants per hectare. However, about 50% of these were juveniles, less than 2 m in height. Mature trees over 25 m in height were scarce.

All south Indian species of *Calophyllum* have been quite a bit exploited as timber and hence are slowly declining. Young trees are sought-after by the local people as a material for poles and fencing, thereby further reducing the chances of continued survival of the species. Although the average time taken for an active principle of plant origin to hit the market as a commercially available drug is 12

years, being much shorter than the generation time of most trees, this will soon lead to an unsustainable harvest of mature trees once any species is found useful. Value addition to species of *Calophyllum* by way of finding use in the anti-AIDS industry can prove to be a threat to the continued existence of the genus unless immediate protective measures are taken.

R. J. RANJIT DANIELS
VISHWANATH PATIL

M. S. Swaminathan Research Foundation
3rd Cross Street
Taramani Institutional Area
Madras 600 113, India

Comments on 'Fullerenes: C₆₀ from camphor – A novel approach'

(*Curr. Sci.*, 1994, 67, 602)

Recently, Mukhopadhyay *et al.*^{1,2} have reported that fullerenes, in particular, C₆₀, are found in the soot formed on burning camphor in air. As evidence, they present powder X-ray diffraction data (XRD), fast atom bombardment mass spectra (FABMS) and scanning electron micrographs of what they believe to be samples of fullerenes.

The extreme reluctance of the fullerenes to form in sooting flames is well documented. As such, the results of Mukhopadhyay *et al.*^{1,2} come as a surprise. Taken at face value, references 1 and 2 are an interesting addition to what we know about the mechanisms for the formation of fullerenes. The claim that this technique could replace the standard arc evaporation procedure is tenuous, since the reported fullerene yields are low.

The main problem is that the experimental data presented in references 1 and 2 are fraught with several inconsistencies. The FABMS data presented in Figure 1 of reference 2 is unconvincing. The isotope ratios are not as expected and the parent C₇₀ peaks, which are normally

found in the mass spectra of soot, are not seen.

The SEM pictures (see Figure 2 of reference 2) are unambiguously misinterpreted. Figure 2 *d* shows a spherical object about 10 μm across (as seen from the scale bar in the photograph). This object is identified as a single C₆₀ molecule. The diameter of the C₆₀ molecule is about 7 Å, and the van der Waals diameter (measured by STM, for example) is 10 Å. It is indeed strange that a sphere 10⁴ times larger than C₆₀ has been identified with the molecule.

It is difficult to conceive these spheres as being comprised of many C₆₀ molecules, since packings of spherical objects invariably result in cubic or related morphologies. Likewise, the 'tubules' shown in reference 2, Figure 3, are entirely unlike the SEM pictures of any reported tubule, carbon or otherwise. The authors claim to see some sort of layering (not obvious to the reader) in these materials, which they ascribe to graphitic sheets. The scale bar again contradicts any such suggestion. In any case, graphitic sheets

are usually separated by about 3.5 Å – beyond the resolution of any extant SEM. The XRD pattern in reference 1 does not resemble the pattern expected for C₆₀. It is difficult to understand how the authors concluded, based on the evidence presented, that their sample was C₆₀.

To conclude, on the face of things it is difficult to accept that Mukhopadhyay *et al.*^{1,2} have made C₆₀ from sooting camphor. Their interpretation of the experimental data is largely incorrect and their papers suffer from the grossest inaccuracies.

- 1 Mukhopadhyay, K., Murali Krishna, K. and Sharon, M., *Phys Rev Lett.*, 1994, 72, 3182.
- 2 Mukhopadhyay, K., Murali Krishna, K. and Sharon, M., *Curr Sci*, 1994, 67, 602.

RAM SESHADRI

Solid State and Structural Chemistry Unit
Indian Institute of Science
Bangalore 560 012, India

Mukhopadhyay et al.'s reply:

To Ram Seshadri's first statement, 'the extreme reluctance of the fullerenes to form in sooting flames is well documented',

we would rather say that, 'it is very much known that fullerenes are present in sooting flames'¹⁻⁸. The recent report

by Heymann *et al.*¹ also confirms the presence of fullerenes at detectable levels in naturally occurring fires and even the

soot from a common decorative candle contained fullerenes at a concentration of 1–10 ppm.

Pyrolysis experiments of Taylor *et al.*⁹ already showed a non-arcng route for the production of fullerenes from naphthalene. Our results^{10,11} are encouraging enough to say that vacuum deposition method could replace the chromatographic technique and we did not see any exaggeration in our opinion. Systematic experiments on quantitative and qualitative studies are in progress in the light of the yield, purity and production cost.

We have reported the FAB mass spectrum as recorded^{10,11}. Showing all the peaks is a typical characteristic property of the FAB mass spectrum. We are interested in confirming the presence of C₆₀ in the deposited film, and the peak at 720 amu along with other supporting techniques clearly confirms the presence of C₆₀. The peak at 841 amu shows the presence of traces of C₇₀, which we have already mentioned in our paper saying that 'C₆₀ and other members of fullerene family...'. The shift in mass could be due to presence of impurities in solvent or isotopic carbon.

About our SEM photographs, there is nothing wrong with them. Seshadri has completely misinterpreted our SEM pictures. We have already reported that those spherical shapes are due to C₆₀ aggregates. We have not used the word 'C₆₀ molecule' in our discussion in any of our papers^{10,11}, as commented by Seshadri. It is known that C₆₀ does form spherical clusters in the condensed phase^{5,12–15}. They also reported that these large clusters (10–100 μm) are not single crystals but randomly packed by very small granules^{14,15}. It is also known that C₆₀ exists in various

shapes like stars, rods, etc.^{16,17} and if we consider the structure of C₆₀ as fcc or hcp, it is obvious that we cannot form these shapes by using the stars, rods, etc. Hence spherical-shaped clusters does not mean that one can build a unit cell which resembles cubic shape, because, once again, they are not single C₆₀ molecules.

The tubules are not produced by the usual graphitic source. Hence, they cannot resemble graphitic tubules. We have said layered structure, which does not mean that they are graphitic networks and their separation should be 3.5 Å, as mentioned by Seshadri. We have proposed a different formation mechanism of these tubules and have recently communicated for publication¹⁸.

His comment on our XRD result is vague and we have nothing to say in this respect as we have already discussed in detail in our earlier communication¹⁰, where we have compared our pattern with all other reported X-ray patterns and that itself speaks about its originality.

All in all, we conclude that the comments made by Seshadri are baseless and are not merited; rather, they are too biased. Also, his comments reflect the lack of clarity in this field and poor overview on current literature.

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K. MUKHOPADHYAY
K. M. KRISHNA
M. SHARON

Department of Chemistry
Indian Institute of Technology
Bombay 400 076, India

Comments on 'Ubiquitous phase grating' (*Curr. Sci.*, 1994, 67, 978)

We received a letter from S. Chandrasekhar (Director, Centre for Liquid Crystal Research) pointing out that an earlier work on this subject has not been cited in the Research News 'The ubiquitous phase grating' by K. A. Suresh (*Curr. Sci.*, 1994, 67, 978). Chandrasekhar's letter also contains some interesting historical information as to how the phase

grating concept was first introduced into the field of liquid crystal research. This is reproduced below:

'In 1967–1968, K. N. Srinivasa Rao and I developed a 'dynamical theory' of light propagation along the optic axis of a cholesteric liquid crystal (S. C. and K. N. S., *Acta Crystallogr.*,

1968, A24, 445) I then considered the case of oblique incidence but it did not take long for me to discover that an analytical solution was well beyond our mathematical capabilities. Next I examined the case of propagation normal to the optic axis and realized at once that this geometry gives rise to the famous corrugated wavefront of