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Invited

The New Round World of Carbon Chemistry and Materials Science

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The Fullerenes were discovered in 1985 during experiments which simulated the chemistry occurring in the shells of Red Giant Carbon Stars. The Family has now come down to Earth bringing us a new *"Periodic Table"* of novel cluster pseudoelements.

1 INTRODUCTION

C_{60} Buckminsterfullerene (Fig 1) has become the starting

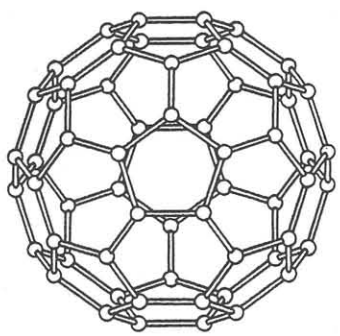

Fig 1 C_{60} Buckminsterfullerene

material for a whole range of new compounds and the chemistry, physics and materials science of thes elegant molecule are now the focus of attention of numerous goups. In addition there are several larger fullerenes such as C_{70}, C_{76} and C_{84} etc which can be isolated. Each fullerene exhibits its own intrinsic *pseudo-valency* and pattern of reactivity and they promise to be precursors of exciting new 21st Century Materials. Indeed it appears that smaller fullerenes that are unstable in the pure form may be stabilised by derivitisation such as in the case of C_{28} (Fig 2).

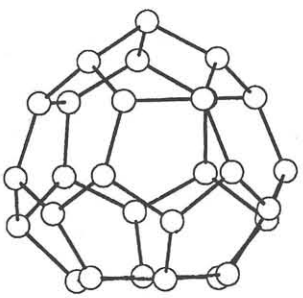

Fig2 C_{28}

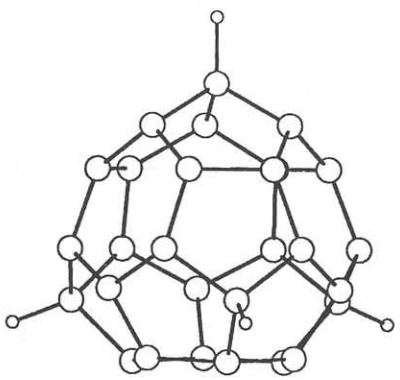

Fig 3 $C_{28}H_4$

C_{28} which was predicted to be semi-satbel in 1987 and was also predicted to form stable "tetravalent" analogues such $C_{28}H_4$.

The recent detection $U@C_{28}$ appears to confirm this suggestion.

The first suggestion that C_{60} might be stable is to be found in the studies of Osawa and Yoshida in 1970. The discovery of the fullerenes in particular C_{60} has its origins in research at Sussex on the chemistry and spectroscopy of carbon chains with David Walton which led to their discovery (with Takeshi Oka and Canadian astronomers) in space by Radioastronomy. This research programme evolved into a collaborative study of stellar-like plasmas at Rice University (where Richard Smalley had made a major breakthrough in cluster science). It was this joint Sussex-Rice carbon cluster programme which serend-ipitously uncovered the existence of C_{60}. Fullerenes were extracted and characterised by a Heidelberg/Tucson group and independently at Sussex in 1990. Since then, fullerene science has exploded as chemistry is producing advanced materials with semi- and super-conducting, ferro-electric and opto-electronic properties. *The advance is an archetypal example of the unique ability of fundamental research to make the key advances and a timely reminder of the severe limitations of strategic and applied research strategies*. The Sussex Program is now probing Fullerene Chemistry, Physics, Materials Science and Astrophysics:

2 CHEMISTRY

The Sussex Chemistry program has already been very successful, producing some of the first fully characterised analogues such as the halogenated materials: $C_{60}Br_n$ (n=6,8,24), Fig 4 and 5 and $C_{60}Cl_6$ as well as the ferrocene complexe $C_{60}(Cp)_2Fe$ and a benzene solvate etc. Hydrogenated analogues and cycloaddition derivatives have also been prepared. Physical studies are being carried which have revealed fascinating information on the intramolecular dynamics and detailed

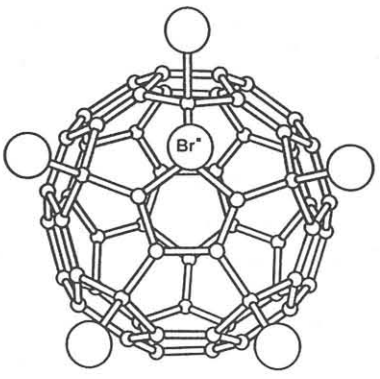

Fig 4 $C_{60}Br_6$

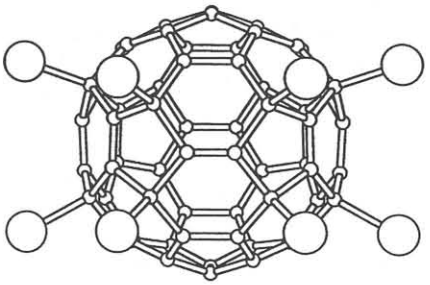

Fig 5 $C_{60}Br_8$

information on how the motion is affected by intermolecular inter-actions.

3 NANOPARTICLES AND NANOFIBERS

Nanoparticle and Nanofiber studies indicate that there is an intimate relationship between carbon chains, fullerenes and graphite particles with fascinating implications for carbon fibers. Studies of onion-like nested giant fullerenes Fig 6 and nanofibers are revealing unexpected structures. It is now clear that pyrolytic nanofibers can be produced which have highly exciting properties. An interesting carbon insertion mechanism has been proposed, Fig 7 which explains the helical structure of carbon nanofibers.

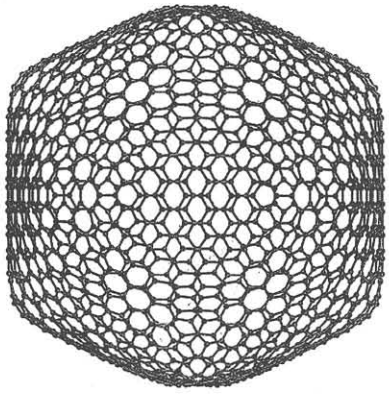

Fig 6 Giant Fullerene C_{1500}

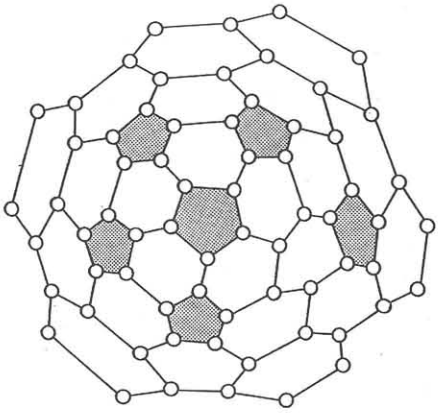

Fig 7 Insertion Mechanism for Nanotube

4 CLUSTER BEAM STUDIES

Supersonic Jet Cluster Beam studies show that sub-C_{60} fullerenes: C_{24}, C_{28}, C_{32} etc.. form during laser vaporization so confirming earlier Sussex work which predicted that fullerene-28 might form stable derivatives. Some evidence for the smallest fullerene, C_{20}, has also been obtained.

5 ASTROPHYSICAL STUDIES

Astrophysical experiments led to the discovery of C_{60} on earth and present studies suggest that analogues may be present in space. A study of the spectra produced in the laboratory during fullerene formation has interesting similarities with emission specta from some carbon rich planetary nebulae.

ACKNOWLEDGEMENTS

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