College of Science
Department of Physics

M.Sc. Lectures
Nano-physics

New Carbon Structures

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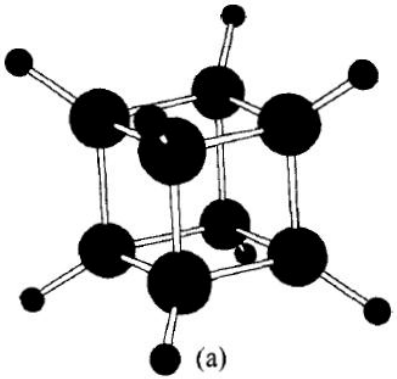
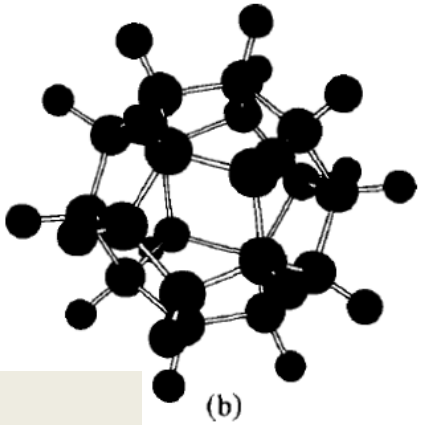
In 1964, Eton synthesized a square carbon molecule, **C_8H_8** which called ***cubane***.

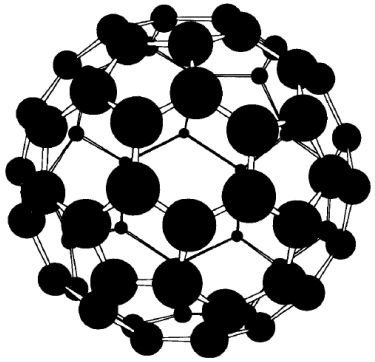


In 1983 Paquette synthesized a **$C_{20}H_{20}$** molecule having a dodecahedron shape,



formed by joining carbon pentagons, and having **C-C** bond angles ranging from 108" to 110".
The synthesis of these hydrocarbon molecules with carbon bond angles different from the standard hybridization values has important implications وهي من الاثار المهمة لتكوين التراكيب النانوية for the formation of carbon nanostructures, which would also require different bonding angles.

Discovery of C_{60}



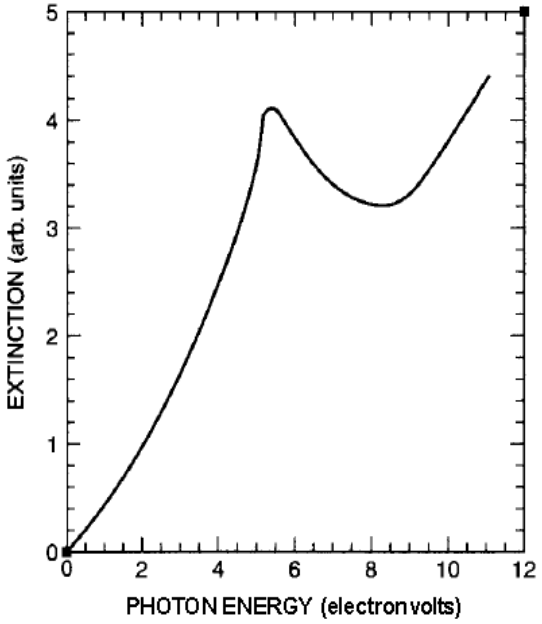
a soccer ball-like molecule containing 60 carbon atoms was a somewhat fortuitous result of research on the nature of matter in outer space involving studies of light transmission through interstellar dust.الغبار بين النجوم

When light from a distant star passes through the cosmos and arrives on Earth, the intensity of the light is reduced. This is referred to as **optical extinction**. الانقراض البصري
It occurs because of the absorption and scattering of the light from the interstellar dust.

Huffman & Kratschmer

tudy this extinction by measuring the intensity of light coming from the stars at different wavelengths, that is, with different colors.

it was noted that there was an increased extinction or absorption in the UV region at a wavelength of 220nm (5.6eV), which was attributed to light scattered from small particles of graphite that were believed to be present in the regions between the stars.



Others were not convinced ليسوا مقتنعينof this explanation, and decided to study the question further.
Their approach was to simulate the graphite dust in the laboratory and investigate light transmission through it. They made smoke like particles by striking an arc between two graphite electrodes in a He gas environment, and then condensing the smoke on quartz glass plates. IR & Raman spectroscopy were used to investigate the condensed graphite. They also observed four additional IR absorption bands that did not originate from graphite, and they found this very puzzling.

Huffman and Kratschmer observed the four bands in the condensed “graphite” material corresponded closely to those predicted for a C_{60} molecule.

The scientists studied the IR absorption spectrum using carbon arcs made of the 1% abundant ^{13}C isotope, and compared it to their original spectrum which arose from the usual ^{12}C isotope. It was well known that this change in isotope would shift the IR spectrum by the square root of the ratio of the masses, which in this case is $\left(\frac{13}{12}\right)^{1/2} = 1.041$ corresponding to a shift of 4.1%. This is exactly what was observed when the experiment was performed. The two scientists now had firm evidence for the existence of an intriguing new molecule consisting of 60 carbon atoms bonded in the shape of a sphere.

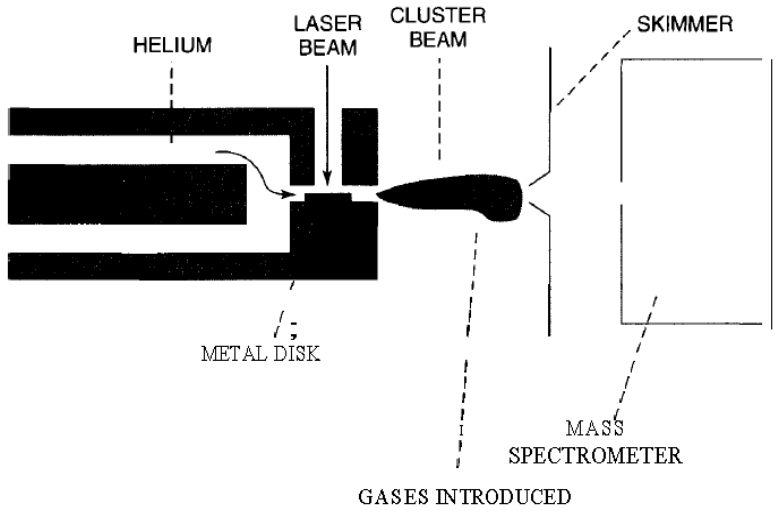
Kroto & Smalley Experimente

In this experiment a graphite disk is heated by a high-intensity laser beam that produces a hot vapor of carbon. A burst of He gas then sweeps the vapor out through an opening where the beam expands.

The expansion cools the atoms and they condense into clusters.

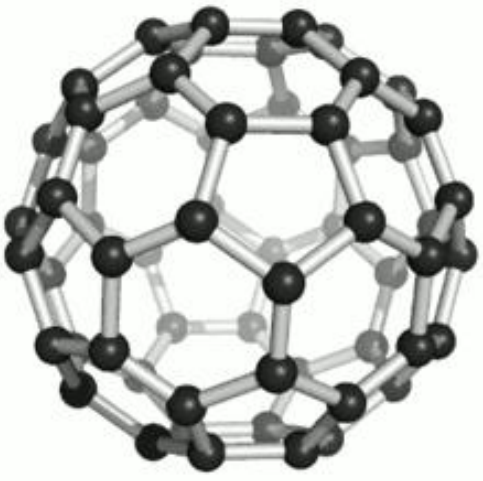
This cooled cluster beam is then narrowed by a skimmer and fed into a mass spectrometer, which is a device designed to measure the mass of molecules in the clusters.

When the experiment was done using a graphite disk, the mass spectrometer yielded an unexpected result. A mass number of 720 that would consist of 60 carbon atoms, each of mass 12, was observed.



Structure of C_{60} and Its Crystal

The C_{60} molecule has been named fullerene after the architect and inventor R. Buckminister Fuller, who designed the geodesic dome that resembles the structure of C_{60}.
Originally the molecule was called buckminsterjiullerene, but this name is a bit unwieldy, so it has been shortened to **fullerene**.
It has **12 pentagonal** (5 sided)
and **20 hexagonal** (6sided) faces
symmetrically arrayed to form a molecular ball.



In the lattice each C_{60} molecule is separated
from its nearest neighbor by 1nm
(the distance between their centers is 1nm),
and they are held together
by weak forces called **Van der Waals forces**

>Because C_{60} is soluble in benzene, single crystals of it can be grown by slow evaporation from benzene solutions.

Larger and Smaller Fullerenes

Larger fullerenes such as C_{70}, C_{76}, C_{80} and C_{84} have also been found.
C_{20} carbon molecule has been synthesized by gas-phase dissociation of $C_{20}HBr_{13}$.

$C_{36}H_4$, has also been made by pulsed laser ablation of graphite.
Solid phase of C_{22} has been identified in which the lattice consists of C_{20} molecules bonded together by an intermediate carbon atom.
One interesting aspect of the existence of these smaller fullerenes is the prediction that they could be superconductors at high temperatures when appropriately doped.