FUNDACIÓN RAMÓN ARECES

De Feynman a Kroto y al Grafeno.
Breve Introducción al origen de lo nano

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RACEFyN

UCM

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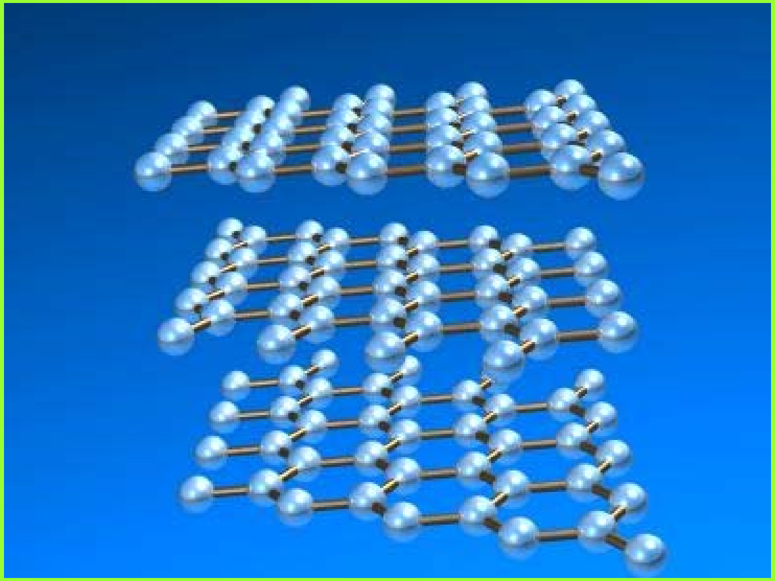
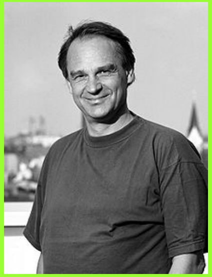
12-XI-2013

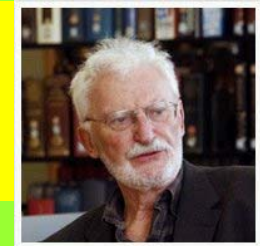
"In Science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs."
Sir Francis Darwin.

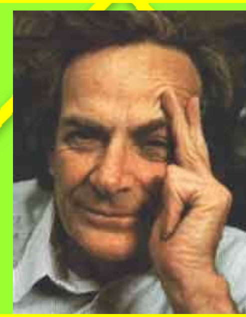


ASTROQUÍMICA, NANOCIENCIA & NANOTECNOLOGÍA y GRAFENO



Binning & Rohrer
SCANNING TUNNELING MICROSCOPE
1981

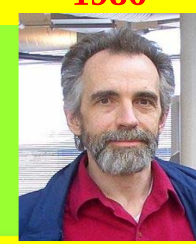


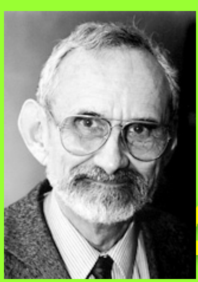


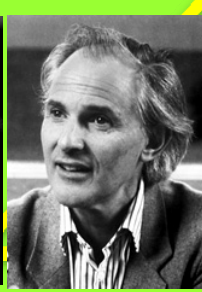
FEYNMAN 1959

TANIGUCHI
NANOTECHNOLOGY 1974

Drexler: ENGINES OF CREATION
1986





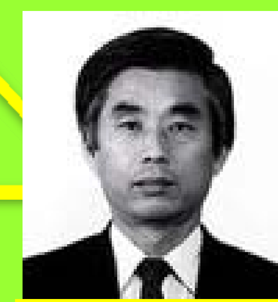


Kroto, Smalley & Curl
FULLERENES
1986

GRAFENO
2004

Andre
Geim

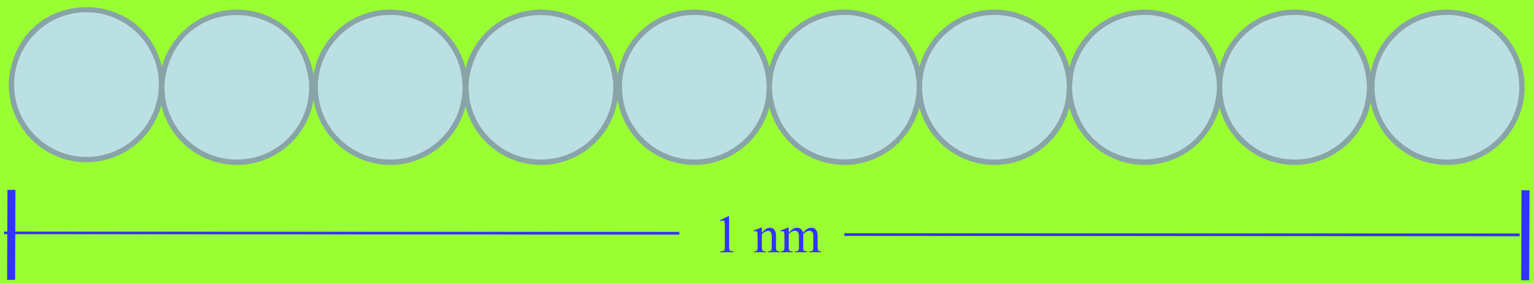
Konstantin
Novoselov

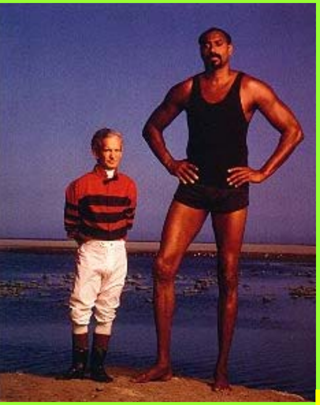


Ijima 1991
NANOTUBE
S

Nanotecnología

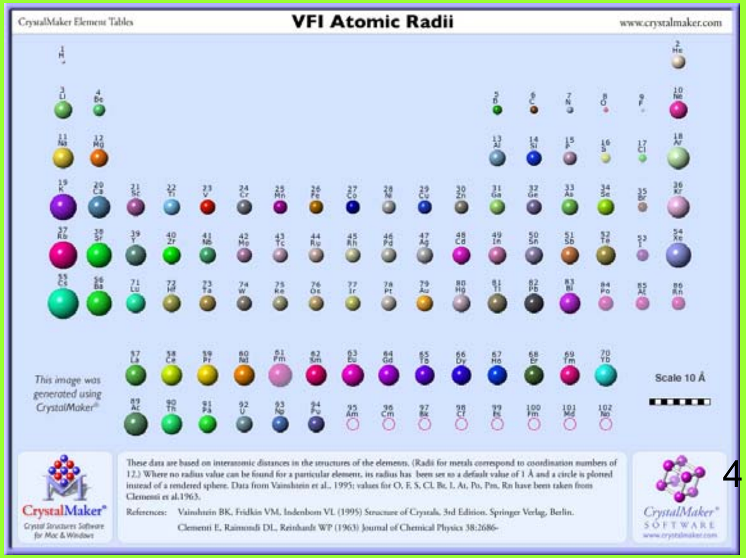
La palabra *nanotecnología* proviene del prefijo griego *nano* (enano).
En el lenguaje actual un nanometro es una millardésima de metro ;
aproximadamete el tamaño de diez átomos colocados en fila.





Juan Carreño de MIRANDA
Retrato del enano Michol

Velázquez: *El bufón don Sebastián de Morra*



Prefix	Symbol	1000^{m}	10^{n}	Decimal	Short scale	Long scale	Since[n 1]
yotta	Y	1000^{8}	10^{24}	1000000000000000000000000	Septillion	CUADRILLÓN	1991
zetta	Z	1000^{7}	10^{21}	1000000000000000000000	Sextillion	“TRILLARDO”	1991
exa	E	1000^{6}	10^{18}	1000000000000000000	Quintillion	TRILLÓN	1975
peta	P	1000^{5}	10^{15}	1000000000000000	Quadrillion	"BILLARDO”	1975
tera	T	1000^{4}	10^{12}	1000000000000	Trillion	BILLÓN	1960
giga	G	1000^{3}	10^{9}	1000000000	Billion	MILLARDO	1960
mega	M	1000^{2}	10^{6}	1000000	MILLÓN		1960
kilo	k	1000^{1}	10^{3}	1000	MIL		1795
hecto	h	$1000^{2/3}$	10^{2}	100	CIEN		1795
deca	da	$1000^{1/3}$	10^{1}	10	DIEZ		1795
		1000^{0}	10^{0}	1 METER	UNO		–

PREFIJOS METRICOS

deci	d	$1000^{-1/3}$	10^{-1}	0.1	DÉCIMO		1795
centi	c	$1000^{-2/3}$	10^{-2}	0.01	CENTÉSIMO		1795
milli	m	1000^{-1}	10^{-3}	0.001	MILÉSIMO		1795
micro	µ	1000^{-2}	10^{-6}	0.000001	MILLONÉSIMO		1960
nano	n	1000^{-3}	10^{-9}	0.000000001	Billionth	MILLARDÉSIMA	1960
pico	p	1000^{-4}	10^{-12}	0.000000000001	Trillionth	BILLONÉSIMA	1960
femto	f	1000^{-5}	10^{-15}	0.000000000000001	Quadrillionth	MILBILLONÉSIMA	1964
atto	a	1000^{-6}	10^{-18}	0.000000000000000001	Quintillionth	TRILLÓN	1964
zepto	z	1000^{-7}	10^{-21}	0.000000000000000000001	Sextillionth	TRILLARDÉSIMA	1991
yocto	y	1000^{-8}	10^{-24}	0.000000000000000000000001	Septillionth	CUADRILLONÉSIMA	1991

LOS GOBIERNOS INVIERTEN MILLONES
y cada año se publican miles de artículos sobre ello, pero
¿Qué es exactamente la NANOTECNOLOGÍA?

Se define la NANOCIENCIA como el estudio de los fenómenos y la manipulación de materiales a escalas atómica, molecular y macromolecuar, donde las propiedades son significativamente diferentes de las habituales a mayor escala

Se define la NANOTECNOLOGÍA como el diseño, caracterización, producción y aplicación de estructuras, dispositivos y sistemas por la manipulación controlada en forma y tamaño a la escala nanométrica (atómica, molecular y macromolecular) dando lugar a dispositivos y sistemas que presentan, al menos una propiedad nueva o una mejora.

El requerimiento más importante de le definición de nanotecnología es que la nano-estructura en cuestión posee propedades especiales debidas exclusivamente a sus proporciones nanométricas.

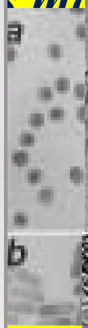
Nature Nanotechnology **1, 8 - 10 (2006); doi:10.1038/nnano.2006.77**

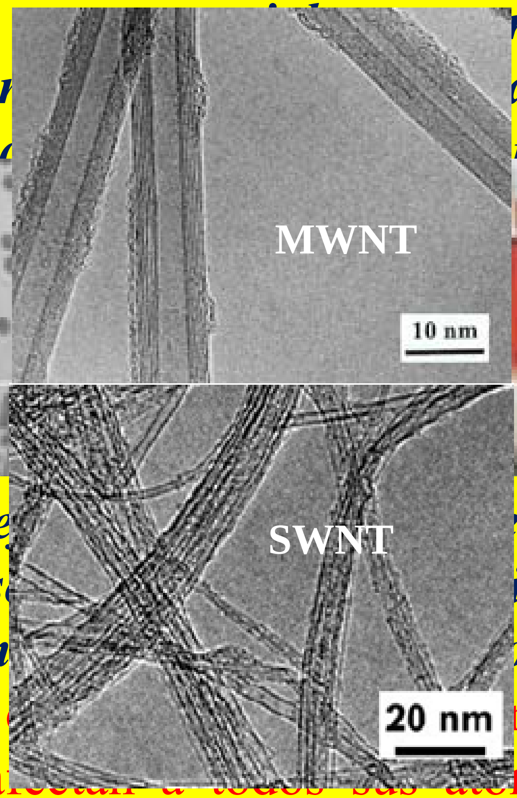
La influencia del tamaño

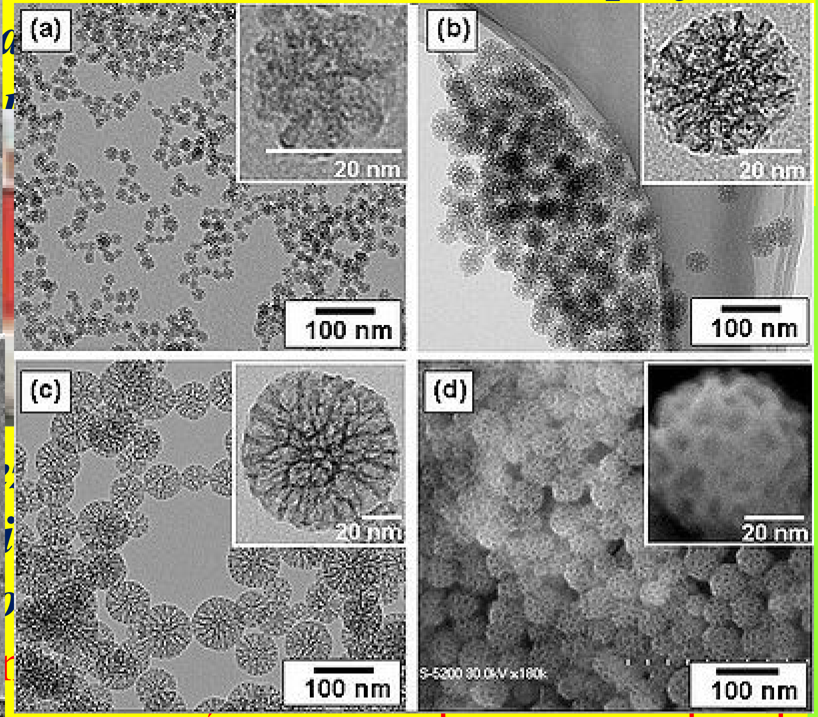
Las propiedades de los nanomateriales pueden ser diferentes por dos razones principales

En primer lugar, Los … ntan una elevada área superficial

co…







…os e…

es…

tam…

Como las propiedades … fuerzas cuánticas que a… …mos, según se va disminuyendo el tamaño, se alcanza un punto en el que ya no sirve el promedio

Los Materiales pueden ser nanométricos en :

una dimension (por ejemplo, recubrimientos muy delgados),

dos dimensiones (por ejemplo, nanohilos y nanotubos)

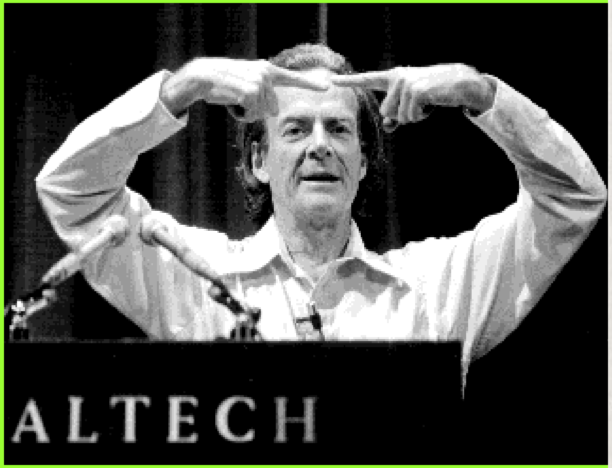
las tres dimensiones (por ejemplo, nanopartículas).

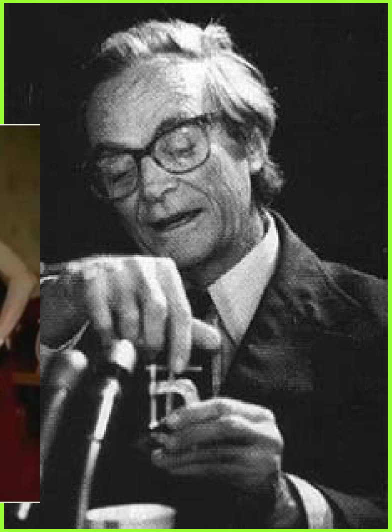
EL VISIONARIO / THE FORESIGHTER

ID badge photo: Los Alamos.

Richard Feynman (1918-1988) fué un físico teórico de CALTECH. Obtuvo el Premiuo Nóbel por sus trabajos en Electrodinámica Cuántica También trabajó en el proyecto Manhatan. Se le conoce además por ser un magnífico profesor y conferenciante, con un tremendo sentido del humor y la infrecuente cualidad de explicar con facilidad cosas muy complejas

Cracking safes!





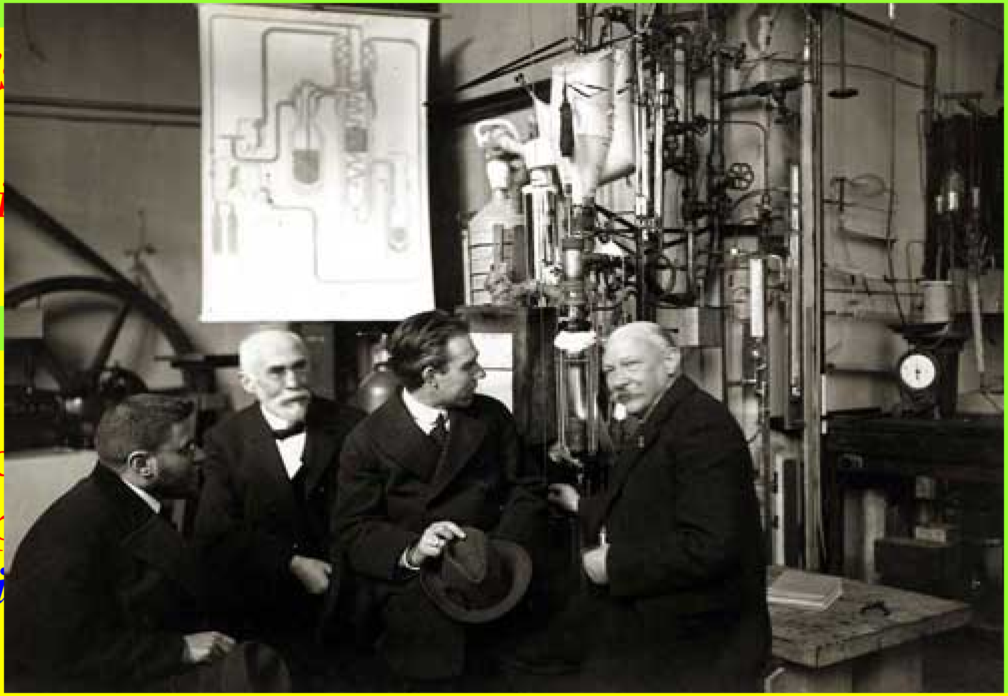
En una charla dada en 1959: “There's Plenty of Room at the Bottom” “Al fondo hay sitio” Feynman ***predijo***: la nanotecnología, la compresión de datos y las microcomputadoras.

[Feynman Lecture in nanotechnology: 25 years later (25-X-1984)](http://www.nanorev.in/nanorev---nanotechnology.html)
http://www.nanorev.in/nanorev---nanotechnology.html

Feynman Idont like honours:Nobel Prize, Academies¡¡¡
http://www.youtube.com/watch?v=f61KMw5zVhg

There'

An Invitati



"Imagino que
menudo a pers
el camp
Superconducti

Ehrenfest,_Lorentz,_Bohr,Kamerlingh_Onnes

"Esa persona es ***un líder*** y tiene por un cierto tiempo el monopolio de una aventura científica"

M.Á. Alario & J.L. Vicent
Superconductividad. Eudema, Madrid 1991

"O Percy Bridgman (PN Física 1946) , que diseñó la m ... er Altas Presiones abriendo otro campo nuevo y llev

Laboratorio Complutense de Altas Presiones
http://www.ucm.es/info/labcoap/index.htm

“Me gustaría describir un campo en el que se ha hecho muy poco pero en el que, en principio, se pueden hacer una enorme cantidad de cosas”

“Más aun, un punto muy importante es que tendrá un número enorme de aplicacciones técnicas.

“De lo que voy a hablar es de la manipulación y el control de las cosas a pequeña escala”.

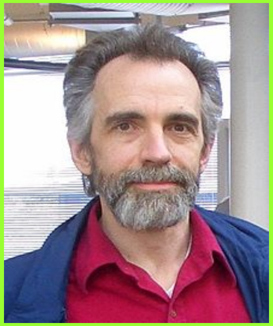
“Los principios de la Física no se oponen, en ningun caso, a la posibilidad de manipular las cosas átomo a átomo”

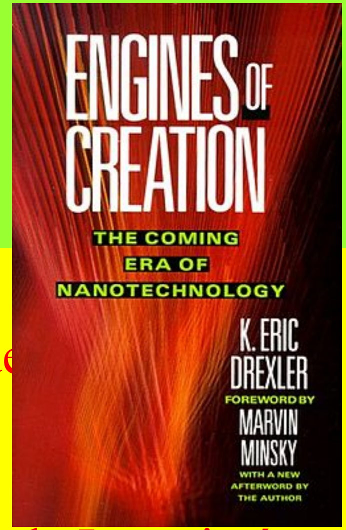
“¿Porqué no podríamos escribir los 24 volúmenes de la Enciclopedia Británica en la cabeza de un alfiler?”

Norio Taniguchi of Tokyo Science University definió por vez primera la ***nanotechnología*** en 1974:

La nano-Tecnología consiste esencialmente en el proceso de separar, consolidar y deformar materiales átomo a átomo o molécula a molécula’

(N. Taniguchi, "On the Basic Concept of 'Nano-Technology'," Proc. Intl. Conf. Prod. Eng. Tokyo, Part II, Japan Society of Precision Engineering, 1974.)
(cita completa: http://nanodot.org/articles/01/06/04/1217257.shtml).





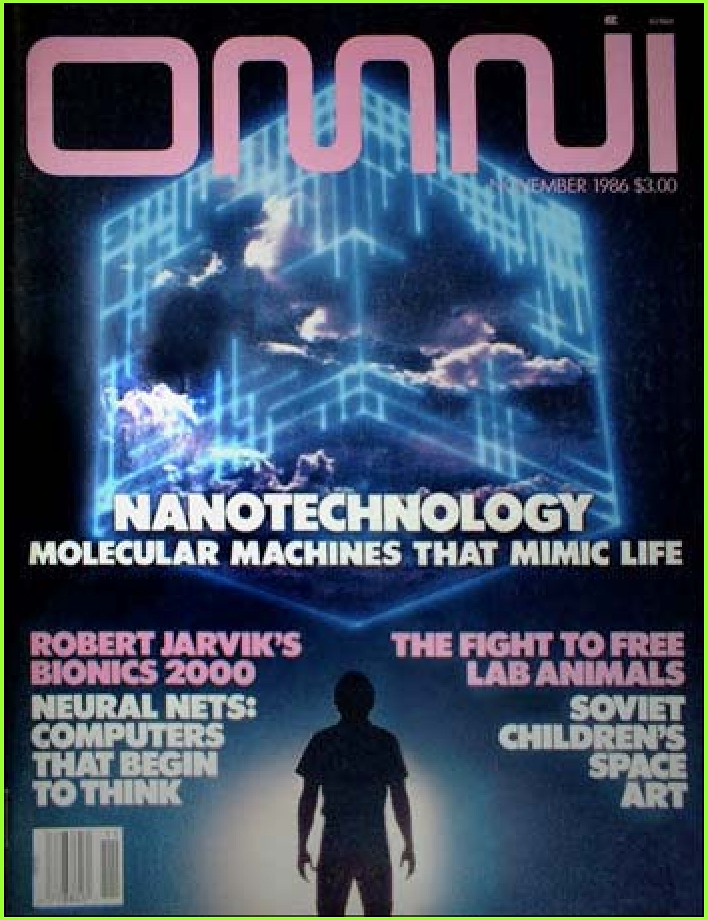
Pero la *nanotecnología* tal y como la conocemos hoy, esto es, NANOTECNOLOGÍA, se le ocurrió a a un discípulo temporal de
***Eric Drexler*.**

Drexler presentó sus visión de la nanotecnología en un artículo de Ingeniería Molecular publicado en 1981 y desarrolló dichas ideas en plan divulgativo en el libro ***Engines of Creation*,** publicado por Doubleday en ***1985*** (que puede consultarse en línea en el Foresite Institute).

Drexler obtuvo un Doctorado único "en el campo de la nanotecnología" en el MIT en 1991, bajo la dirección de Marvin Minsky, el célebre pionero en Inteligencia Artificial

El año siguiente piblicó un libro más técnico: Nanosystems: Molecular Machinery, Manufacturing and Computation, que describe los principios y mecanismos de la Nanotecnología Molecular

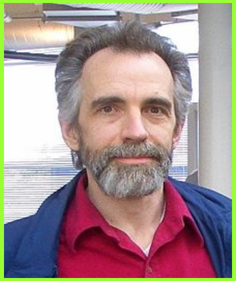
NANOTECHNOLOGY MOLECULAR MACHINES THAT MIMIC LIFE Fred Hapgood



La difusión generalizada del término nanotecnología tuvo lugar, sin embargo, cuando se publicó, en* Noviembre de 1986, *un artículo en la revista OMNI, que para entonces tenía más de ¡un millón de lectores¡

A partir de ahí el término y el concepto pasaron al común.

Norio Taniguchi,basándose en la miniaturización de las tecnologías existentes llegó a la nanotecnología, en ***1974***, desde el punto de vista ***"de arriba a abajo"*** (***'top-down'),*** el punto de vista de un ingeniero de precisión



K. Eric Drexler , por su parte, introdujo la nanotechnología en ***1986***, utilizando un modelo "de abajo a arriba" (***'bottom-up')*** el punto de vista de físicos y químicos

¿Cuál fue la influencia real de : “Al fondo hay sitio”?

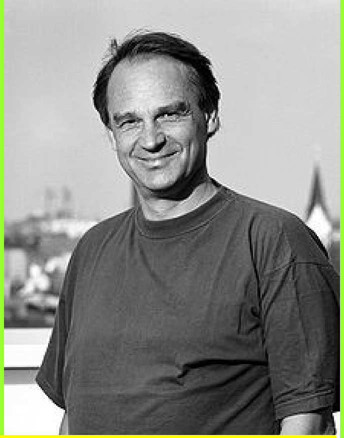
Años después de la muerte de Feynman (1988), los investigadores que analizaron el desarrollo histórico de la Nanotecnología, basándose en escritos y entrevistas con los científicos que han trabajado en el campo de ***nanotecnología*** en los años 80 y 90 han concluido que ***la influencia de la charla para catalizar la nanotecnología fue muy limitada***

En particular, Chris Toumey, un antropólogo cultural de la Universidad de Carolina del Sur ha reconstruido la historia de la publicación y reedición de la charla de Feynman y de las citas que ha recibido *“Al fondo hay sitio”* en la literatura científica.

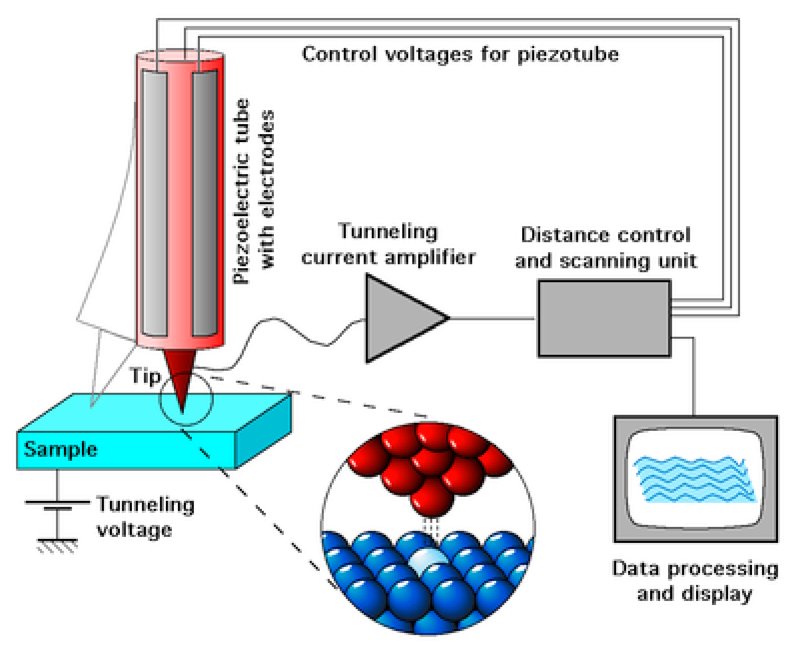
Tal y como recoge en un artículo de 2008 “Leyendo a Feynman en Nanotecnología” encontró que la versión publicada de la charla ha tenido una influencia mínima en los veinte años siguientes a su publicación de acuerdo con las citas que ha recibido en la literatura científica.

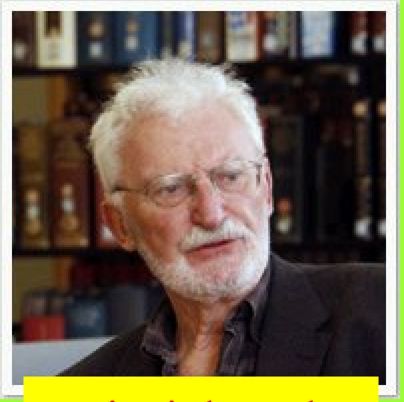
…y tampoco tuvo mucha influencia en la década que siguió a la invención y el desarrollo de la ***microscopía túnel*** en 1981.

Microscopía de Efecto Túnel/ Scanning Tunneling Microscope IBM (1981)

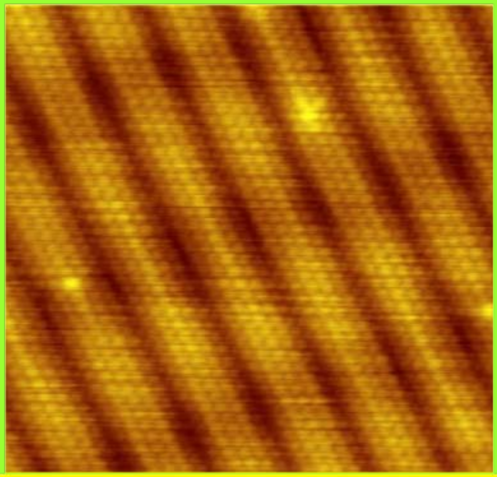


Gerd Binning

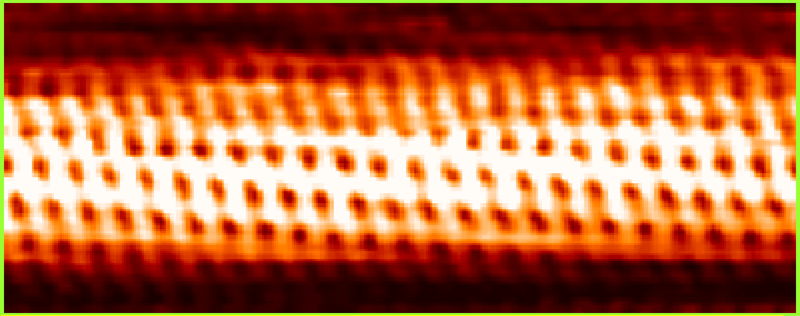




Heinrich Rohrer

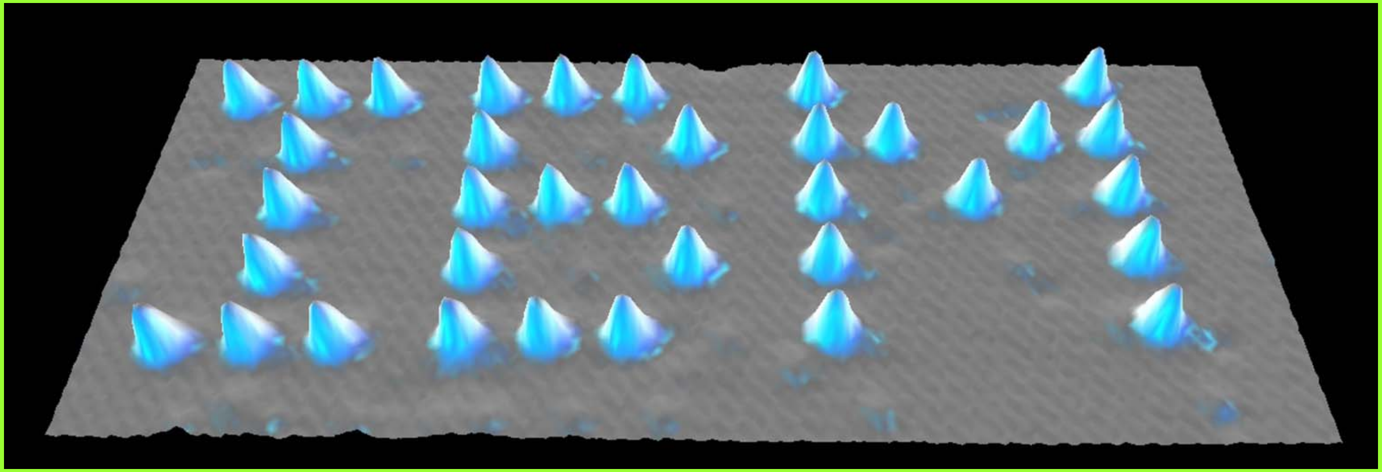


Atomic_resolution_Au100



An STM image of a single-walled carbon nanotube

El Microscopio de Fuerza Atómica, no solo permite estudiar la superficie de los sólidos. Mas importante aun, permite manipular los átomos uno a uno



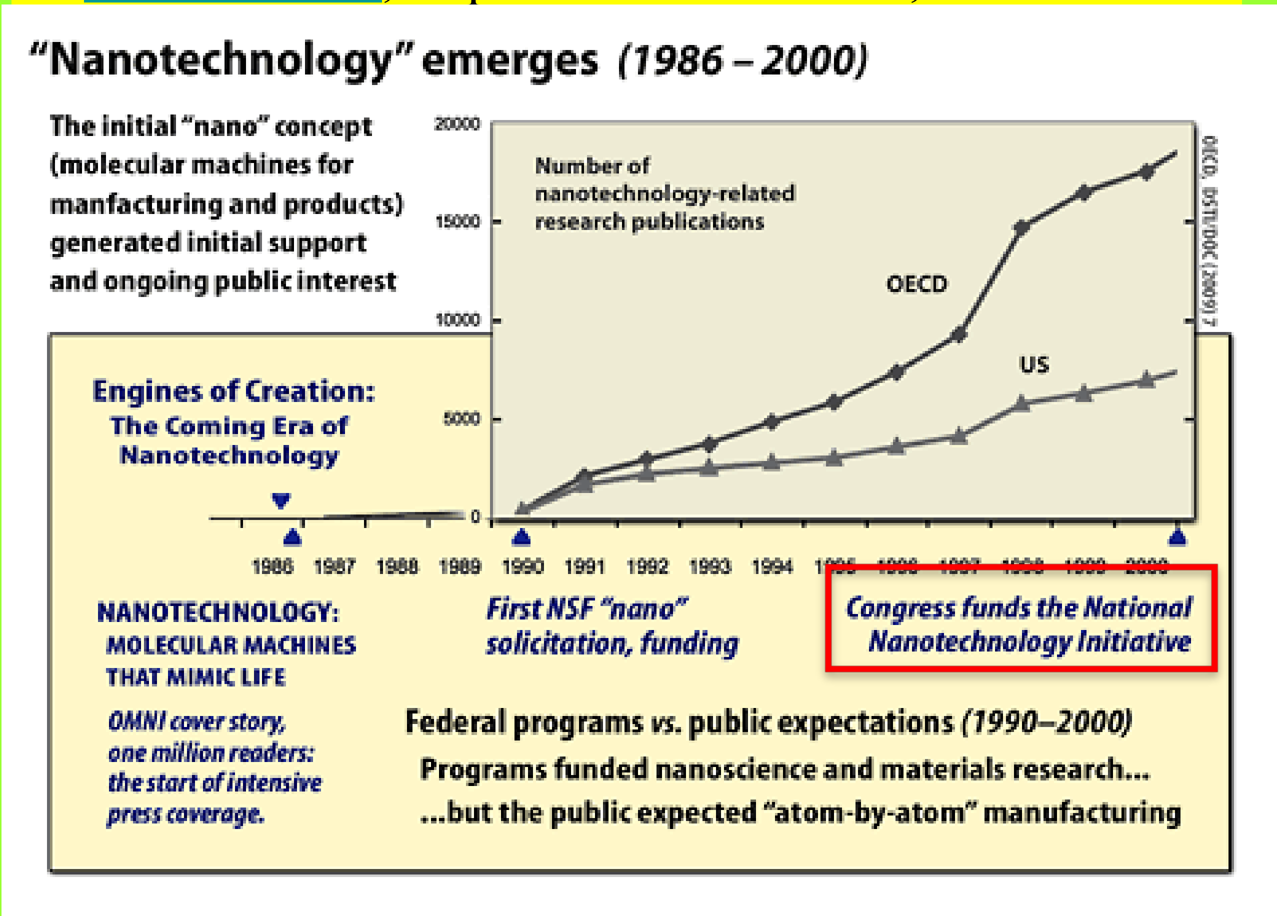
El primer ejemplo de este tipo de proceso se desarrolló en los laboratorios de IBM el 11 de November de 1989, cuando Don Eigler y su equipo consiguieron, literalmente, mover 35 átomos de Xenon en un sustrato de cobre para formar el logo de la compañía. (*Nature* , Abril 1990)

Don Eigler en 2007 con sus dos perros ***Neon & Argon***

PUBLICACIONES EN NANOTECNOLOGÍA

***Nanotechnology* aparece en 1989**

1. Nature Nanotechnology, Impact Factor = **20.571**, Publisher: Nature Publishing Group
2. Nano Letters, Impact Factor = **10.371**, Publisher:



Informa Healthcare

10. Plasmonics, Impact Factor = **3.488**, Publisher: Springer

A pesar de que el análisis bibliográfico de Toumey demostró que "Al fondo hay sitio" no influyó mucho en el desarrollo de la *nanotecnología*, es evidente que su fama y elevada estatura científica ayudó a los pioneros de la nanotecnología y proporcionó una unión con el pasado..

Más aun, dicha fama y mérito –de Feynman- jugaron un importante papel en la provisión de fondos para desarrollar la investigación en Nanotecnología:

Y así, en su presentación del presupuesto federal para el año 2000, el presidente Bill Cliton indicaba: "Mi presupuesto apoya una nueva Iniciativa Nacional en Nanotecnología con 500 millones de dólares".

Y seguía Clinton: "Caltech no es ajeno a la idea de Nanotecnología, - el manipular la materia a las escalas atómica y molecular-. Hace más de 40 años, el profesor de Caltech Richard Feynman se preguntaba ¿"Qué pasaría si pudiéramosorganizar los átomos uno a uno a nuestro antojo?"

http://nano.gov/ www.nanospain.org

A menudo se predice que la Nanotecnología será el motor del próximo ciclo de crecimiento…

HASTA AQUÍ, LA “HERENCIA” DE FEYNMAN

PASEMOS AL ENFOQUE “QUÍMICO”

ASTROQUÍMICA

La ASTROQUÍMICA es el estudio de las especies químicas -elementos y compuestos- que existen en el espacio exterior más allá del Sistema Solar, en particular en los cuerpos celestes - estrellas, galaxias… - y en las nubes de gas estelar así como de su formación y reactividad.

Constituye pues una zona de conjunción entre la Química y la Astronomía.

La ASTROQUÍMICA utiliza los telescopios para determinar las carácterísticas fisico-químicas de dichas especies: *temperatura*, *composición*, *estructura…*, complementados por el trabajo espectroscópico realizado en los laboratorios terrestres

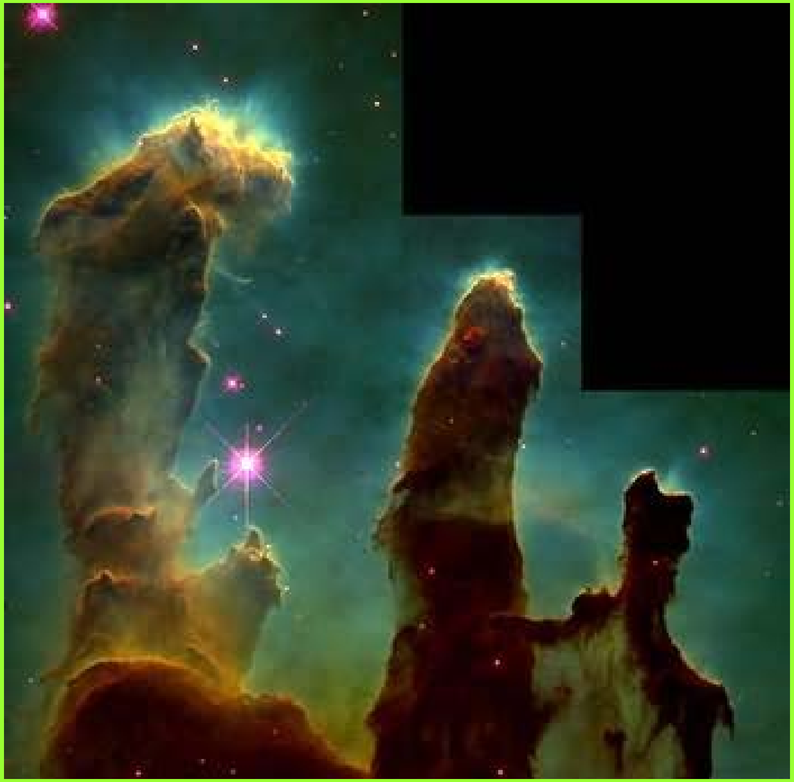
Observatorio del Teide (IAC)

Milky Way From The Alabama Hills

Atacama Large Millimeter Array (ALMA)

ASTROCHEMISTRY

***Pilares de la creación* de estrellas en la Nebulosa del Águila (M16): 6.500 LY**

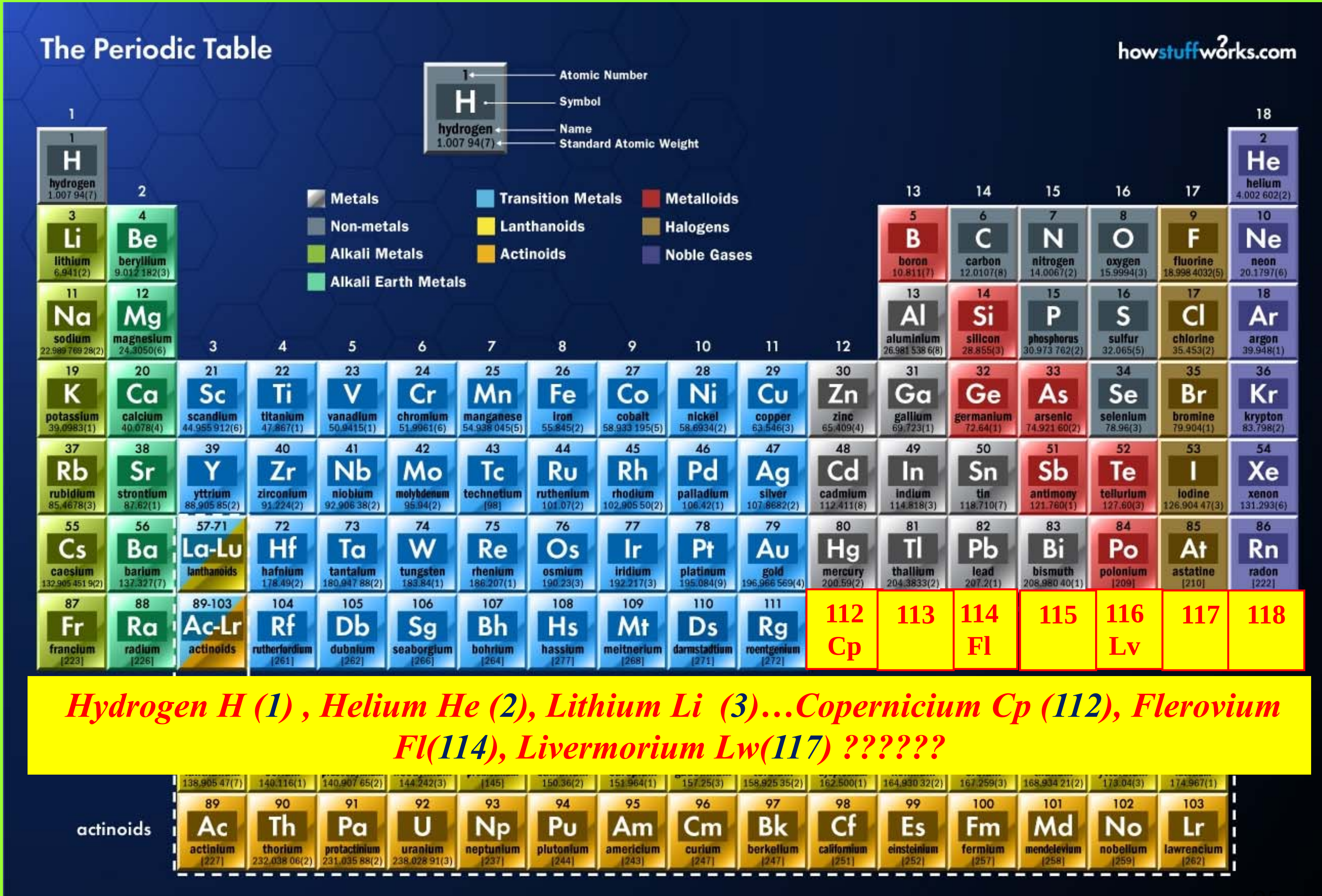


ROJO: AZUFRE ; VERDE: HIDRÓGENO; AZUL: OXÍGENO

LA PALETA DEL HUBBLE 1999

Nube de gas desprendido de la nebulosa Carina

ASTROQUÍMICA



Hydrogen H (1) , Helium He (2), Lithium Li (3)…Copernicium Cp (112), Flerovium Fl(114), Livermorium Lw(117) ??????

Hasta ahora se han descubierto unas 140 especies químicas en el espacio exterior (*c.f.* ¡más de $75x10^6$ en la Tierra!) incluyendo especies moleculares tales como alcoholes, aldehidos, cetonas, etc

También se ha postulado el descubrimiento de aminoácidos, en particular de Glicina (NH_2CH_2COOH), en el espacio y, de ahí, sugerido la posible venida de la vida del espacio exterior. Pero la cuestión no ha sido aceptada de modo unánime

Snyder et al.The Astrophysical Journal, Volume 619, Issue 2, pp. 914-930(2005)

http://www.nrao.edu/pr/2013/newchem/

Algunas Especies Químicas detectadas en el Espacio

Radical metilidino (CH^+) la primera en 1937

Diatómicas (33): C_2, AlCl; AlF, PN, SO^+…

Triatómicas(37): AlNC, C_2H, HCN, HNC, H_2O …

Tetratómicas(22): c-C_3H, H_2CN, HCCN, NH_3, SiC_3…

Pentatomicas (16): CH_4, HCOOH, NH_2CN

Hexatómicas(14): c-H_2C_3O, C_5H, CH_3C

Nonatómicas(8):, CH_3C_4H, CH_3CH_2CN

Decatómicas:, $(CH_3)_2CO$, CH_3CH_2CHC

Dodecatómicas:, $CH_3OC_2H_5$, C_6H_6…

Terdecatómicas: $HC_{10}CN$: cianodecapenta

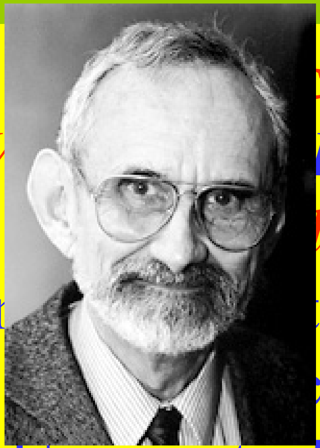
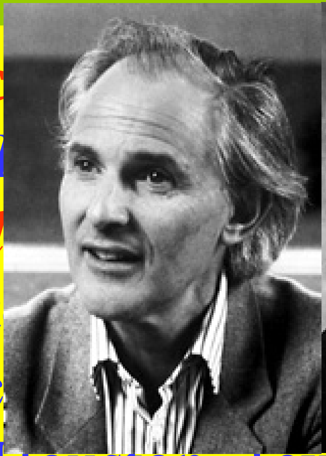
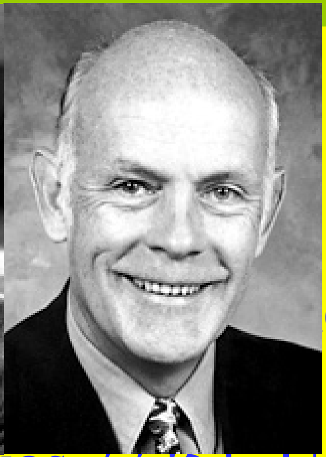
C_{60}, C_{70}, GRAPHENE…

The detection has been made by an international team of researchers at the *Instituto de Astrofísica de Canarias* (IAC), Spain. D. A. Garc´ıa-Hernandez ,S. Iglesias-Groth1, *et al. The Astrophysical Journal Letters, 737:L30 (7pp), 2011 August 20*

ASTROCHEMISTRY

Un primer descubrimiento sorprendente

Nature ***318***, *162 - 163 (14 November 1985)*

H. W ... ***R.***

Rice Quar ... emistry

Rice University, Houston, Texas 77251, USA

Curl, Kroto &Smalley
FULLERENES 1986

*Permanent address: School of Chemistry and Molecular Sciences, University of Sussex, Brighton BN1 9QJ, UK.

http://www.youtube.com/watch?v=0Vh8PQXC9po&feature=youtu.be%20(KROTO)

"During experiments aimed at understanding the mechanisms by which long-chain carbon molecules are formed in interstellar space and circumstellar shells… "

HC_5N $\quad$ **H – C ≡ C – C ≡ C – C ≡ N**

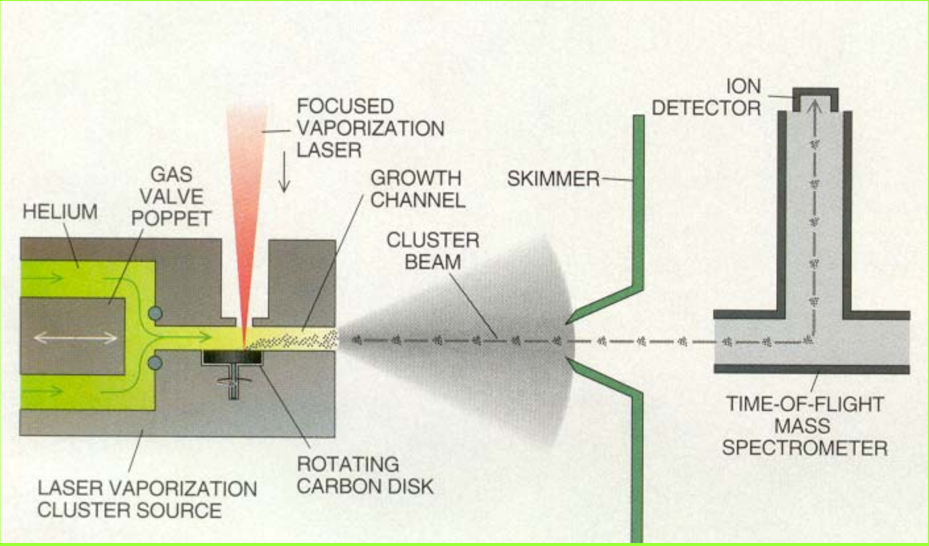
HC_7N $\quad$ **H – C ≡ C – C ≡ C– C ≡ C – C ≡ N**

HC_9N $\quad$ **H – C ≡ C – C ≡ C – C ≡ C– C ≡ C – C ≡ N**

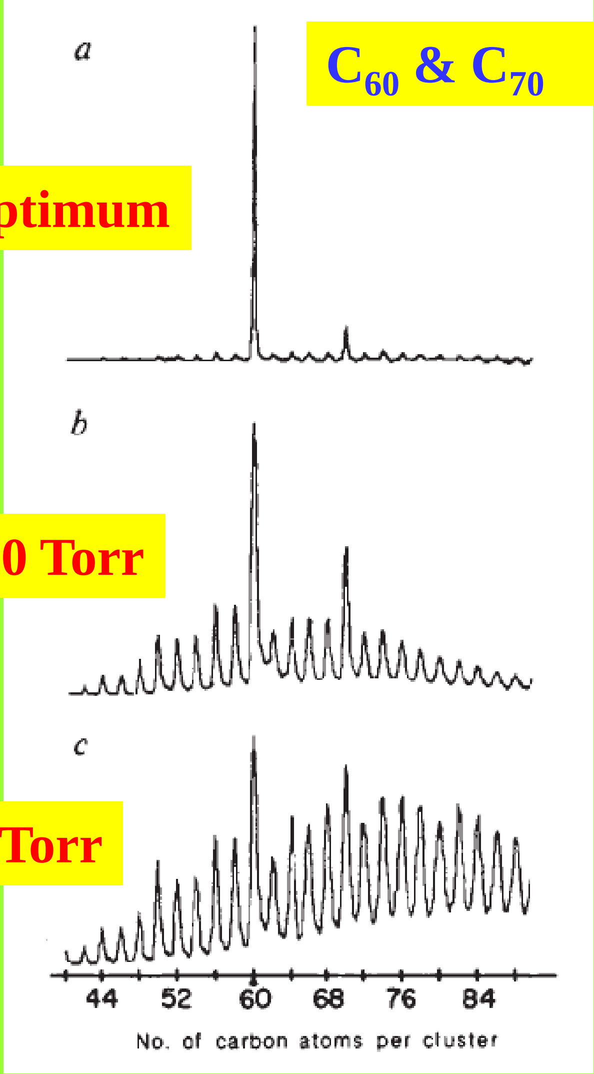
¡Estaban buscando hidrocarburos poli-insaturados de cadenas largas…!

¡No fullerenos!

graphite has been vaporized by laser irradiation, producing a remarkably stable cluster consisting of 60 carbon atoms..



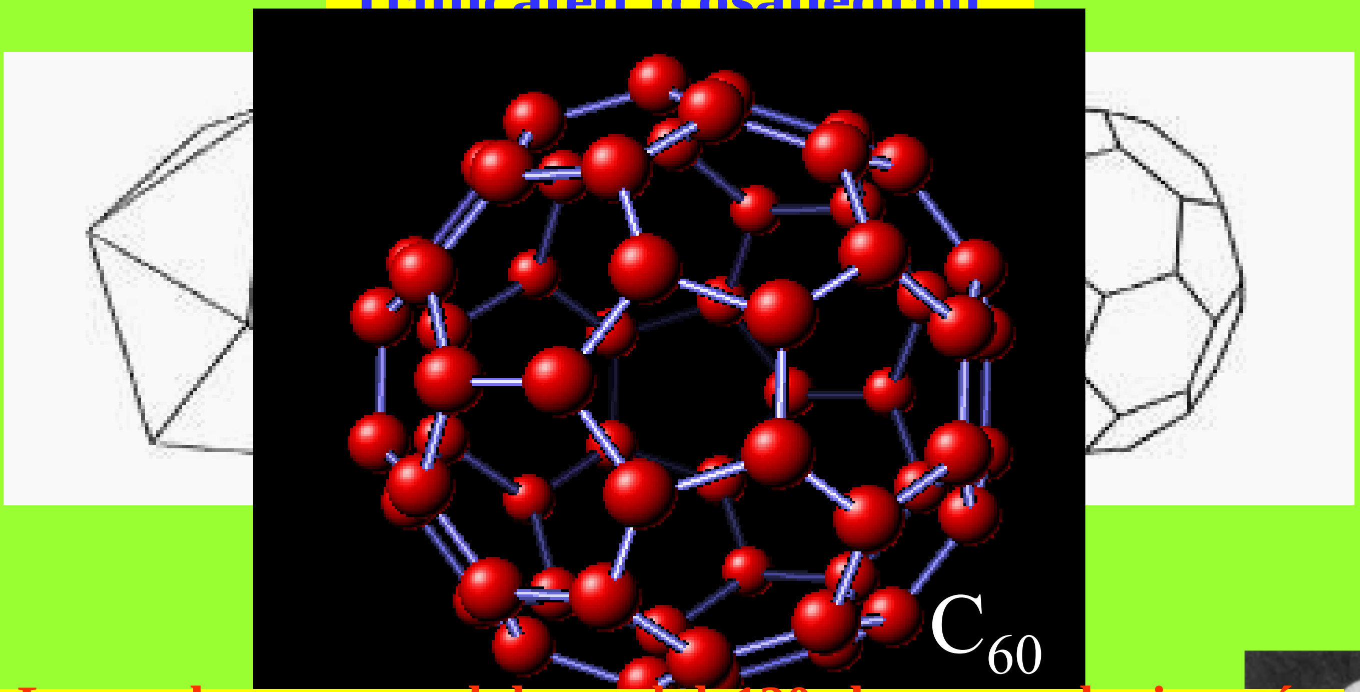
Graphite evaporation apparatus (R. Smalley)



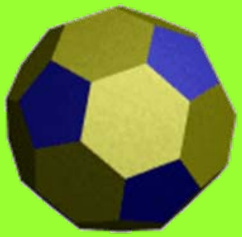
Mass spectra of the product of graphite in helium

En relación con la cuestión de qué tipo de estructura atómica puede ser la de C_{60}, sugerimos la de un icosaedro truncado, *un polígono con 60 vértices y 32 caras, 12 de las cuales son pentagonales y las otras 20 hexagonales*

Truncated Icosahedron



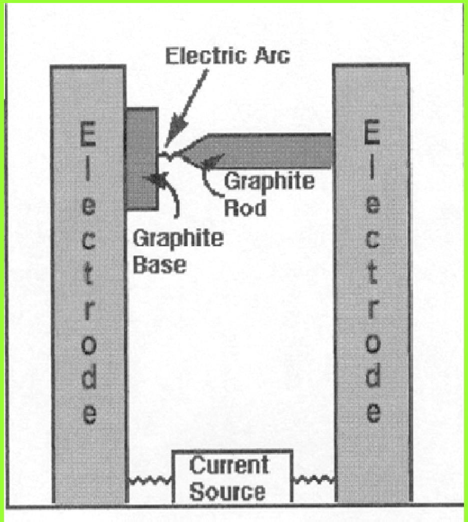
Lo que hace un total de total de120 elementos de simetría
Y resulta ser la molécula más simétrica que se conoce¡



Este objeto se encuentra comúnmente en los campos de balompié y se le denomina balón de Fútbol

Un desarrollo crucial

Un reactor para la preparación masiva de fullerenos



OBTENCIÓN DEL POLIMORFO C_{60}

SíNTESIS: EVAPORACiÓN DE ELECTRODOS DE GRAFITO EN

ATMÓSFERA DE HELlO (~100 TORR)

HOLLÍN

Disolución en Benceno

Filtración

Liquido rojo + sólido negro

FILTRACIÓN

Liquido rojo

DESTILACIÓN SUAVE

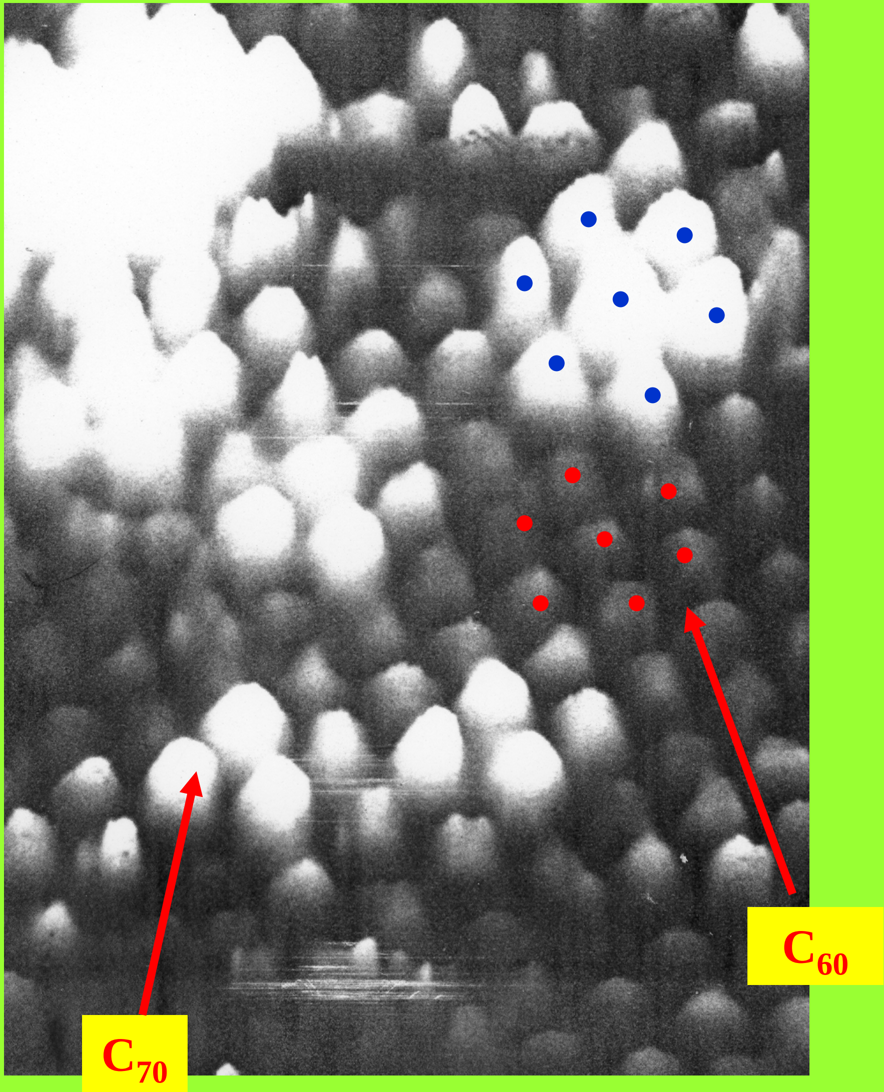
CRISTALES (ESTABLES AL AIRE)

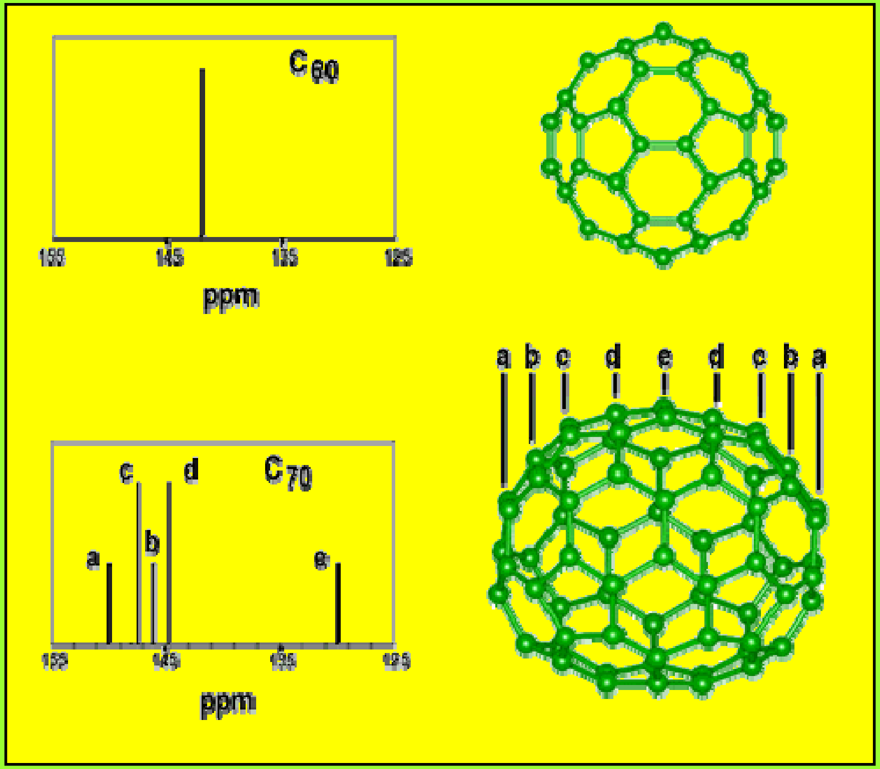
SISTEMA HEXAGONAL

a = 10.02 A c = 16.36 A

W. Kratscchmer et al: Nature 347 354 (1990)

Molecular imaging:AFM



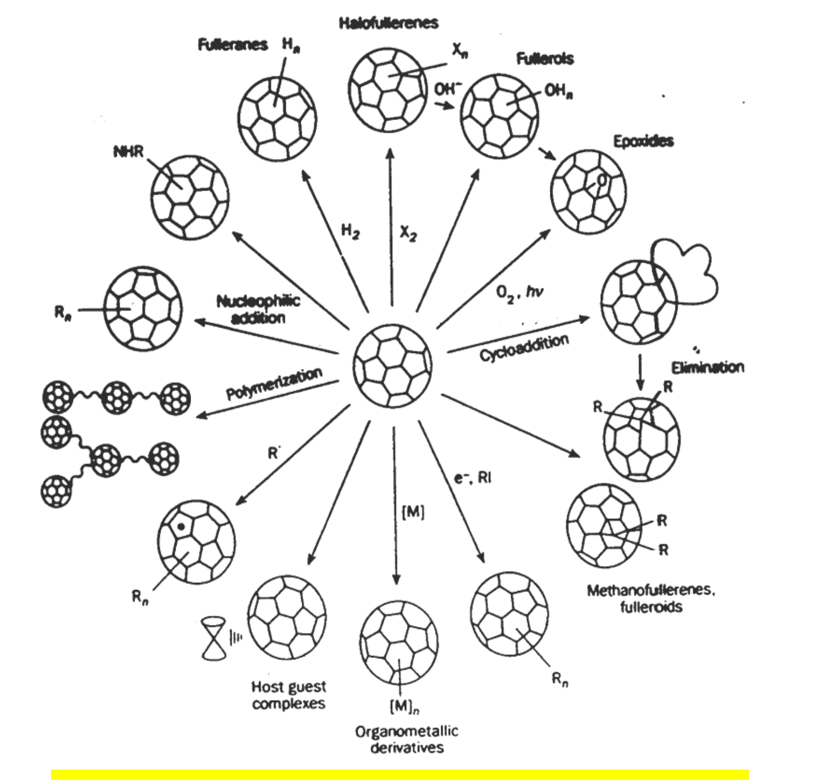


NMR Spectra of C_{60} y C_{70}

A new Chemistry:NANOCHEMISTRY

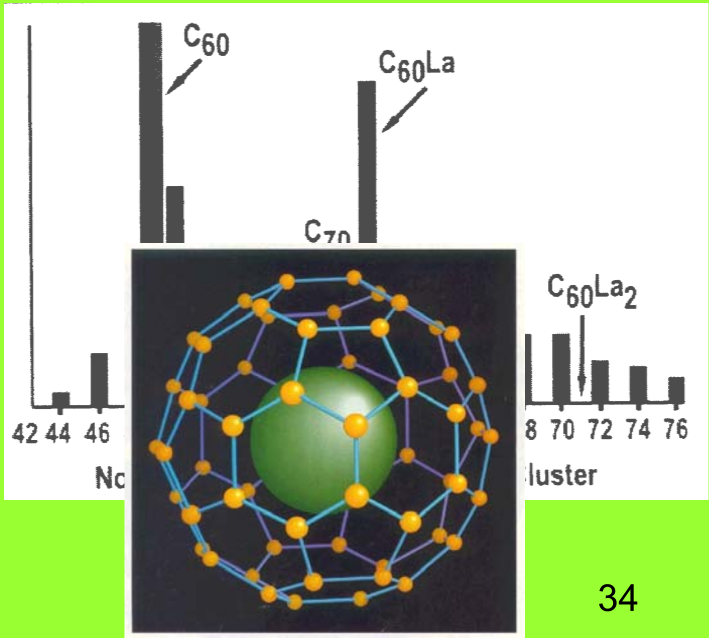
EXOÉDRICA
O
EXOQUÍMICA

ENDOÉDRICA O
ENDOQUÍMICA



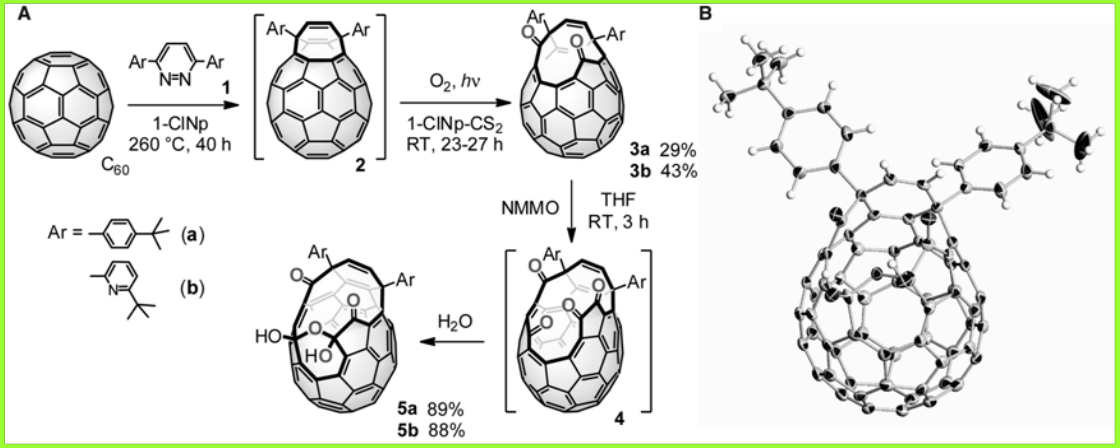
FUNCIONALIZACIÓN de C_{60}

GraFitO + $LaCl_3$+ $h\nu$ $\Rightarrow$ $La@C_n$



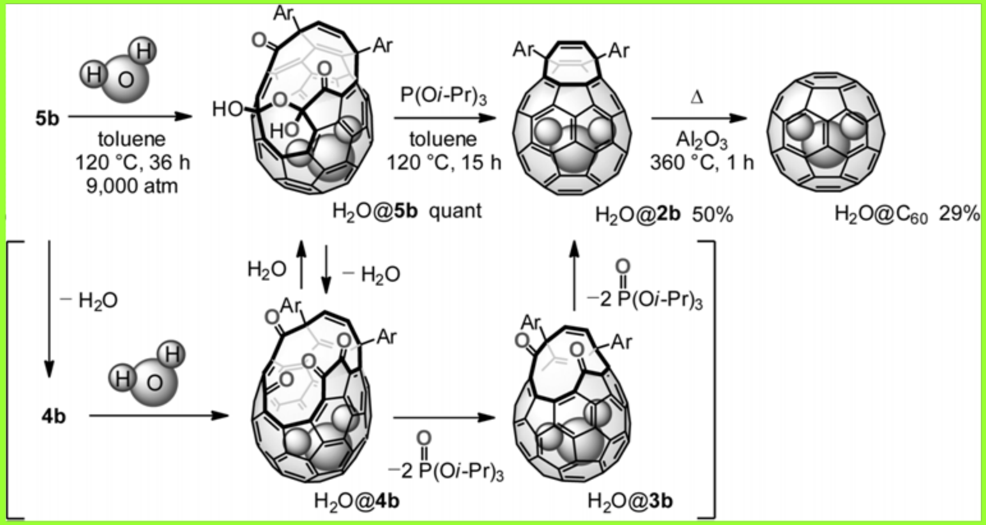
MÁS **ENDOQUÍMICA**:*Cirugía Molecular*

¿Agua en C_{60}?



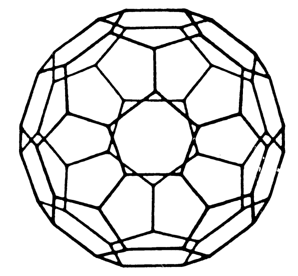
(A) Synthetic route of open-cage C60 5 (1-chloronaphthalene being abbreviated as 1-ClNp)
(B) the x-ray structure of 5a at the 50% probability level.

Encapsulation of an H_2O molecule to open-cage C60 5b and restoration of the opening for the synthesis of H2O@C60.



Kei Kurotobi and Yasujiro Murata:Institute for Chemical Research Kyoto University, Uji, Kyoto 611-0011, Japan.

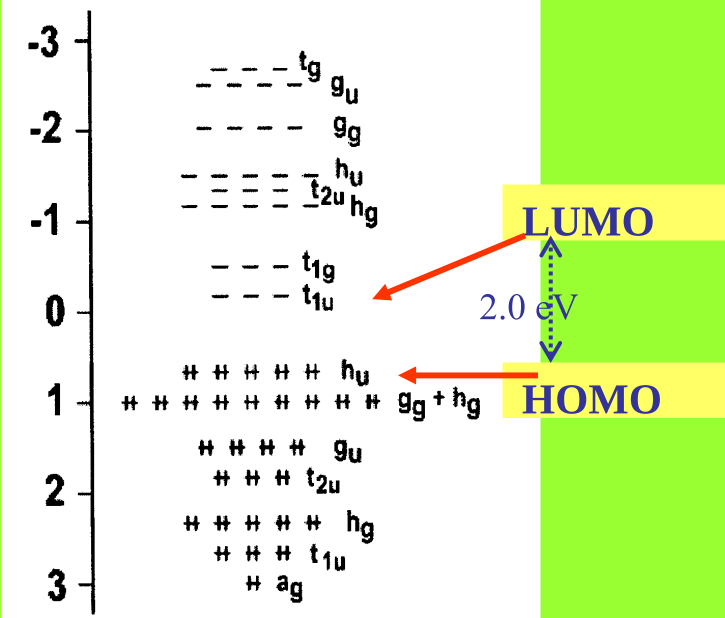
MÁS EXOQUÍMICA en C_{60}

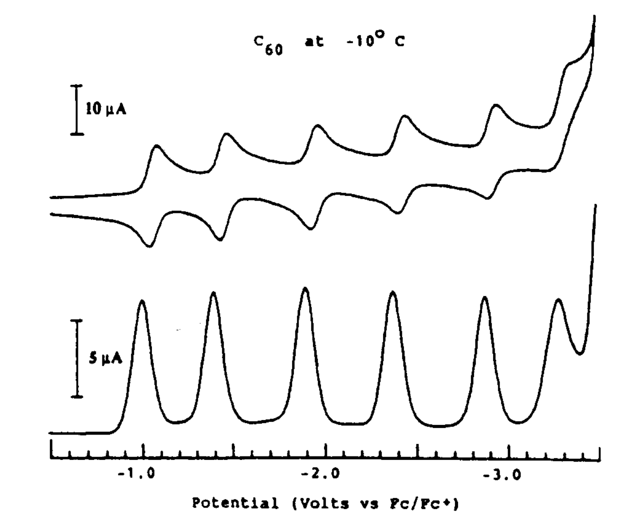


Electroquímica Propiedades Red-Ox

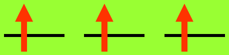
SUPERCONDUCTIVIDAD EN C_{60}

Orbitales Moleculares





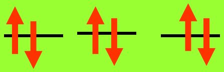
Cathodic cyclic and differential pulse voltammograms of C60 in CH3CN/toluene at -10ºC showing successive reversible reductions to $C60^{6-}$ (*Fullerides* /Fulleruros)



A3 C_{60} SC

6 Aniones Fulleruro C_{60}^{n-}

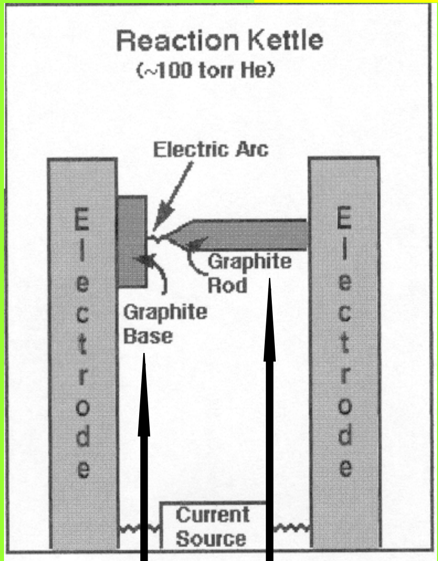
C_{60}^{1-}; C_{60}^{2-} ; C_{60}^{3-} ; C_{60}^{4-} ; C_{60}^{5-} ; C_{60}^{6-}



A6 C_{60} NSC

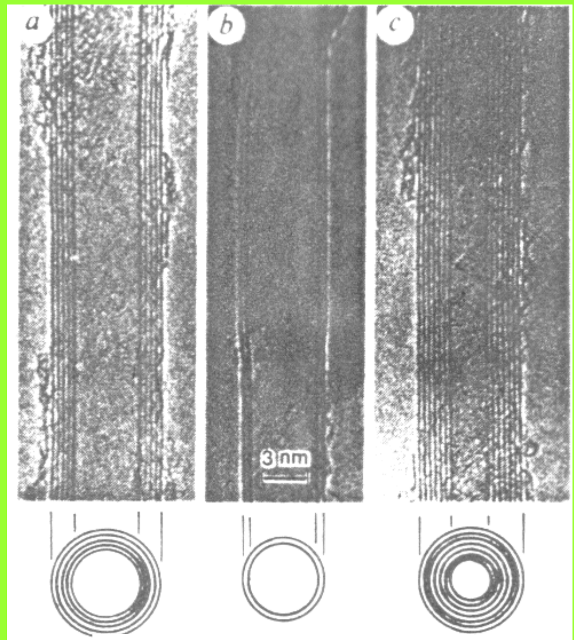
2 Cationes Fullerenio :C_{60}^{1+} ; C_{60}^{2+}

Un segundo descubrimiento sorprendente



Electrodos de Grafito

Nanotubos multipared
MWNT



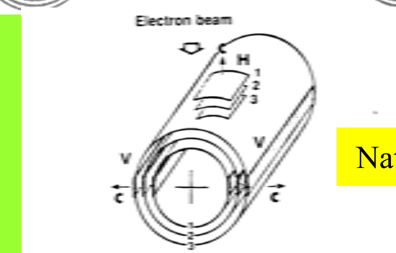
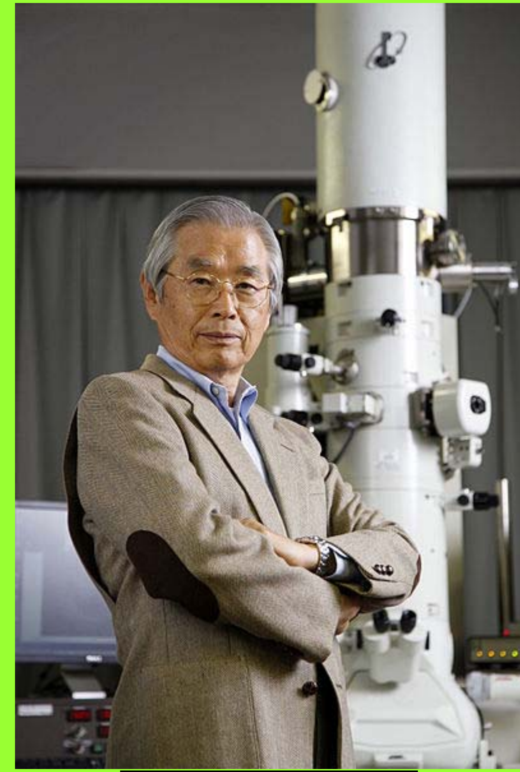


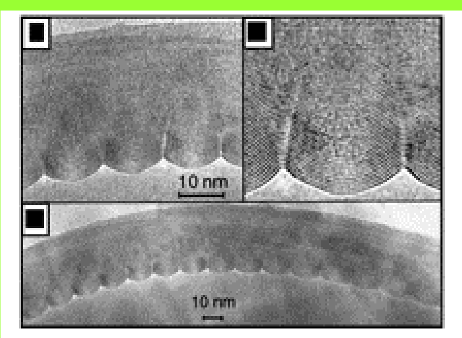
FIG. 2 Clinographic view of a possible structural model for a graphitic tubule. Each cylinder represents a coaxial closed layer of carbon hexagons. The meaning of the labels V and H is explained in the text.

Nature **354**(1991)



Sumio Ijima

Pemio Príncipe de Asturias de Investigación 2008



D. Ugarte, (1999)

SIN EMBARGO…

…HABÍA ANTECEDENTES de los NANOTUBOS

Hughes and Chambers (US Patent)**, and Schützenberger and Schützenberger(c.r. Acad.Sci** 111**, 774(1890)**2 **reported the growth of filamentous carbon in 1889 and 1890, respectively.**

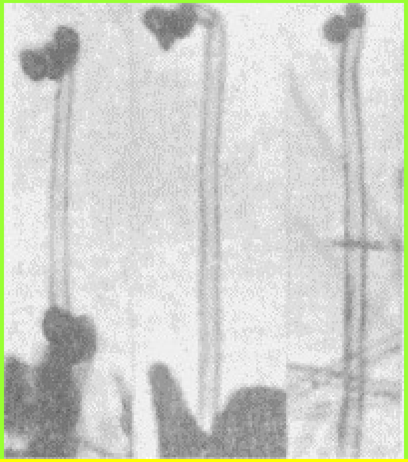
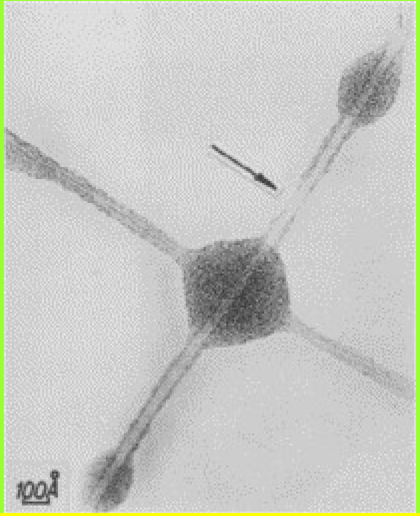


Fig. 1. Low-resolution transmission electron micrograph depicting three hollow carbon fibers at MAG 20 000. These fibers were first reported by Radushkevich and Lukyanovich in 1950.

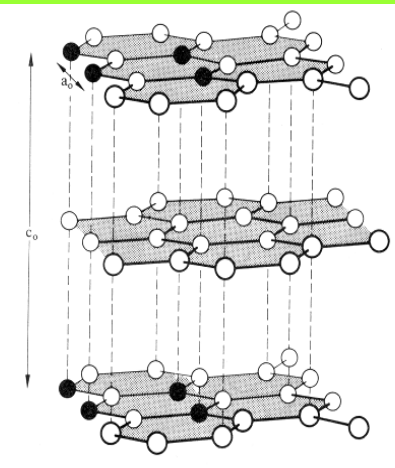


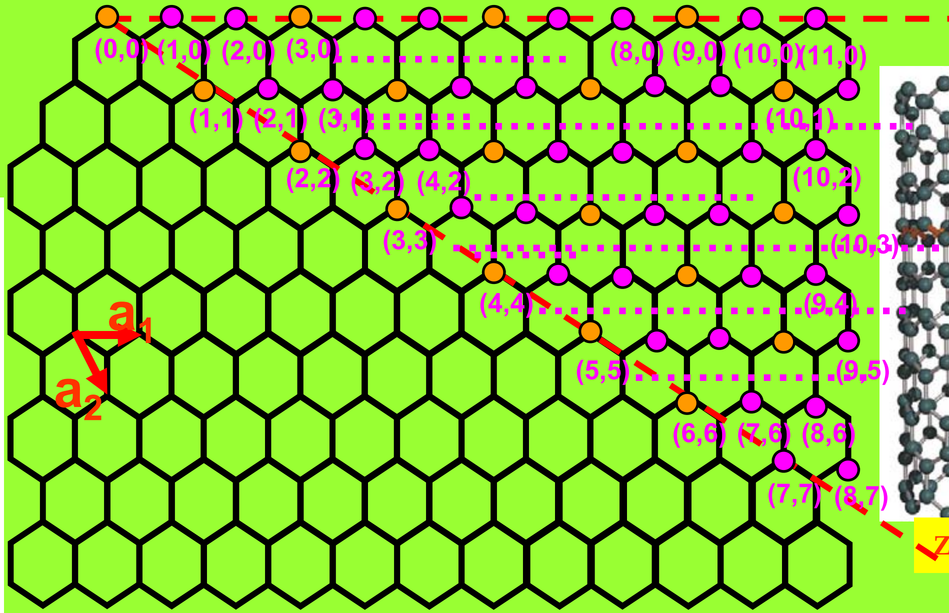
First viewgraph of what today is called SWNT or DWNT. Based on this image, it is difficult to determine the exact number of walls.

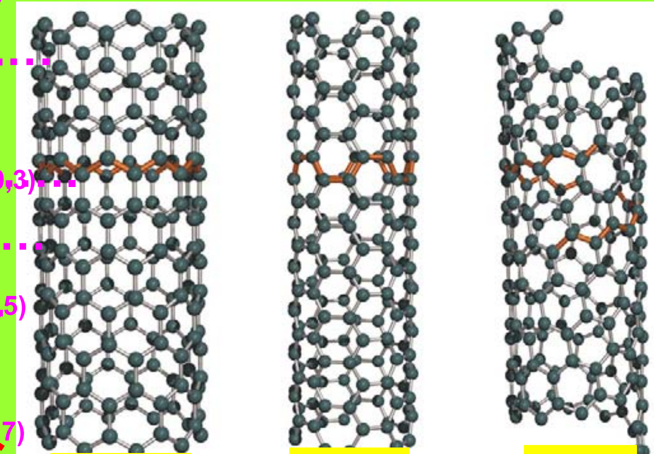
SINGLEWALL NANOTUBES SWNT

Nanotubes formally derive from Graphene

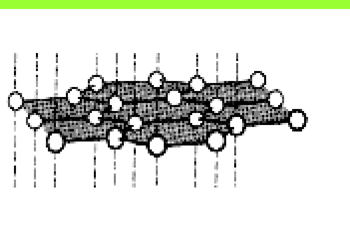
GRAPHITE







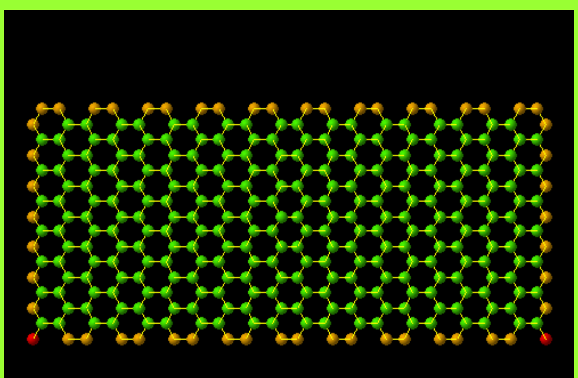
Zig-Zag Chair Helix



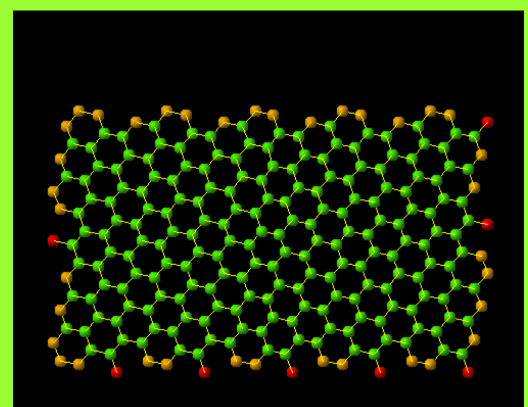
GRAPHENE

Metállic

Semiconducting

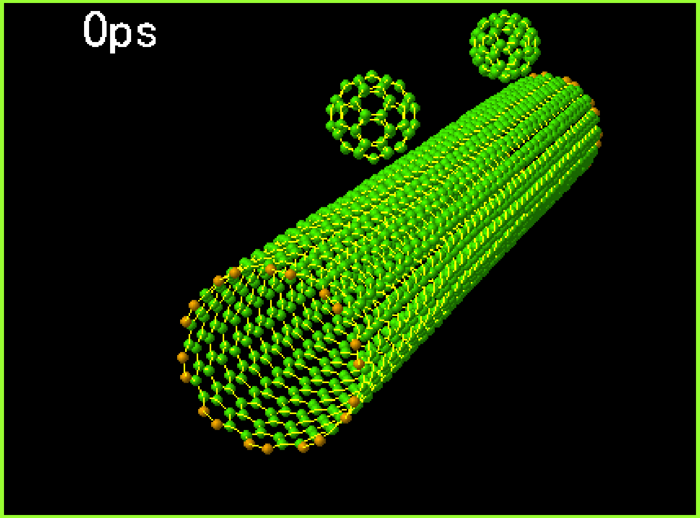


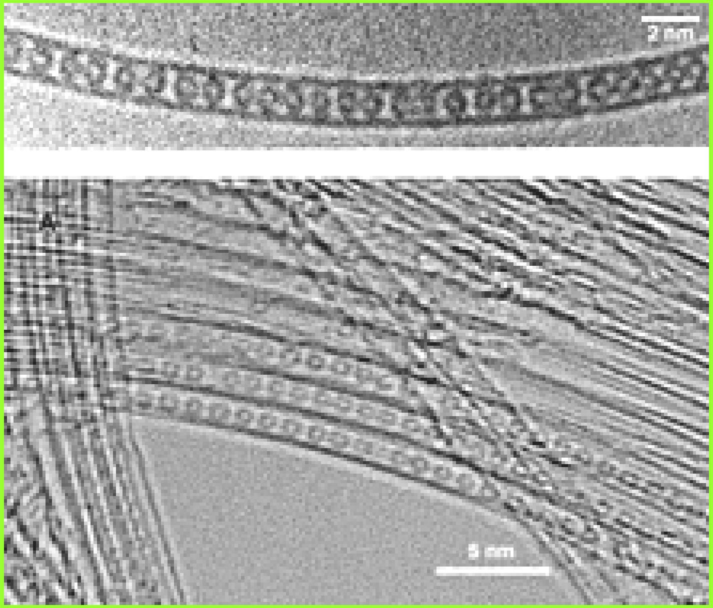
(10, 10)



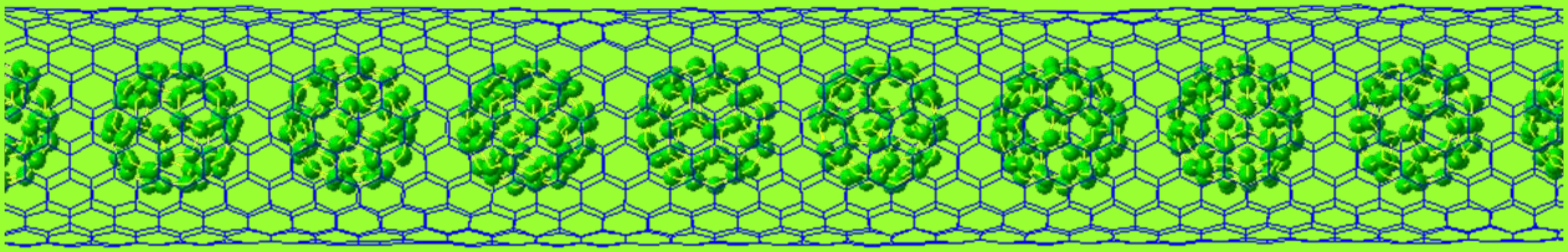
(10,5)

NANOGUISANTES





Hot threads. Packing fullerene spheres into carbon nanotubes may boost their superconductivity threshold to high temperatures.

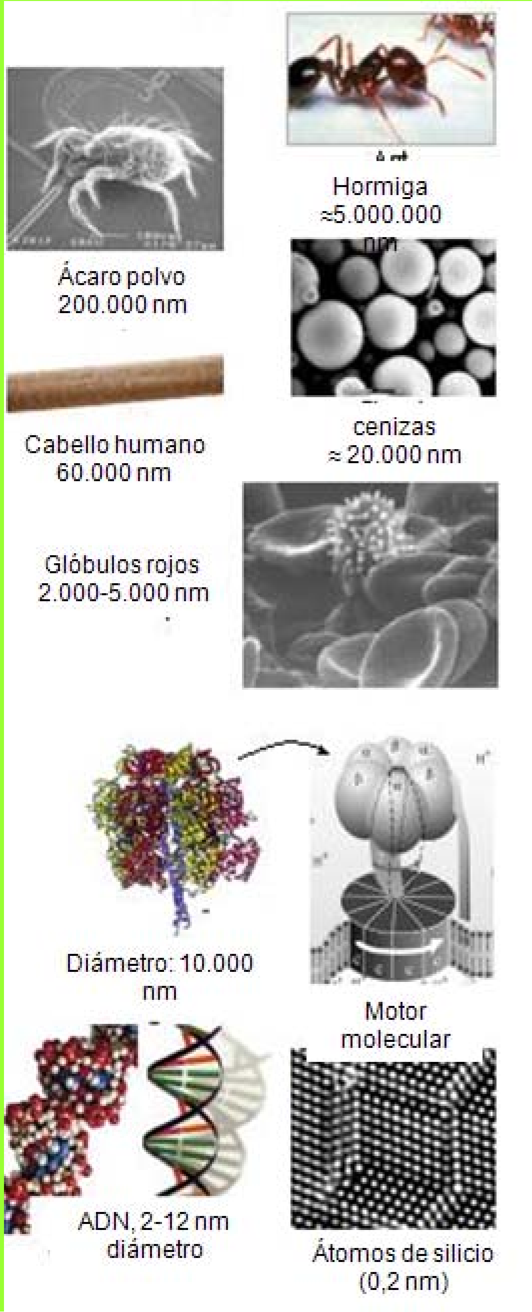


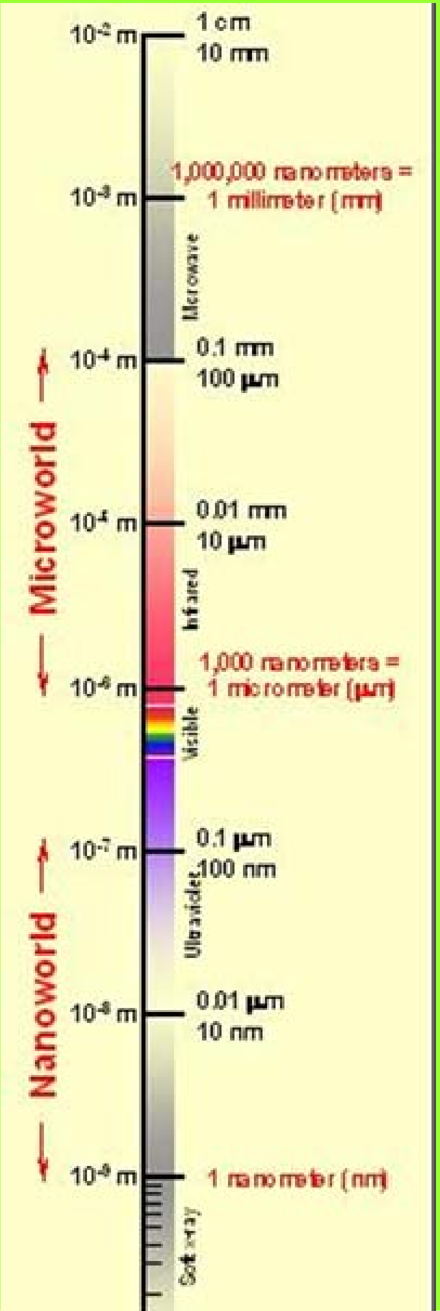
Nanopods Vibrations

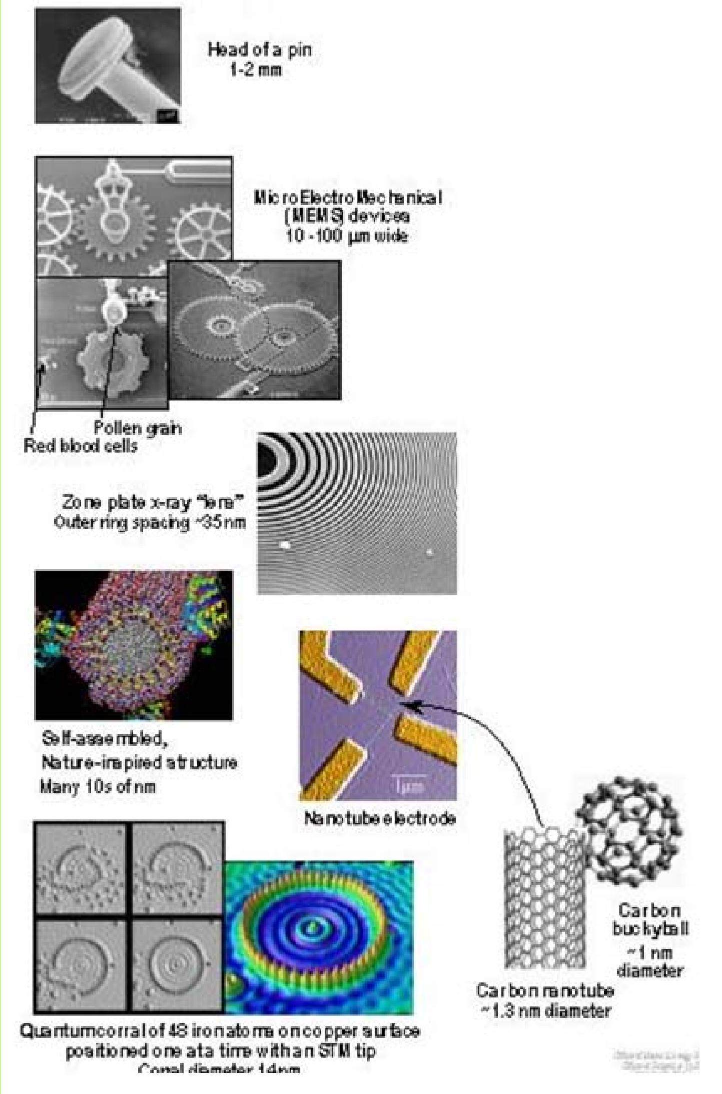
NATURAL WORLD

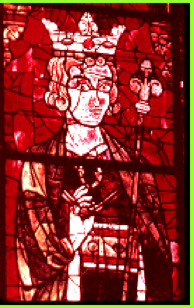
The world in nanometers

ARTIFICIAL WORLD

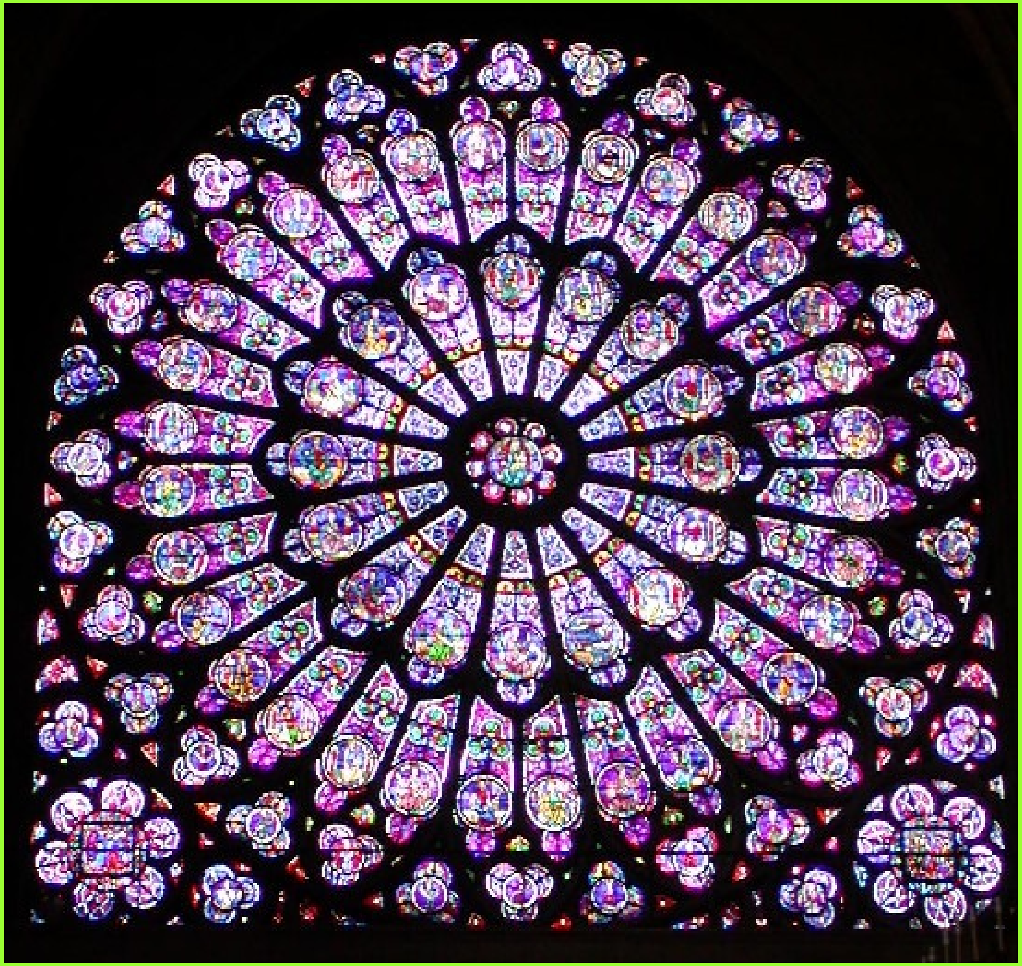




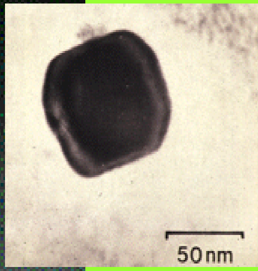




Nanotecnology in the distant past



vidriera en la catedral de Notre Dame (X d.c.)



copa de Licurgo (IV d.c.)

Some example of nanotech products

Nanochemical Systems Holding
Automotive SunScreen

Mercedes Clearcoat

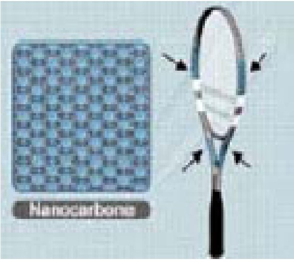
Nano Care Technology Ltd
Antibacterial kitchen ware

Smith & Nephew
Acticoat wound dressing

Samsung "Silver Nano"
Washing Machine

Nanogate Technologies GmbH
Functional coatings

Nanodesu X Bowling Ball
American Bowling Service Company



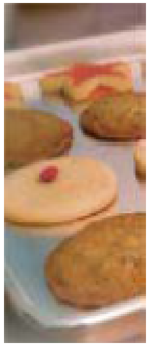
Babolat
NS Tour tennis racket

Gap Inc
Nanocare Stressfree Khakis

Boots, Oxonica Ltd
Soltan® Facial Sun Defence Cream - Optisol®

Nanoprotect CS
Nanotec Pty Ltd

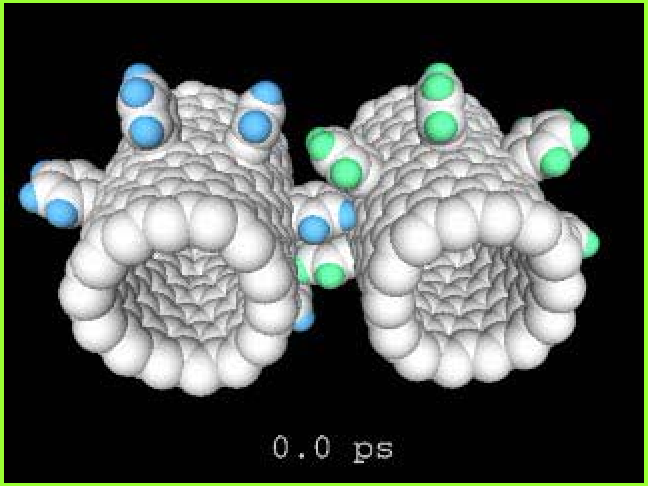
RF shielding paint
NaturalNano Inc



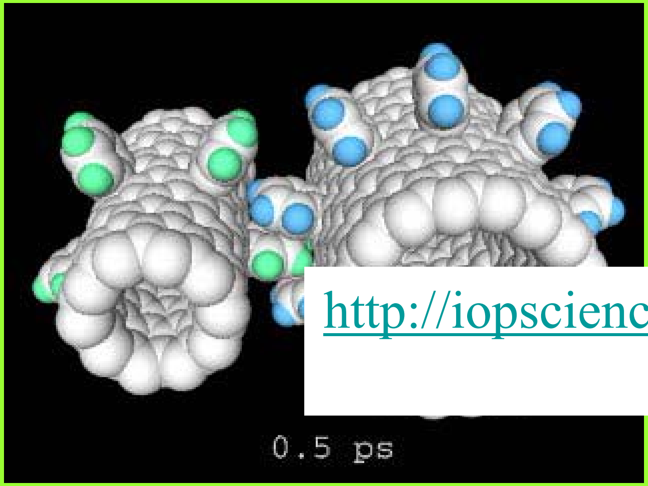
Non-stick self-assembling nanofilms for glass bakeware NanoFilm Ltd

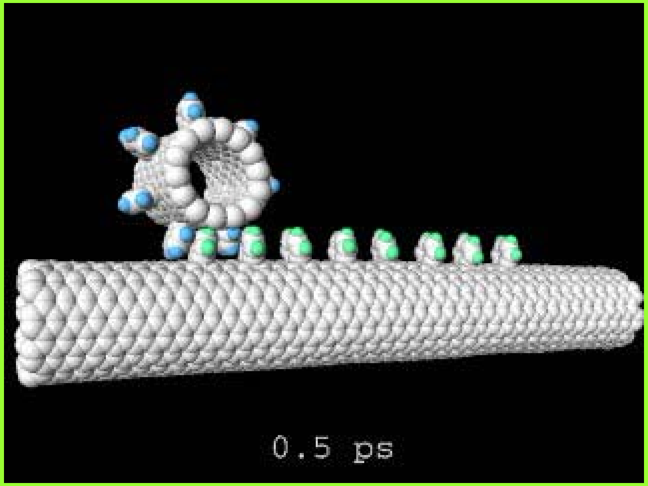
NanoSEE

“Fabricación” de nanoengranajes

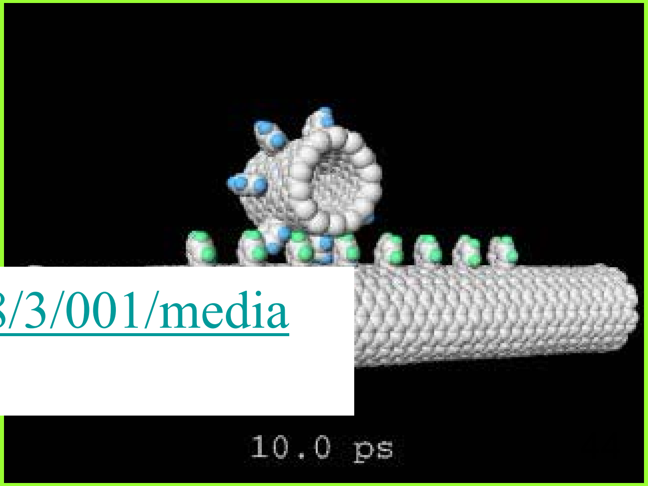


Transmisión en paralelo

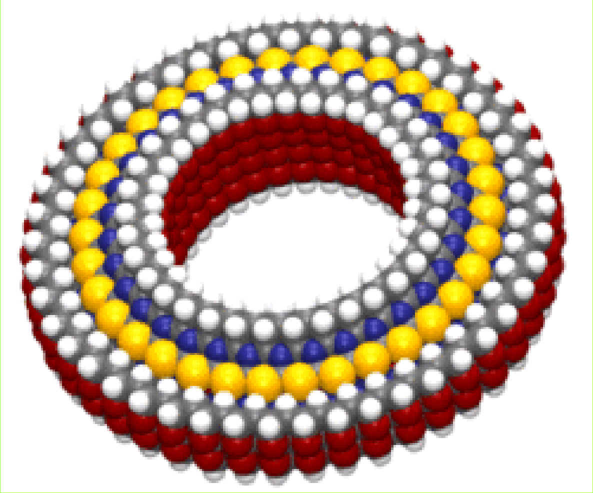




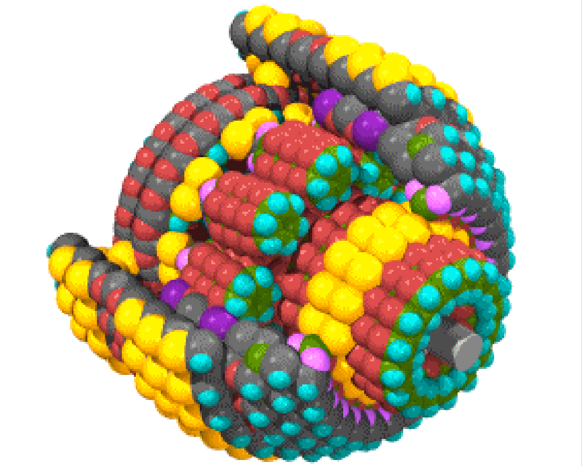
Transmisión perpendicular



http://iopscience.iop.org/0957-4484/8/3/001/media

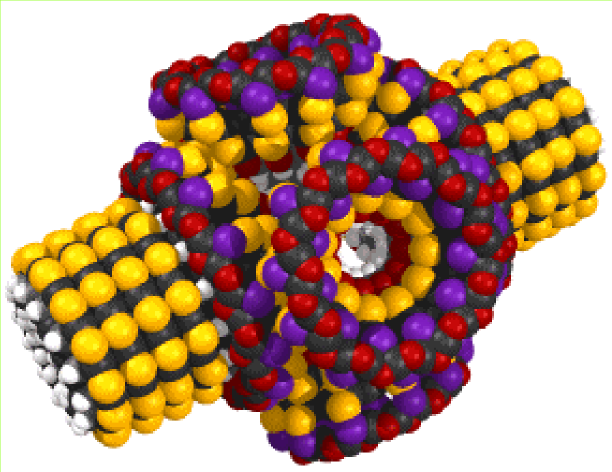


Nano-RODAMIENTO

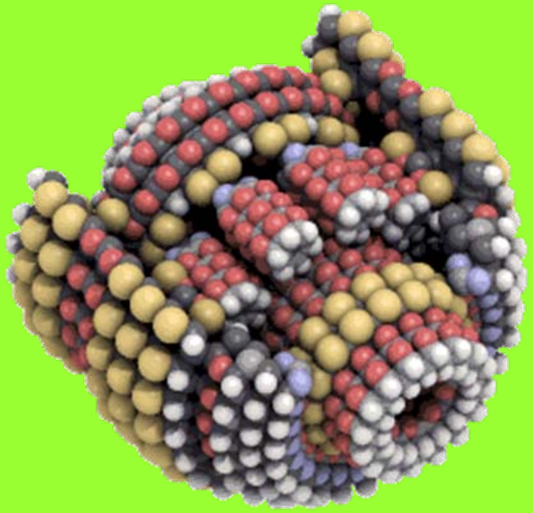


Nano-ENGRANAJE EPICICLOIDAL

http://vivelavapeur.tumblr.com/post/14811502361/universe-of-waves-nano-machines-source

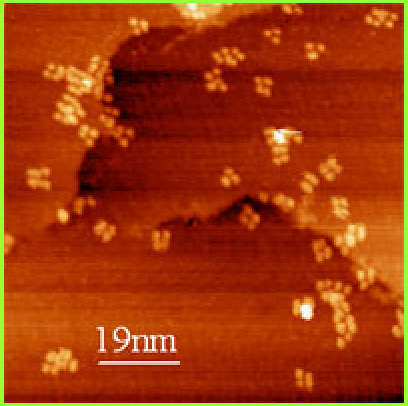


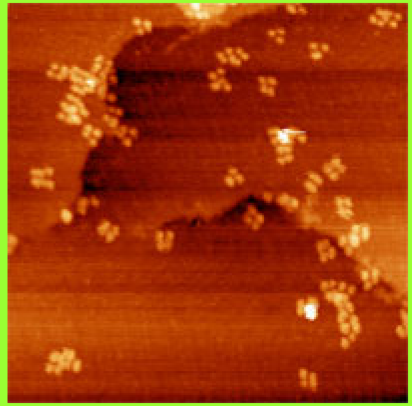
Nano-DIFERENCIAL

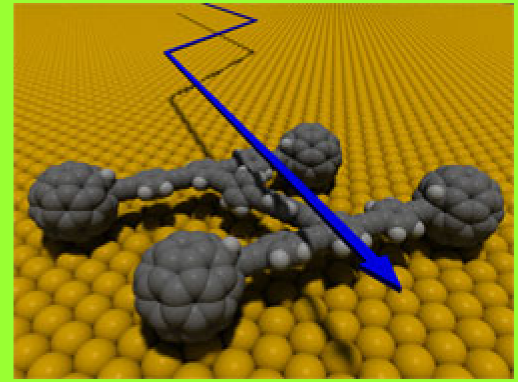


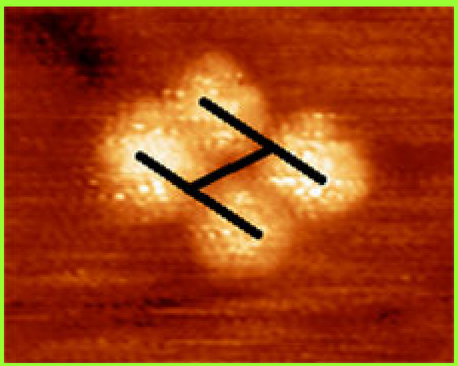
Nano-ENGRANAJE

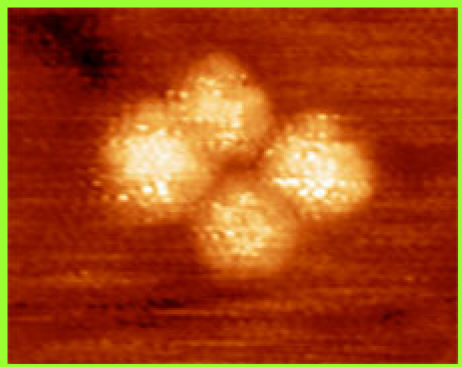
THE NANOCAR/EL NANOCOCHE

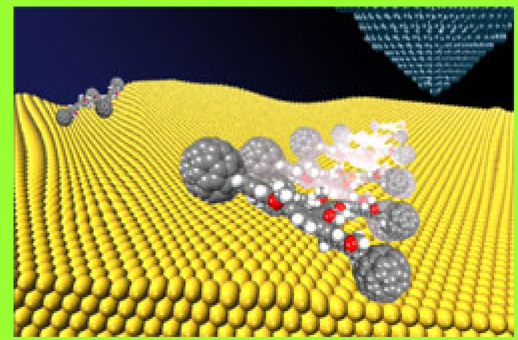












Rice scientists build world's first single-molecule car

'Nanocar' with buckyball wheels paves way for other molecular machines

Rice University scientists have constructed the world's smallest car -- a single molecule "nanocar" that contains a chassis, axles and four buckyball wheels.

The "nanocar" is described in a research paper that is available online and due to appear in an upcoming issue of the journal Nano Letters.

NANOCAR/NANOCOCHE

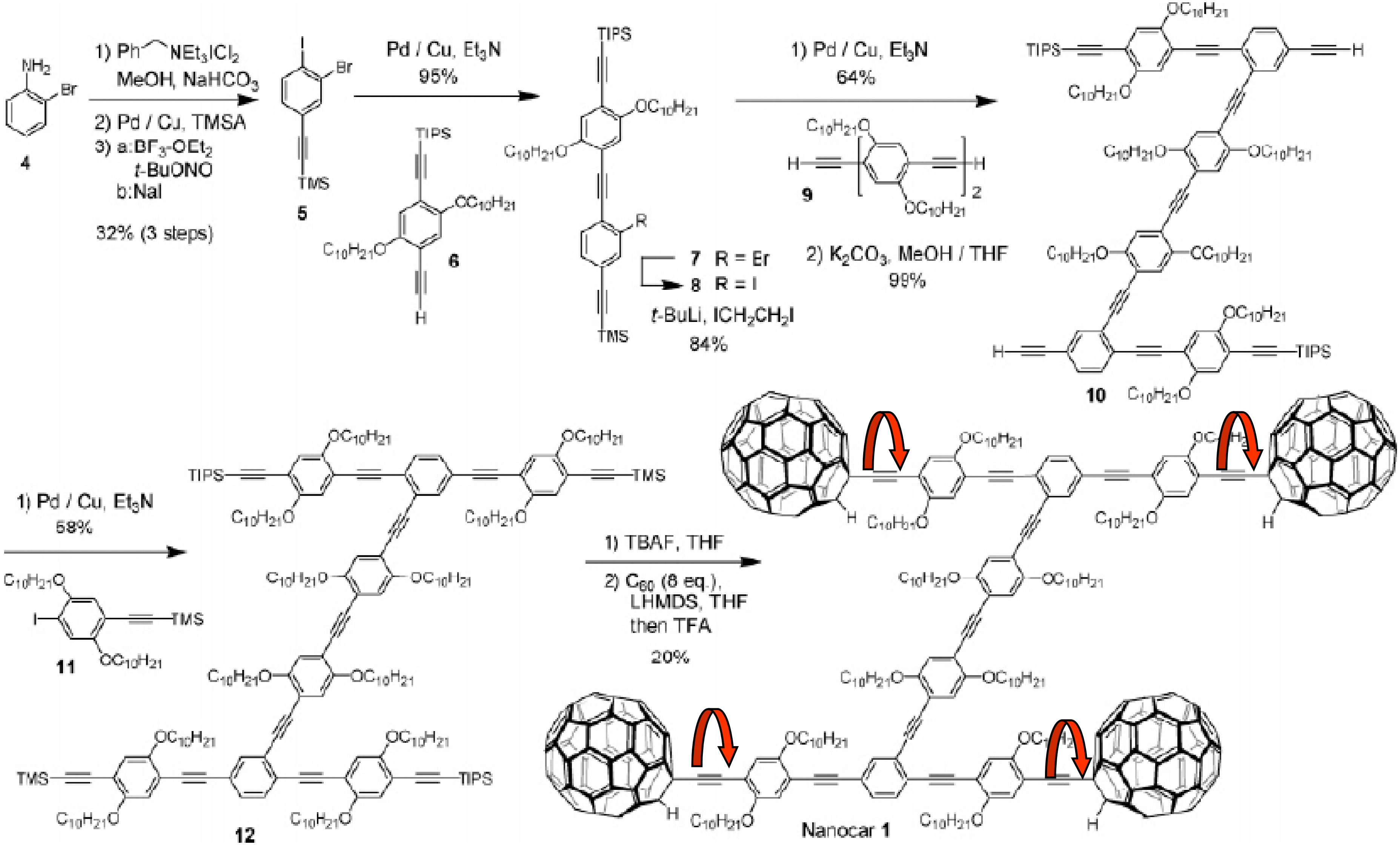


Figure 1. Synthesis and structure of nanocar **1**. The synthesis of nanocar **1** involves extensive Pd-catalyzed coupling reactions, and four fullerene "wheels" were attached in one reaction step.[21] Structure was definitively characterized spectroscopically.[20] Through the synthesis and study of several related structures including trimers **2** and **3**, it was clear that the alkyl units were critical for the requisite solubility of these molecules. Fullerene wheels and chassis parts can rotate because of the alkyne connections, giving the nanocar the ability to roll on the surface and flexibility orthogonal to the surface plane.

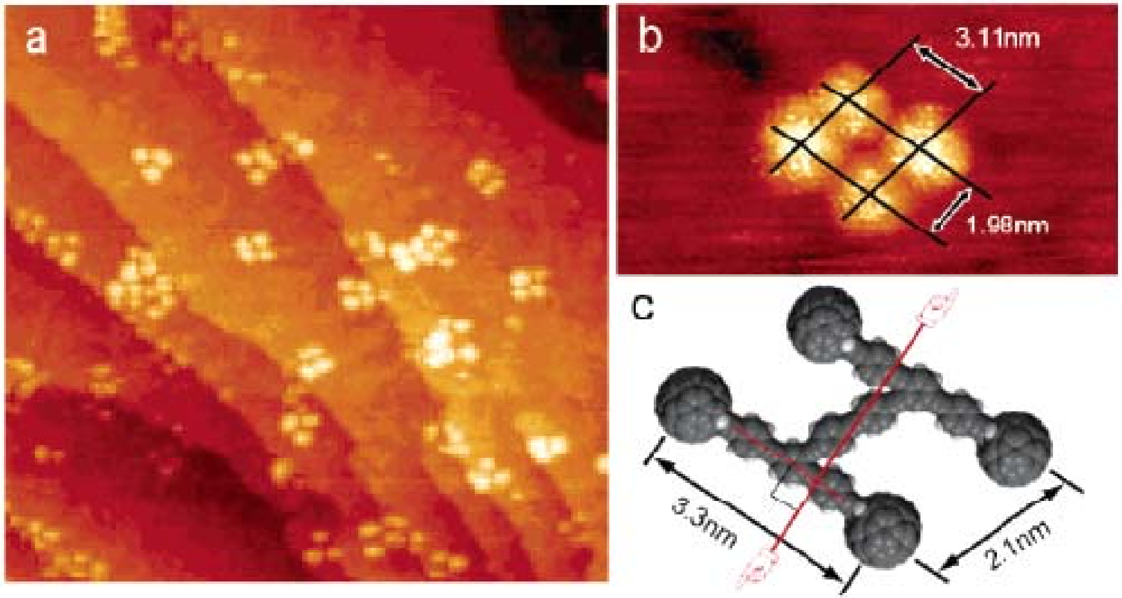


Figure 2. Nanocar **1** on Au(111) surface. (a) STM image (bias voltage [V_b] = 0.4 V, tunneling current [I_t] = 10 pA; image size is 73 × 70 nm^2) of the nanocars (**1**) deposited on Au(111) by dosing valve. Bright features are fullerene wheels; intramolecular OPE and alkyl groups are not visible. (b) High-resolution STM image (V_b = 0.4 V, I_t = 60 pA). The orientation of the molecules can be determined by the fullerene peak-to-peak distances, with (c) modeled distances at 3.3 nm across the width and 2.1 nm across the length, or the axle and chassis directions, respectively, as shown in this alkyl-free space-filling model. The red fingers indicate the expected direction of rolling perpendicular to the axles.

NANOCAR/NANOCOCHE

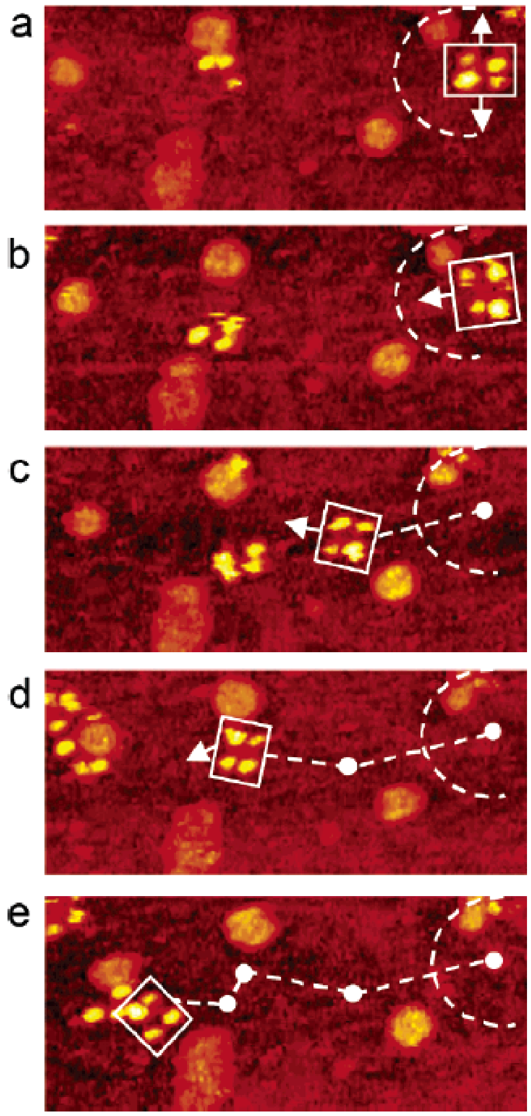


Figure 3. Nanocar **1** rolling on Au surface. (a−e). A small section of a sequence of images taken during annealing at ~200 °C (V_b = −0.95 V, I_t = 200 pA; image size is 51 × 23 nm^2). The orientation of **1** is determined easily by the fullerene wheel separation, with

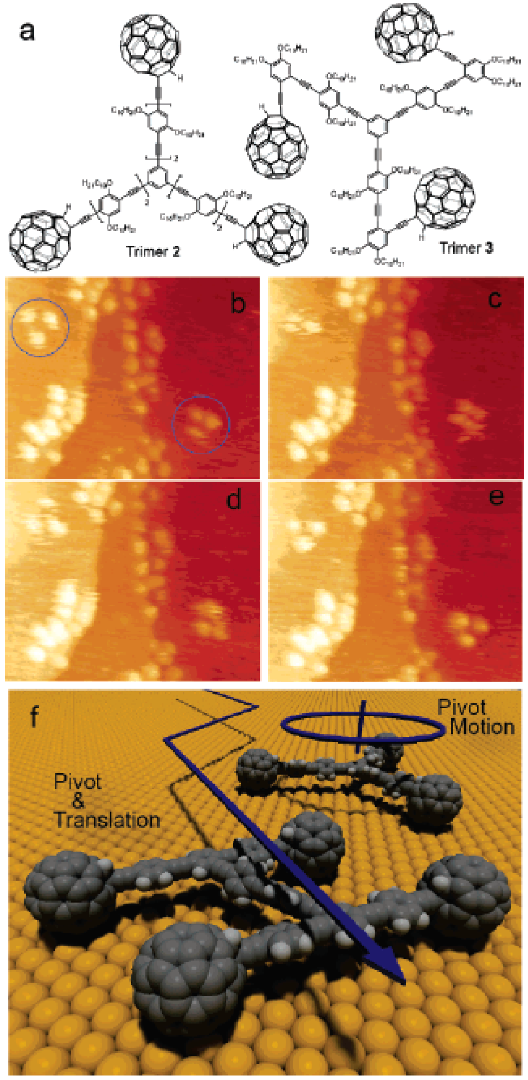
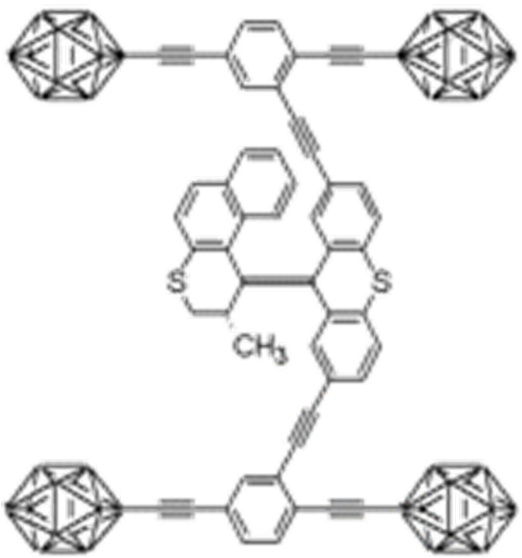


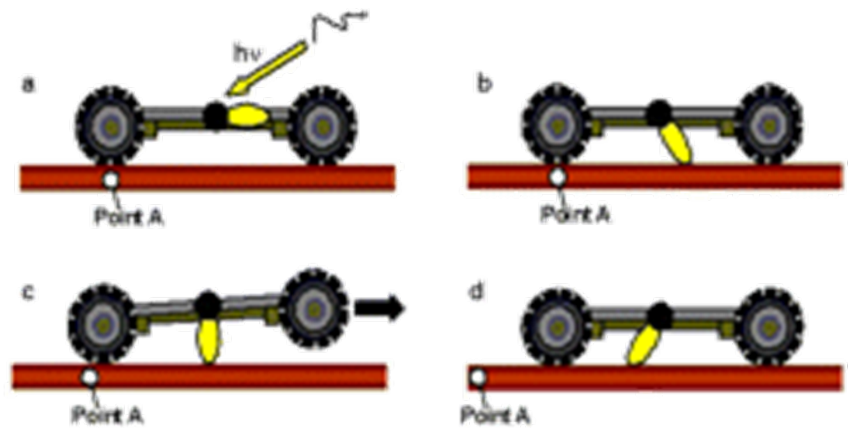
Figure 4. Structure and pivot motion of the trimers. (a) Structure of trimers **2** and **3**. A sequence of STM images (b−e) acquired approximately 1 min apart during annealing at ~225 °C show the pivoting motion of **2** (both circled molecules) and lack of translation in b−e of any molecules. These images were taken from a much

En Route to a Motorized Nanocar (*Org. Lett.*, 8 (8), 1713 -1716, 2006.)

Jean-François Morin, Yasuhiro Shirai, and James M. Tour*

Departments of Chemistry and Mechanical Engineering and Materials Science, and the Smalley Institute for Nanoscale Science and Technology, Rice University, Houston, Texas 77005



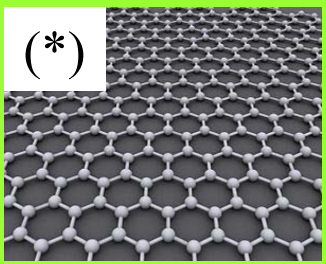


With the eventual goal of demonstrating a motorized nanocar, the key structure has been synthesized which bears a light-activated unidirectional molecular motor and an oligo(phenylene ethynylene) chassis and axle system with four carboranes to serve as the wheels. Kinetics studies in solution show that the motor indeed rotates upon irradiation with 365 nm light, and the fullerene-free carborane wheel system is an essential design feature for motor operation

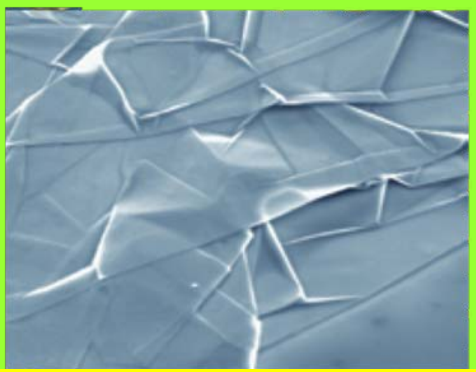
Y ¡LLEGAMOS AL GRAFENO…!

¿Qué es el GRAFENO? Es una forma alotrópica "bidimensional"(*) del Carbono en la que cada átomo está unido a otros tres, por enlace covalente a través de orbitales híbridos sp^2, dando lugar a una estructura hexagonal, como en los panales de abejas. *Es, en cierto modo, como una capa individual de grafito.*

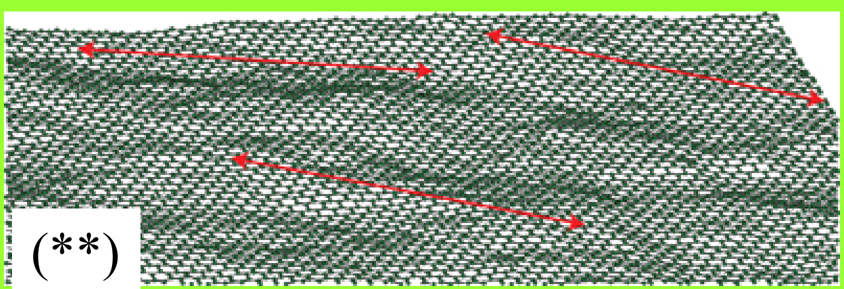
(De acuerdo con la termodinámica, el ***grafeno*** es inestable con relación a otros fullerenos por debajo de 6000 átomos y solo es la forma más estable por encima de 24.000. También es inestable con respecto a la *estructura arrugada* (**), que es el estado de menor energía)



(*)

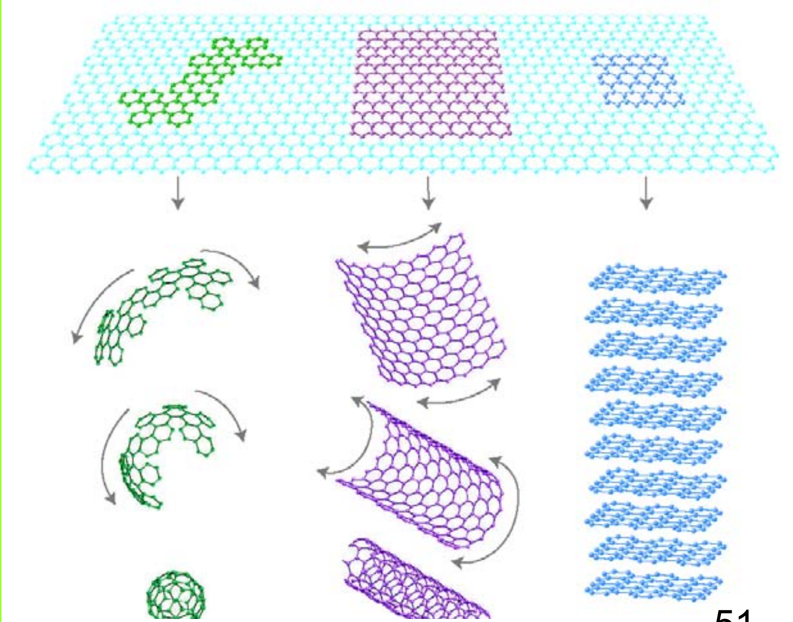


Micrografía electrónica de barrido de una capa arrugada de grafeno



(**)

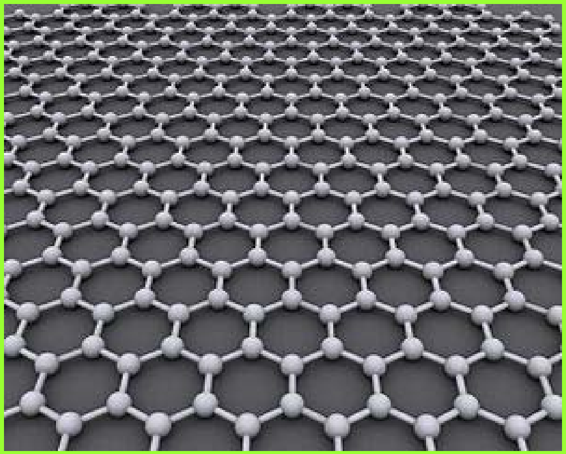
Puede considerarse como ***la estructura madre*** de otras formas alotrópicas del carbono



G & N: Nature materials | VOL 6 | MARCH 2007

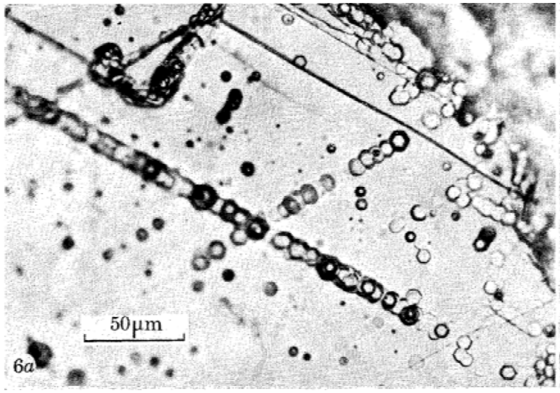
El GRAFENO…

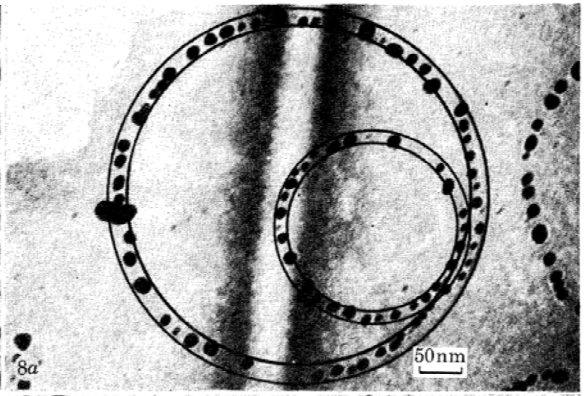
El Premio Nobel que salió del cubo de la basura…

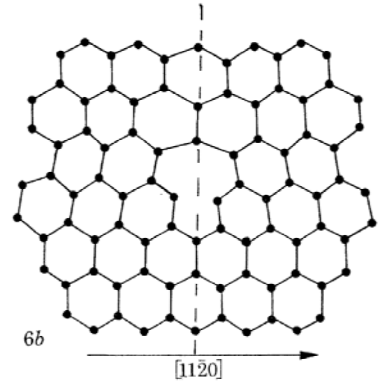


"por sus experimentos pioneros en el material bidimensional GRAFENO"

Dislocaciones y vacantes en grafito: Thomas *et al* 1968 y siguientes…







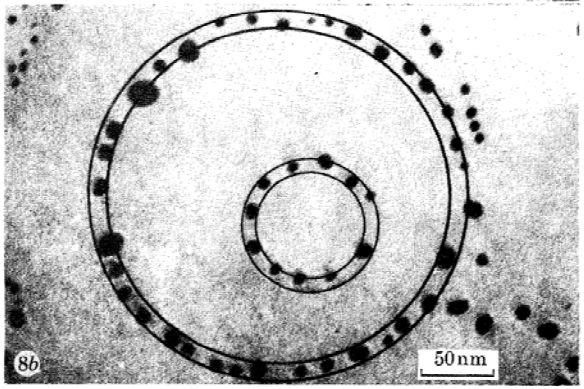
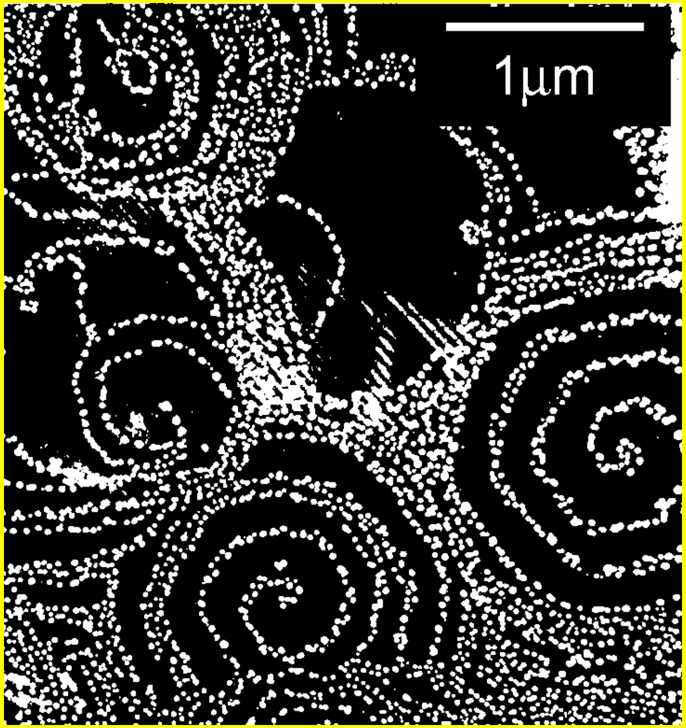


FIGURE 6. (*a*) Optical micrograph of (00*l*) face of partially oxidized graphite, showing intersecting tilt boundaries made up of edge-dislocations of the kind schematized in (*b*). (See Thomas & Roscoe 1968.)

FIGURE 8. Gold-decoration (see text) confirms the picture schematized in figure 7. Circles have been drawn for clarity on the micrographs of the indigenous (*a*) and created (*b*) vacancies (Davies 1972).



The occurrence of emergent screw dislocation (of opposite chirality) at the cleaved basal surface of graphite may be rendered visible by the gold- decoration technique

O. P. Bahl, E. L. Evans and J. M. Thomas, *Proc. R. Soc. London, Ser.* 55.*A*, 1968, **306**, 53.

John Meurig Thomas and Paul A. Midgle. Chem Comm 2004

Imágenes del grafeno

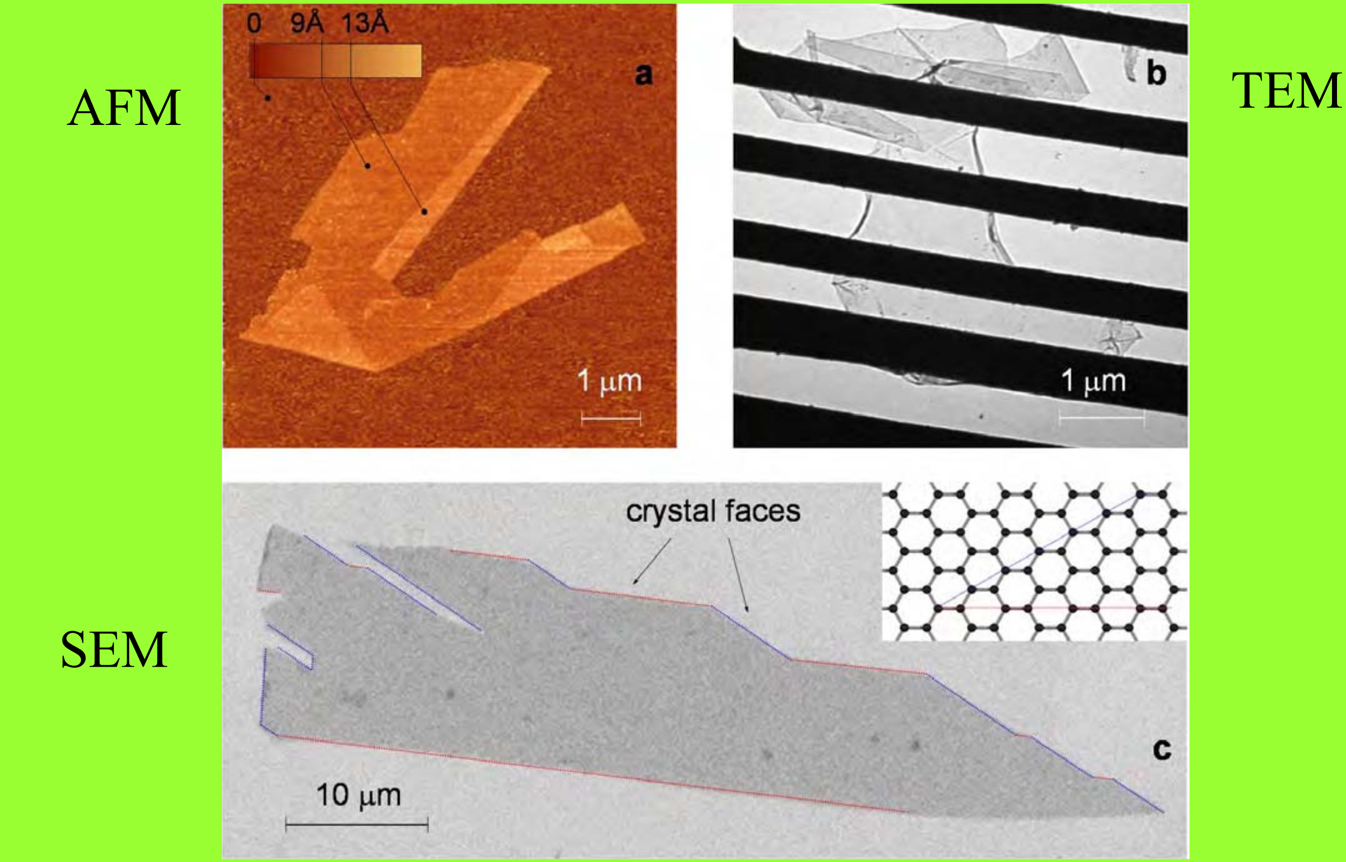
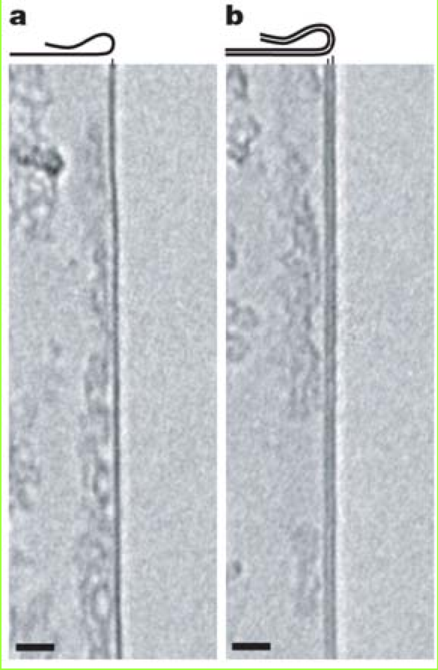


Figure 2. **One-atom-thick single crystals: the thinnest material you will ever see**. **a**, Graphene visualized by atomic-force microscopy (adapted from ref. 8). The folded region exhibiting a relative height of ≈4Å clearly indicates that it is a single layer. **b**, A graphene sheet freely suspended on a micron-size metallic scaffold. The transmission- electron-microscopy image is adapted from ref. 18. **c**, scanning-electron micrograph of a relatively large graphene crystal, which shows that most of the crystal's faces are zigzag and armchair edges as indicated by blue and red lines and illustrated in the inset (*T.J. Booth, K.S.N, P. Blake & A.K.G.* unpublished). 1D transport along zigzag edges and edge-related magnetism are expected to attract significant attention.

THE RISE OF GRAPHENE A.K. Geim and K.S. Novoselov:Manchester Centre for Mesoscience and Nanotechnology, University of Manchester, Oxford Road M13 9PL, United Kingdom

Imágenes del grafeno

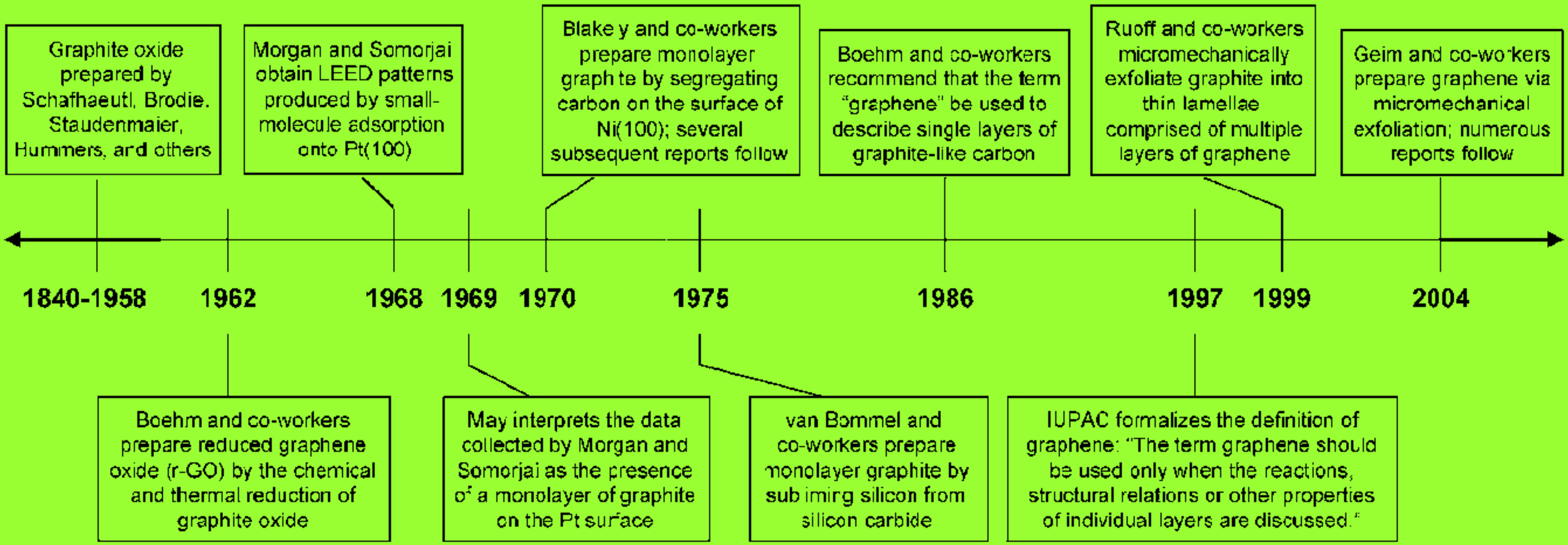
Bright-field TEM image of a suspended graphene membrane. Its central part (homogeneous and featureless region indicated by arrows) is monolayer graphene. Electron diffraction images from different areas of the flake show that it is a single crystal without domains. We note scrolled top and bottom edges and a strongly folded region on the right. Scale bar, 500 nm.



a, b,: TEM images of folded edges for monolayer and bilayer graphene, respectively, using a Philips CM200 TEM. Scale bars, 2 nm.

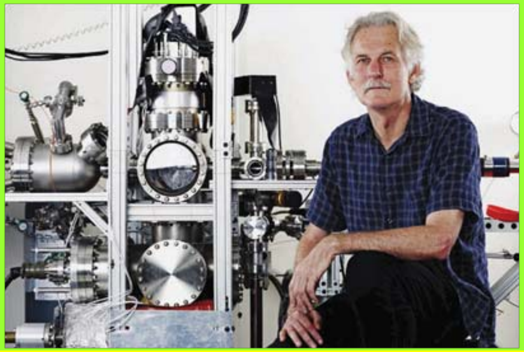
The structure of suspended graphene sheets: Jannik C. Meyer, A. K. Geim, M. I. Katsnelson, K. S. Novoselov, T. J. Booth & S. Roth:Nature 446, 60-63(1 March 2007)

HITOS PRINCIPALES EN EL DESCUBRIMIENTO Y PREPARACIÓN DEL GRAFENO



H.P. Boehm:Angew. Chem. Int. Ed. 2010, 49, 9332 – 9335

Polémica por el Premio Nóbel de 2010



Walter de Heer says that background information supporting the physics award contains inaccuracies.

De Heer says in his letter that Novoselov and Geim did not report measurements on single-layer graphene until 2005 (ref. 2).

2.Novoselov,K.S.etal.Proc.NatlAcad.Sci.US A102, 10451–10453 (2005).

He also says that a 2004 paper by his own group(ref 3) included measurements made on a single layer of graphene, although he did not realize it at the time.

3. Berger,C.etal.J.Phys.Chem.B108,19912–19916 (2004).

According to *Nobel Committee*, Geim and Novoselov galvanized the field with a widely cited 2004 paper. In a caption, the Nobel document describes a figure from the paper as showing data on graphene's electronic properties — but the data were actually collected from a few layers of graphene stacked together, a material better known as graphite. The distinction is significant because the two have different electronic properties.

1. Novoselov,K.S.etal.Science306,666–669 (2004).

Other alleged errors in the document down play the work of Philip Kim of Columbia University in New York, who many think should have shared the prize. When the Manchester group published crucial electronic measurements on graphene in Nature in 2005

4. Novoselov, K. S. et al. Nature 438, 197–200 (2005)

The paper appeared back-to-back with one from Kim's group (5).

"He made an important contribution and I would gladly have shared the prize with him," says Geim.

5. Zhang, Y. et al. Nature 438, 201–204 (2005).

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¿Y, CUALES SON LAS PROPIEDADES DEL GRAFENO QUE LE HACEN TAN IMPORTANTE Y FAMOSO?

Graphene is a one atom thick layer made of carbon. It is a transparent and flexible metal, which shows a number of unique features, not found together in any other material: graphene conducts electricity better than copper and silver, it is the stiffest material known, chemically intert and biocompatible, it can be stretched reversibly much more than other systems, the electrons inside behave in a similar manner to relativistic high energy elementary particles, …

GRAFENO: UNA ACCIÓN MOVILIZADORA EN UN CAMPO EMERGENTE Acción complementaria MAT2010-12279-E

F. Guinea: http://www.gecarbon.org/Boletines/articulos/boletinGEC_019_art.2.pdf

http://graphene-flagship.eu/

Y, PARA TERMINAR…

IBM researchers make world's smallest movie using atoms (w/video)

http://www.nanowerk.com/news2/newsid=30271.php?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+NanowerkEmergingTechnologiesNews+%28Nanowerk+Emerging+Technologies+News%29#at_pco=cfd-1.0

FIN
THE END

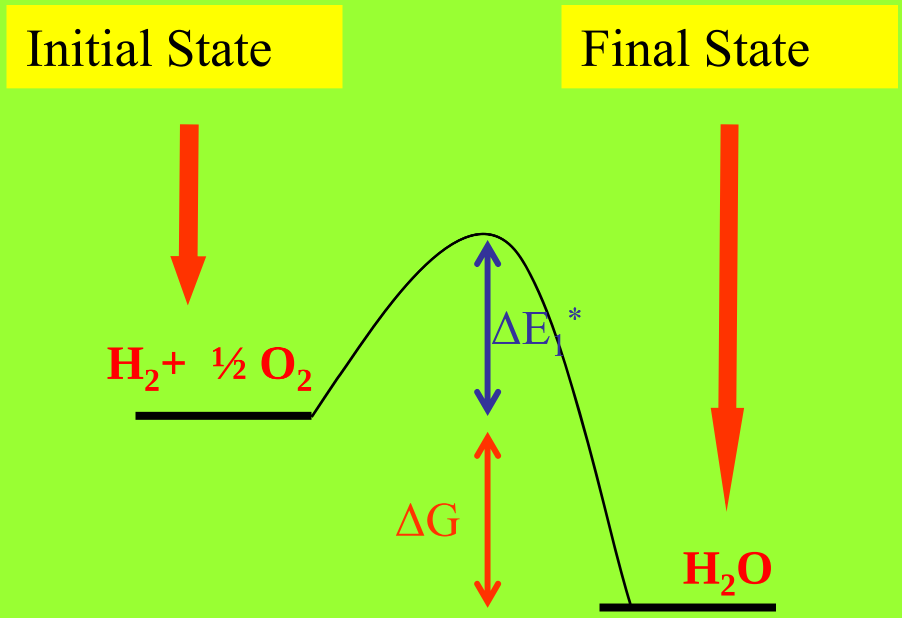

THANK
you!

Nanotubes in Catalysis

The Nanotube Effect ¡

Nanotubes in Catalysis

Exemple of an oxidation reaction: $H_2 + ½\ O_2 = H_2O$



Without a catalyst

ΔE_1^*

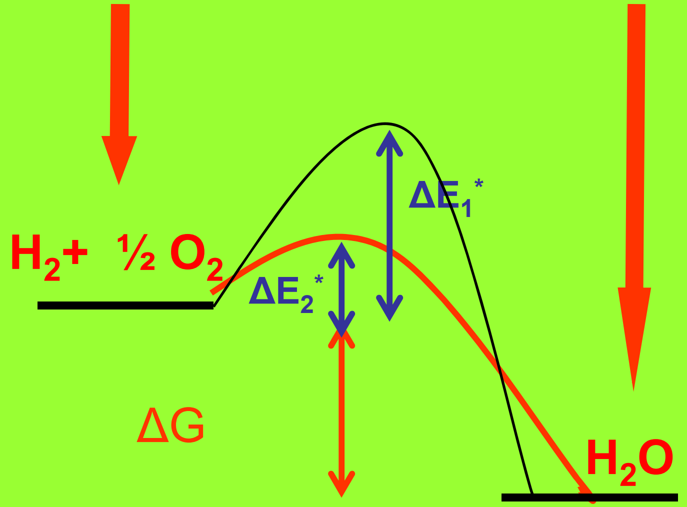
Nanotubes in Catalysis

Exemple of an oxidation reaction: $H_2 + \frac{1}{2} O_2 = H_2O$

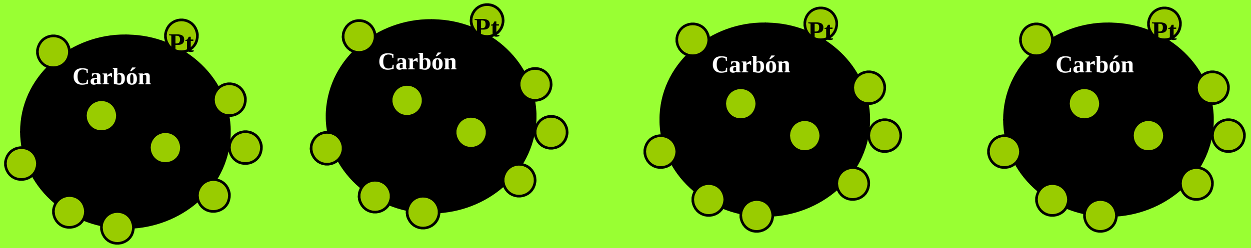
Initial State

Final State

With a catalyst ΔE_2^*



TEM of catalyst



Ethanol production from *Syngas*

1) $CO + 3/2\ H_2 = CH_2OH$

2) $3CO + 5H_2\ (\text{Rh catalyst}/SiO_2) = CH_3\text{-}CH_2OH + 2H_2O$

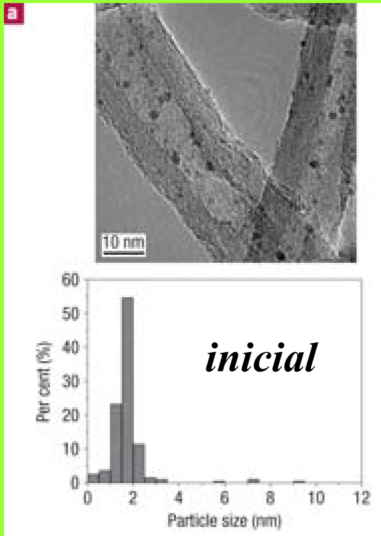
$CH_3\text{-}COOH$

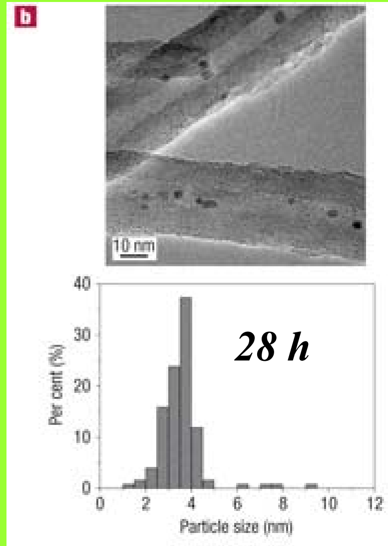
(Belgian Patent 824822)

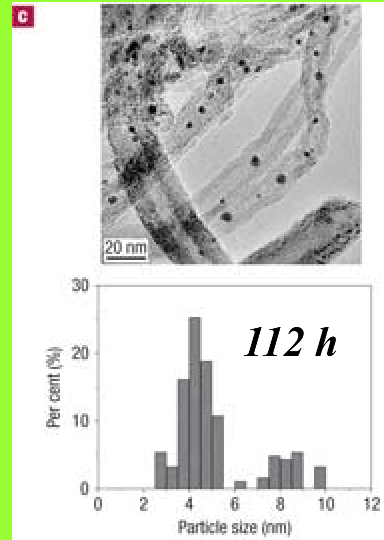
$CH_3\text{-}COH$

$$\left.\begin{array}{l} 3)\ CH_3\text{-}CH_2OH \\ \\ CH_3\text{-}COOH \\ \\ CH_3\text{-}COH \end{array}\right\} + H_2 = CH_3\text{-}CH_2OH$$

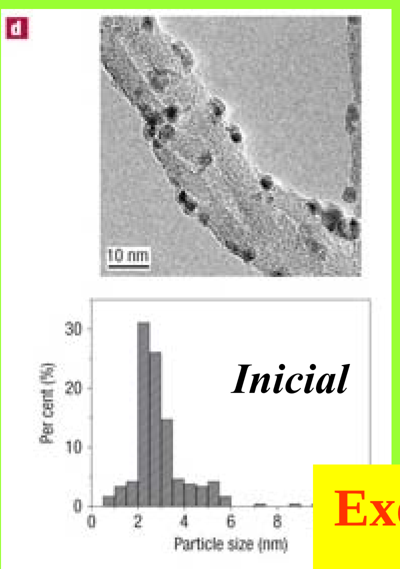
Nanotubes in Catalysis: *Yield*



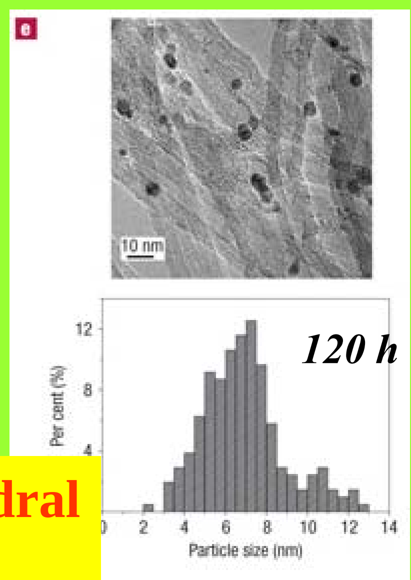


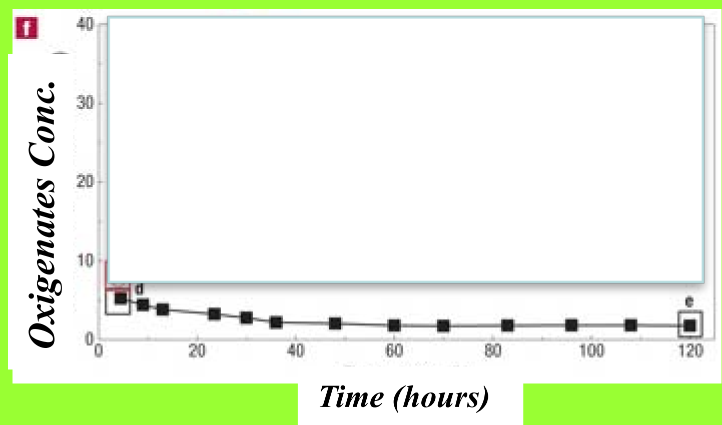


Endohedral Catalyst

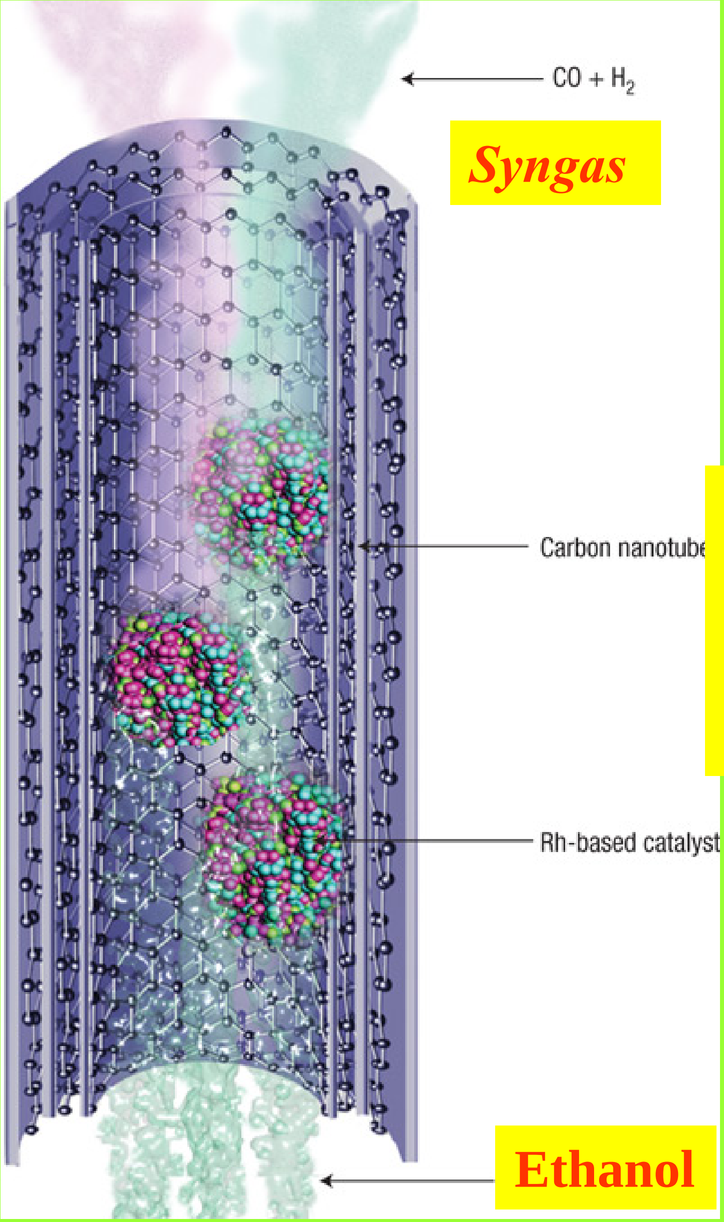


Exohedral Catalyst





Nanotube Effect ¡



Nanotubes in Catalysis

(Schematic)

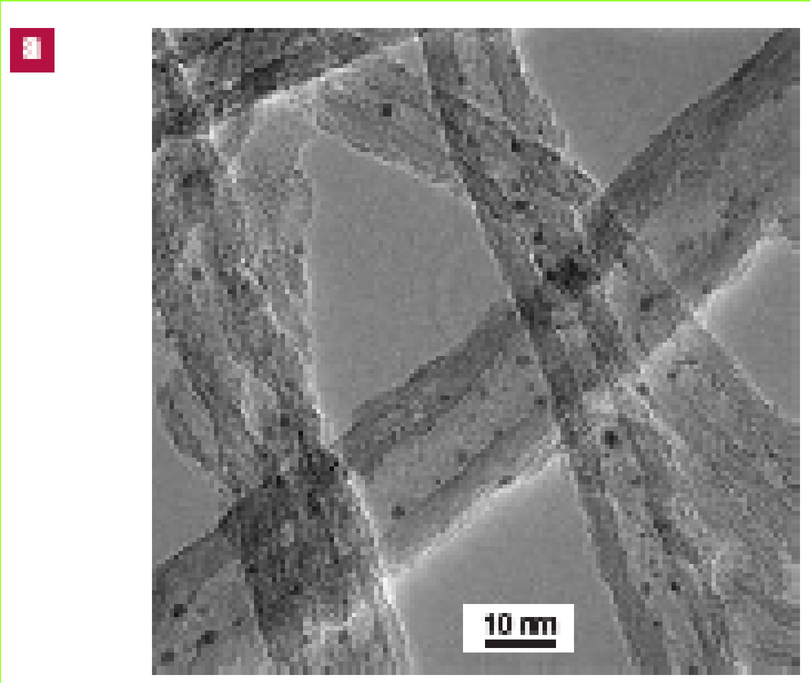
[Enhanced ethanol production inside carbon-nanotube reactors containing catalytic particles]

Xiulian Pan, Zhongli Fan, Wei Chen, Yunjie Ding, Hongyuan Luo & Xinhe Bao

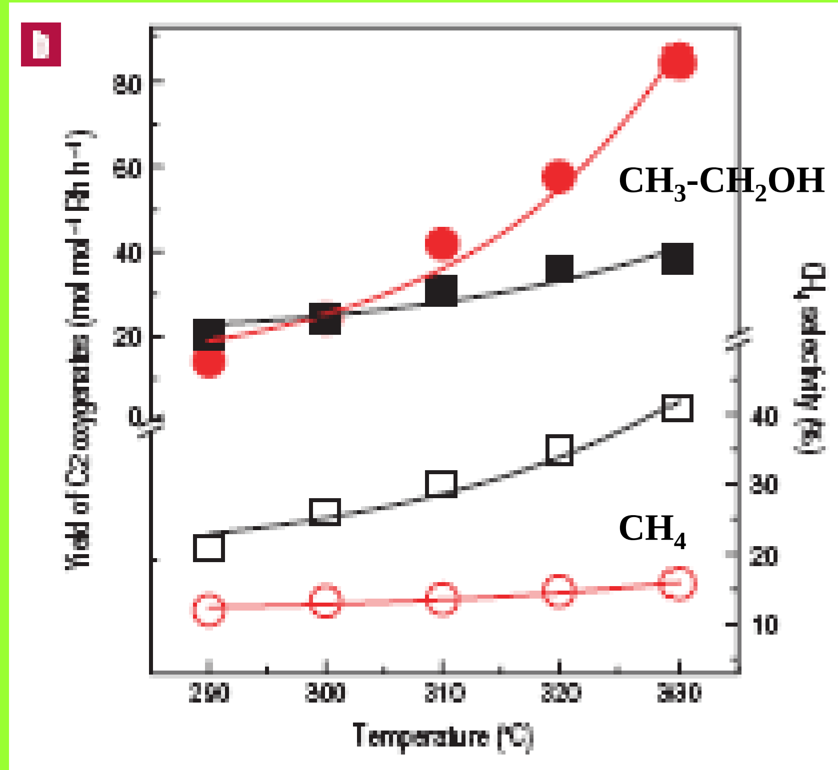
***Nature Materials* 6**, *507 - 511 (2007)*

Nanotube Effect ¡

Nanotubes in Catalysis: *Selectivity*



Endohedral Catalyst : 80 %



□ Rh/SiO_2

○ Rh/CNT

Full Symbols: Ethanol yield

EmptySymbols: Methane yield

Nanotube Effect ¡

Feynman Idont like honours:Nobel Prize, Academies¡¡¡
http://www.youtube.com/watch?v=f61KMw5zVhg

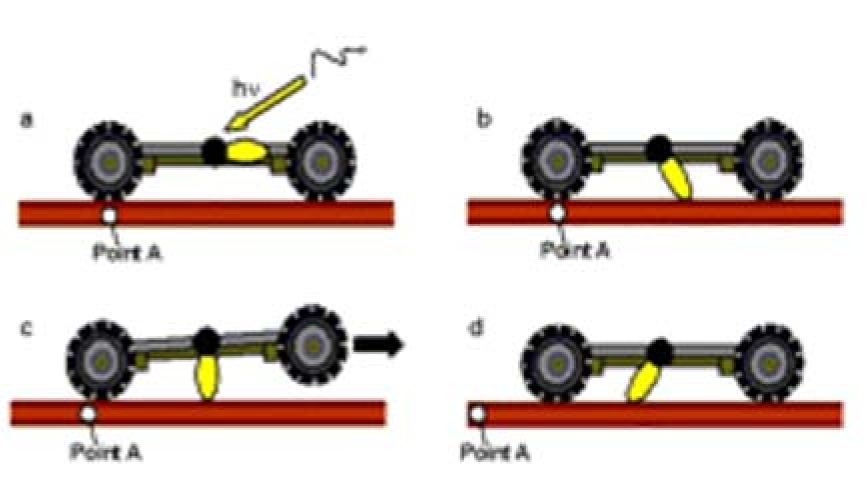
Richard Feynman: Not Knowing Things
http://www.youtube.com/watch?NR=1&feature=fvwp&v=E1RqTP5Unr4

FEYNMAN: Disrespect for authority
http://www.youtube.com/watch?v=yhD0MxacnIE&feature=endscreen&NR=1

FEYNMAN: Space Shuttle Challenger Investigation
http://www.youtube.com/watch?v=UCLgRyKvfp0&feature=topics

Richard Feynman on pseudosciences:
http://www.youtube.com/watch?v=HtMX_0jDsrw&feature=related

FEYNMAN: The importance of a father
http://www.youtube.com/watch?v=695Flhmjmg4&feature=related



Ya que tenemos AUTO-MÓVIL…podemos terminar….

¡Gracias por su atención!

Feynman Idont like honours:Nobel Prize, Academies¡¡¡
http://www.youtube.com/watch?v=f61KMw5zVhg

Richard Feynman: Not Knowing Things
http://www.youtube.com/watch?NR=1&feature=fvwp&v=E1RqTP5Unr4

FEYNMAN: Disrespect for authority
http://www.youtube.com/watch?v=yhD0MxacnIE&feature=endscreen&NR=1

FEYNMAN: Space Shuttle Challenger Investigation
http://www.youtube.com/watch?v=UCLgRyKvfp0&feature=topics

Richard Feynman on pseudosciences:
http://www.youtube.com/watch?v=HtMX_0jDsrw&feature=related

FEYNMAN: The importance of a father
http://www.youtube.com/watch?v=695Flhmjmg4&feature=related

“This field is not quite the same as the others in that it will not tell us much of fundamental physics (in the sense of, ``What are the strange particles?") but it is more like solid-state physics in the sense that it might tell us much of great interest about the strange phenomena that occur in complex situations”.

View the Milky Way at 10 million light years from the Earth. Then move through space towards the Earth in successive orders of magnitude until you reach a tall oak tree just outside the buildings of the National High Magnetic Field Laboratory in Tallahassee, Florida. After that, begin to move from the actual size of a leaf into a microscopic world that reveals leaf cell walls, the cell nucleus, chromatin, DNA and finally, into the subatomic universe of electrons and protons.

http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/

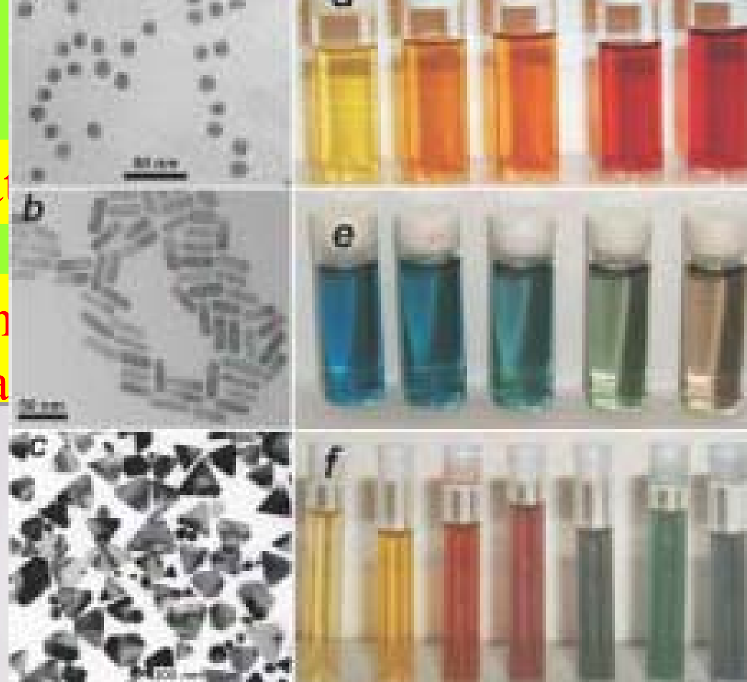
EN CIENCIA ¿VALE TODO?

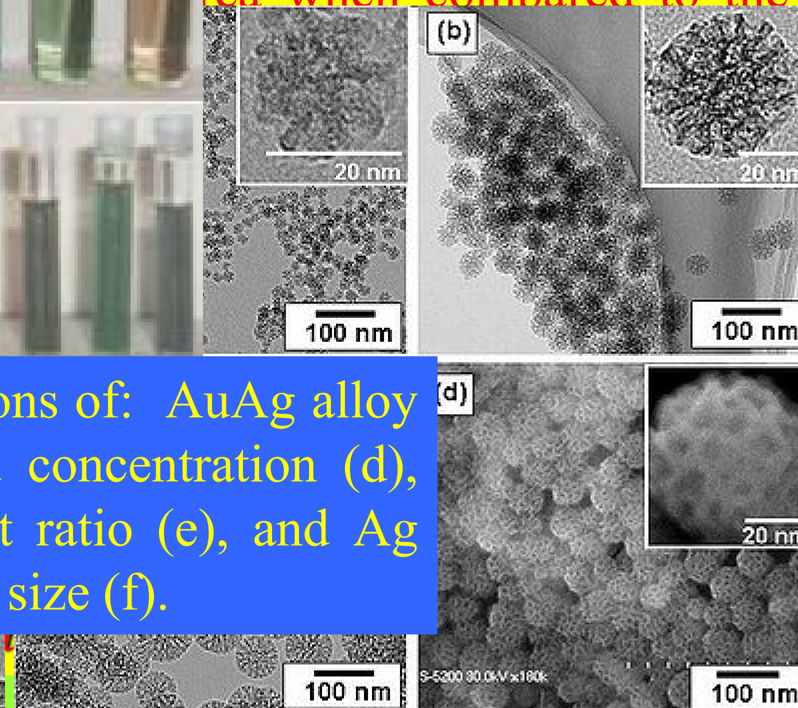
EN CIENCIA: ¡ TODO VALE!

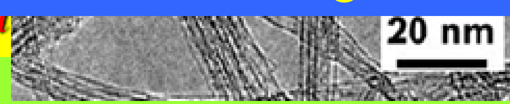
http://www.nanowerk.com/news2/newsid=30271.php?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+NanowerkEmergingTechnologiesNews+%28Nanowerk+Emerging+Technologies+News%29#at_pco=cfd-1.0

The properties of ma … cale for two main reasons

First, nanomaterials h … rea when compared to the same mass of materia …







Photographs of colloidal dispersions of: AuAg alloy nanoparticles with increasing Au concentration (d), Au nanorods of increasing aspect ratio (e), and Ag nanoprisms with increasing lateral size (f).

Materials can be produced that are nanoscale in :
one dimension (for example, very thin surface coatings),
two dimensions (for example, nanowires and nanotubes)
all three dimensions (for example, nanoparticles).

Sir Harry Kroto:
http://youtu.be/0Vh8PQXC9po

http://youtu.be/B9QK4wjlCyw

Feynman on Pseudoscience

http://youtu.be/SVrkfiQHEsI

Feynman on Certitude

http://youtu.be/Ys0Oy2cjUgY

FEYNMAN ON HONORS¡

UHV STM of 1nm C60 molecules

http://www.nanoscience.com/education/gallery/c60_ani.html

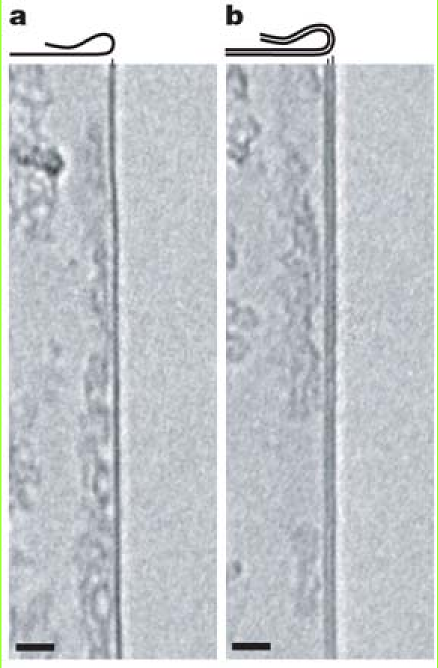
UHV-STM image of three one-nm-diameter C60 molecules adsorbed on Si missing dimmer rows. Courtesy: Dror Sarid, University of Arizona.

Graphene is the future. Plain and simple. It's 200 times stronger than steel, thinner than a sheet of paper, and more conductive than copper.

Researchers the world over are using it for critical advances in a variety of industries. Graphene makes:
Solar – 50x-100x more efficient
Semiconductors – 50x-100x faster
Aircraft – 70% lighter
We're talking batteries that charge 10x faster and store 10x more power...
Phones and computer displays that bend and fold...
And even the potential to make people and things completely invisible.
Indeed, the Huffington Post notes graphene will “change the world.”
It's so vital to our future that it's been named a "supply critical mineral" and a "strategic mineral" by the United States and the European Union.

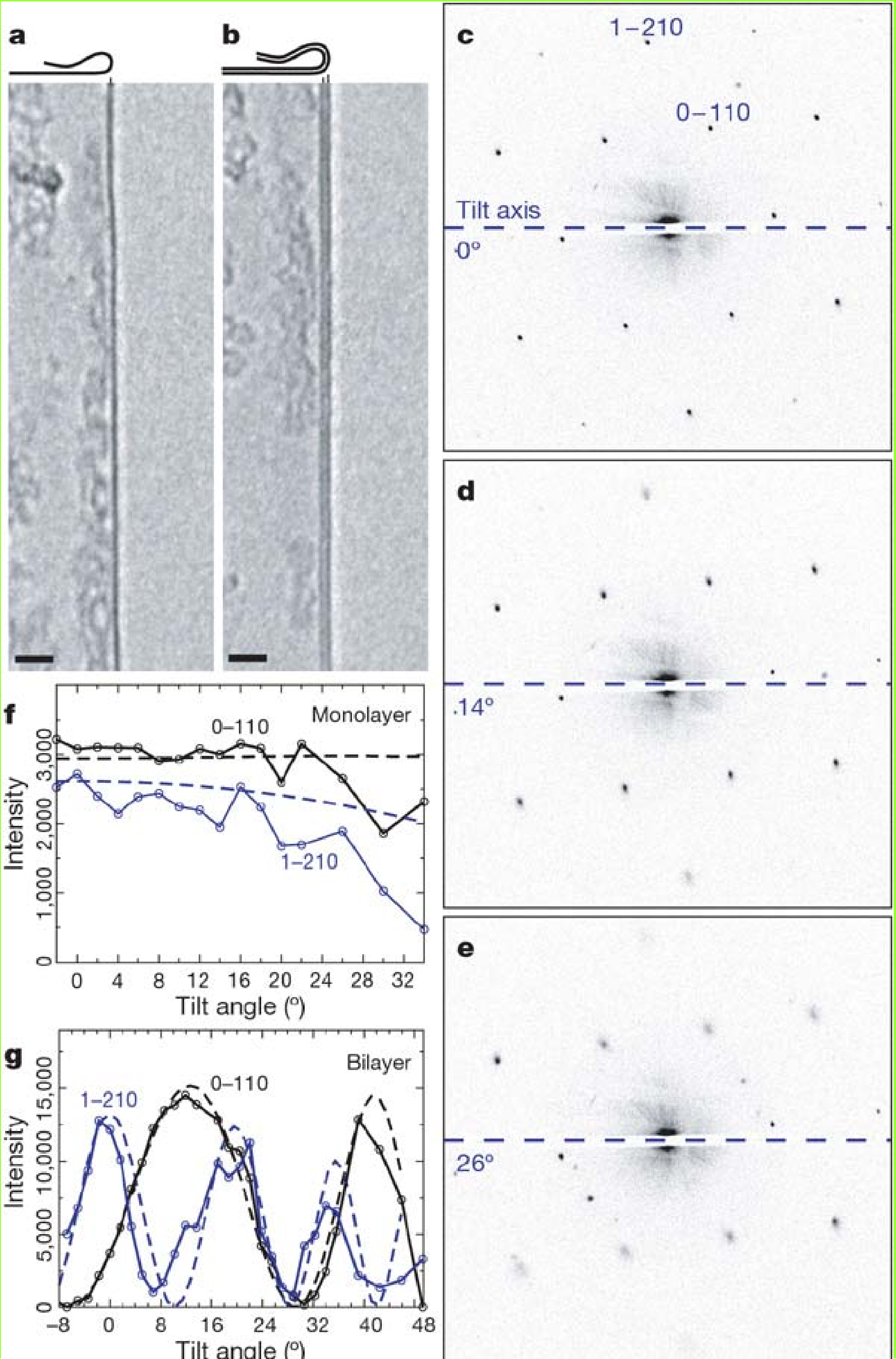
Imágenes del grafeno

Bright-field TEM image of a suspended graphene membrane. Its central part (homogeneous and featureless region indicated by arrows) is monolayer graphene. Electron diffraction images from different areas of the flake show that it is a single crystal without domains. We note scrolled top and bottom edges and a strongly folded region on the right. Scale bar, 500 nm.

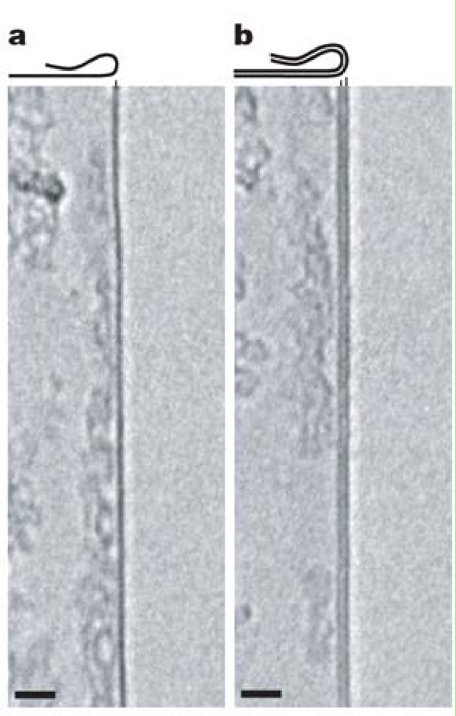


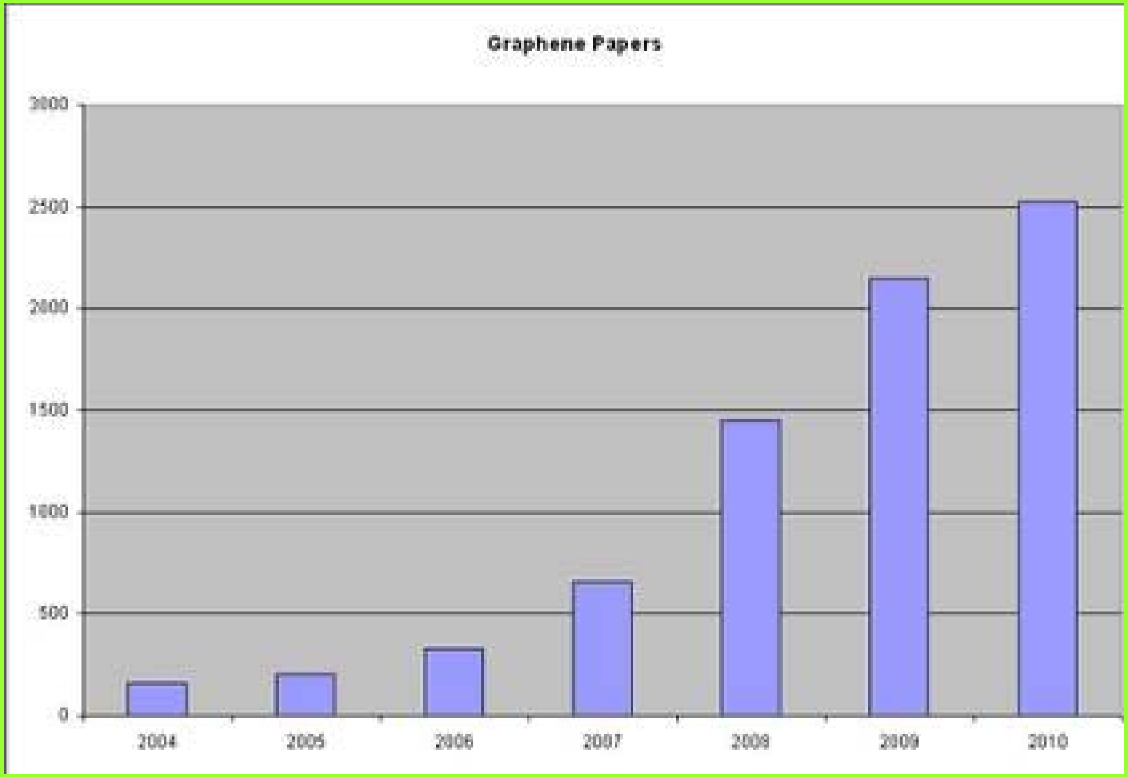
a, b,: TEM images of folded edges for monolayer and bilayer graphene, respectively, using a Philips CM200 TEM. Scale bars, 2 nm.

The structure of suspended graphene sheets: Jannik C. Meyer, A. K. Geim, M. I. Katsnelson, K. S. Novoselov, T. J. Booth & S. Roth:Nature 446, 60-63(1 March 2007)



a
b
c
1−210
0−110
Tilt axis
0°
d
14°
e
26°
f
Monolayer
0−110
1−210
Intensity
Tilt angle (°)
g
Bilayer
0−110
1−210
Intensity
Tilt angle (°)


a
b



Graphene Papers
3000
2500
2000
1500
1000
500
0
2004
2005
2006
2007
2008
2009
2010

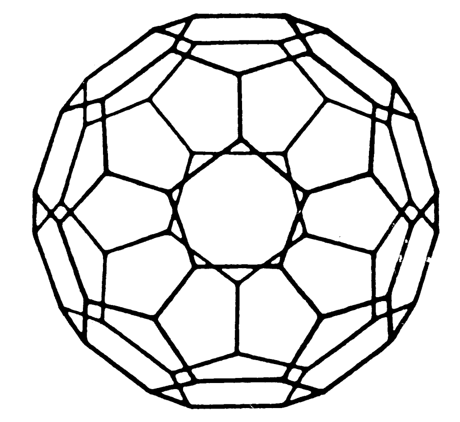
Since the announcement of the prizes in October, there has been controversy over the physics prize. The Nobel Committee awarded Geim and Novoselov for "groundbreaking experiments regarding the two-dimensional material graphene". However, the document issued by the Nobel Commitee for Physics to explain its awarding is reported to have contained several errors that raised questions about the decision. Among them, was data cited from a 2004 paper of the prize winners showing the electronic properties of graphene, yet the data actually related to thin sections of graphite, which has different electronic properties. According to Walter de Heer, Georgia Institute of Technology, Atlanta, USA, Geim and Novoselov did not report measurements on single-layer graphene until 2005.

Andre Geim

Konstantin Novoselov

for groundbreaking experiments regarding
the two-dimensional material graphene"

Why are they called FULLERENES?

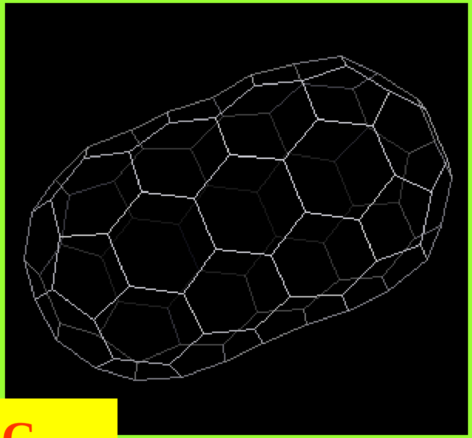


C_{60} :Buckminster*fullerene*

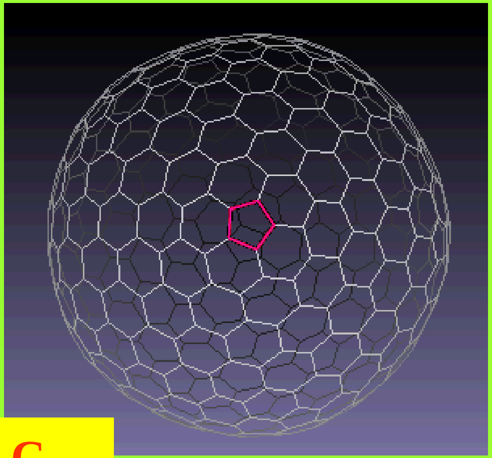
R. Buckminster Fuller

The biggest fullerene?

The smallest fullerene?

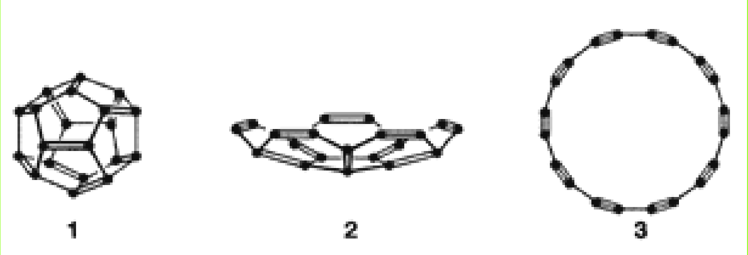


C_{100}



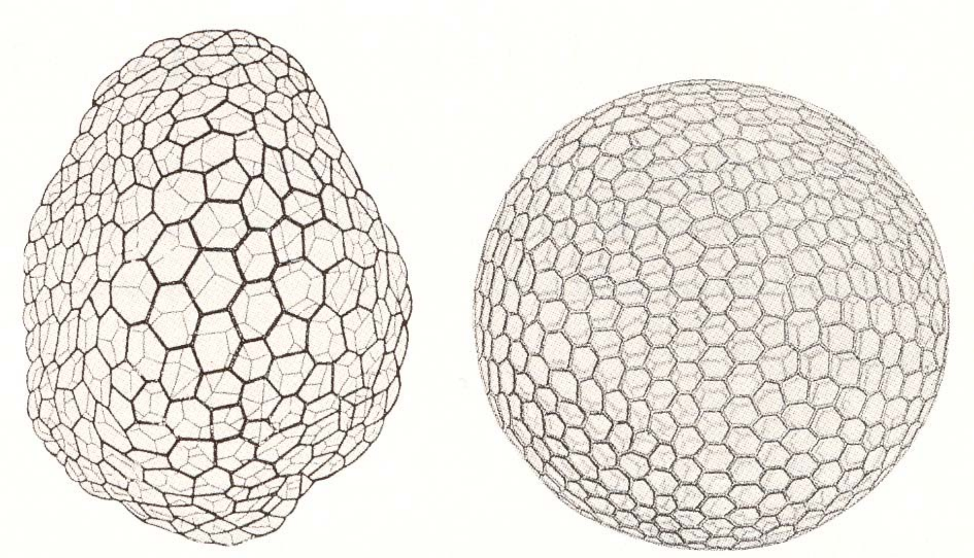
C_{540}

C_{20} : Pentagonal Dodecahedron



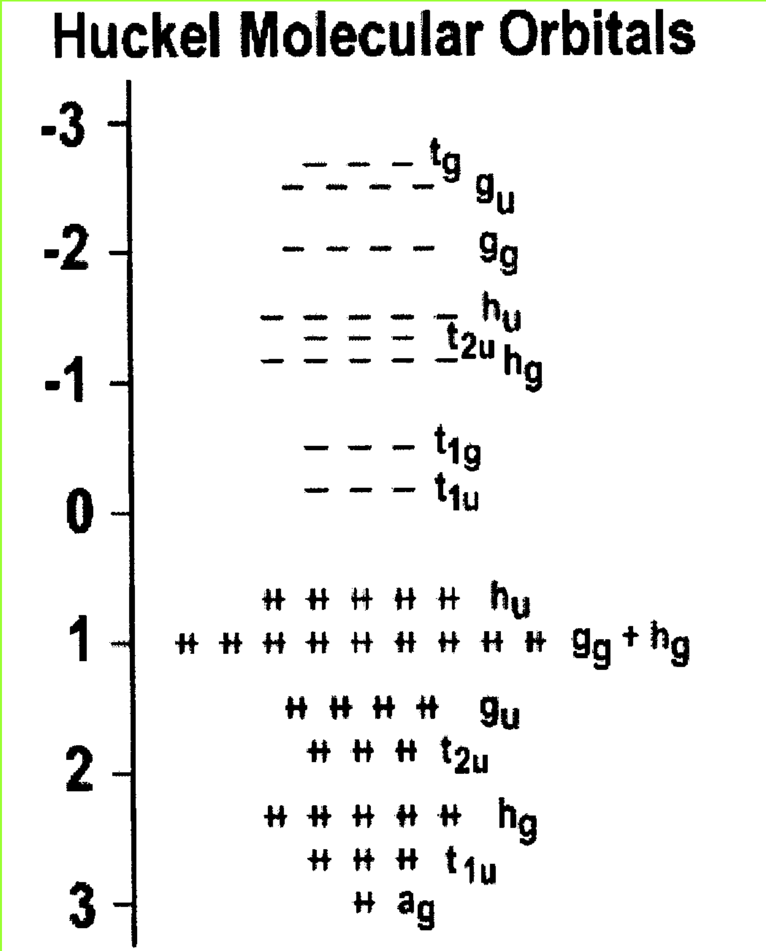
Cage *Bowl* *Ring*

3 Isomers



LIVING FULLERENES: these radiolarians—protozoans having siliceous skeletons—appear in D'Arcy Thompson's 1917 classic, *On Growth and Form*.

SOLID C_{60}: Electrical Conductivity & Superconductivity

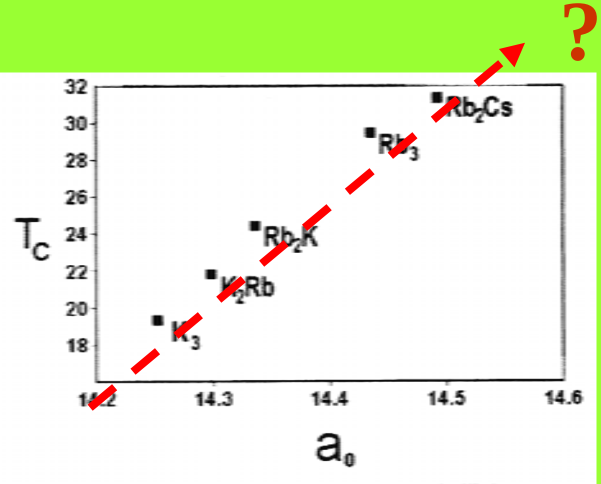


C_{60}: Insulator

$A_3 C_{60}$: M/SC

$A_6 C_{60}$:Insulator

?

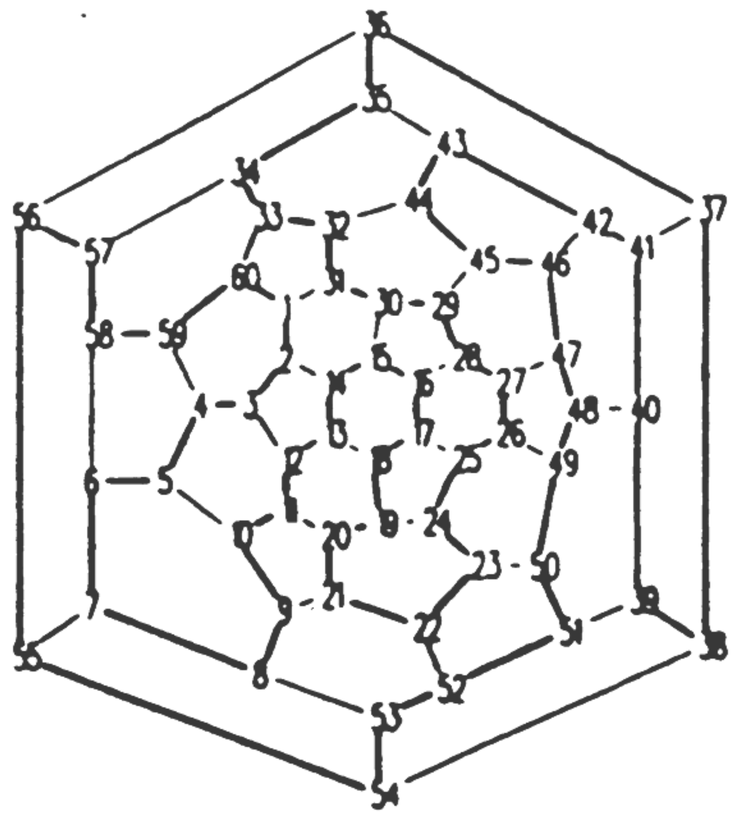


The A_3C_{60} phase is a conductor at room temperatura due to the partial filling of the t_{1u} "conduction band". Electrons can move between C_{60} molecules through the radiating π-orbitals. At low temperatura, A_3C_{60} becomes super-conducting. In contrast, the A_6C_{60} phase is an insulator due to the complete filling of the t_{1u}- orbitals.

Nombre oficial

-IUPAC

Hentriacontacyclo[29.29.0.0^{2,14}.0^{3,12}.0^{4,59}.0^{5,10}.0^{6,58}.0^{7,55}.0^{8,53}.0^{9,21}.0^{11,20}.0^{13,18}.0^{15,30}.0^{16,28}.0^{17,25}.0^{19,24}.0^{22,52}.0^{23,50}.0^{26,49}.0^{27,47}.0^{29,45}.0^{32,44}.0^{33,60}.0^{34,57}.0^{35,43}.0^{36,56}.0^{37,41}.0^{38,54}.0^{39,51}.0^{40,48}.0^{42,46}]hexaconta-1,3,5(10),6,8,11,13(18),14,16,19,21,23,25,27,29(45),30,32(44),33,35(43),36,38(54),39(51),40(48),41,46,49,52,55,57,59-triacontaene



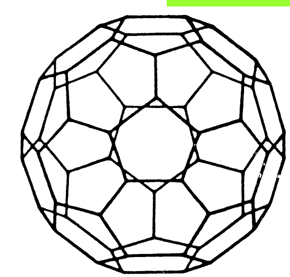
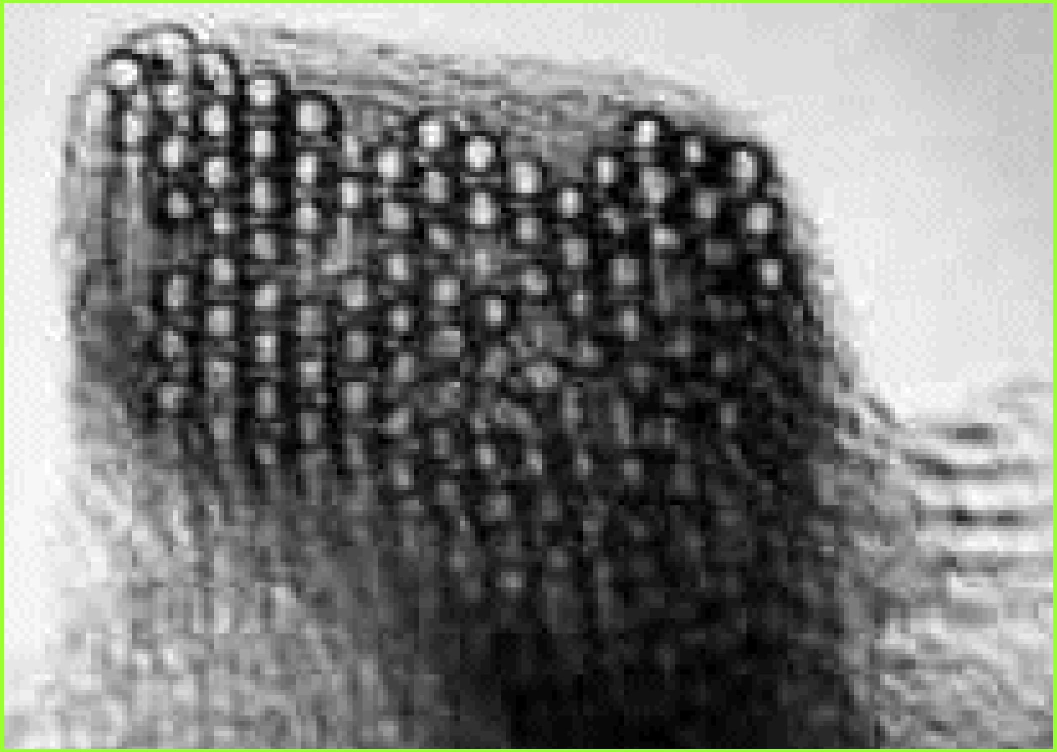
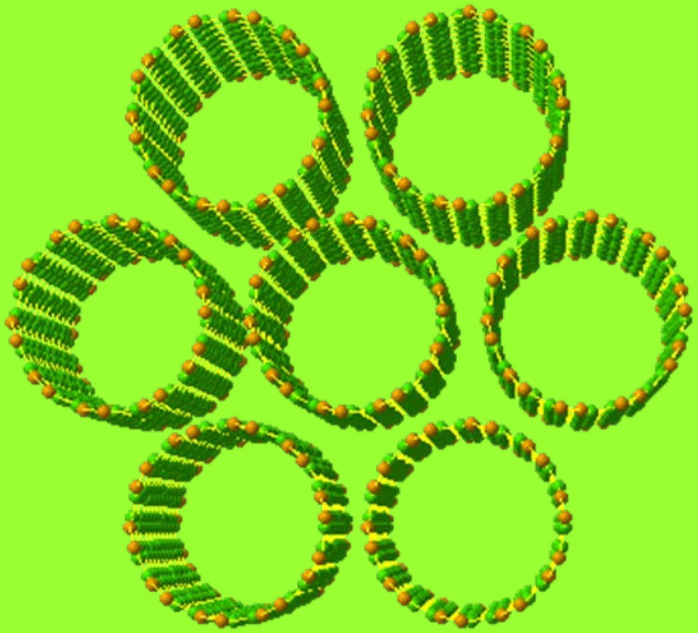


Figure 7. The IUPAC name of fullerene-60 determined by computer analysis—according to P. Rose.[47]

Nanotubes Bundles: Cuerdas de nanotubos



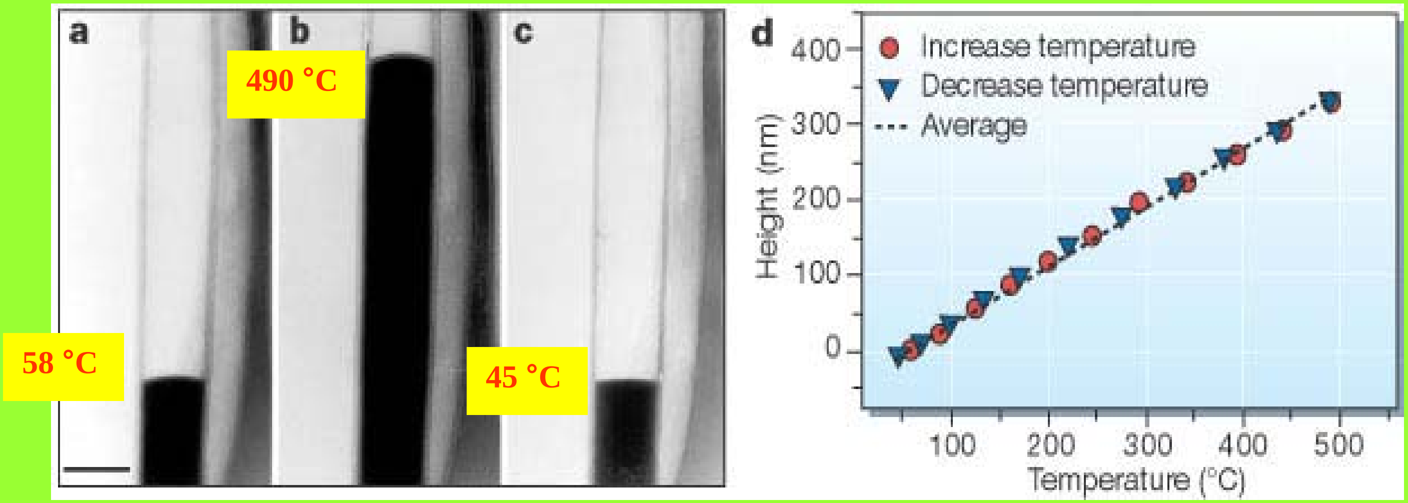
Micrografía electrónica de una "cuerda" de unos 100 nanotubos monopared de diametro uniforme



Un Manojo (*Bundle*)

An interesting application of nanotubes¡

A Gallium thermometer in a carbon nanotube



Expansion of gallium inside a carbon nanotube with increasing temperature. a–c, Changing level of the gallium meniscus at 58 ℃ (a), 490 ℃ (b) and 45 ℃ (c); scale bar, 75 nm. d, Height of the gallium meniscus plotted against temperature, measured in steps of 30–50 ℃; results are averaged (green curve) from closely similar measurements obtained during heating (red) and cooling (blue). The nanothermometer was synthesized in a vertical radiofrequency furnace (which differs from a one-step arc-discharge method). A homogeneous mixture of Ga_2O_3 and pure, amorphous, active carbon (weight ratio, 7.8:1) was reacted in an open carbon crucible under a flow of pure N_2 gas: at 1,360 ℃, the reaction Ga_2O_3(solid) + 2C(solid) Ga_2O(vapour) + 2CO(vapour) occurs. However, on the inner surface of a pure graphite outlet pipe at the top of the furnace, the temperature is lower (around 800 ℃), causing the reaction Ga_2O(vapour) + 3CO(vapour) 2Ga(liquid) + C(solid) + $2CO_2$(vapour) to occur, during which the 'nanothermometers' are created.

http://www.youtube.com/watch?feature=endscreen&NR=1&v=05WS0WN7zMQ

Feynman Idont like honours:Nobel Prize, Academies¡¡¡
http://www.youtube.com/watch?v=f61KMw5zVhg

Richard Feynman: Not Knowing Things
http://www.youtube.com/watch?NR=1&feature=fvwp&v=E1RqTP5Unr4

FEYNMAN: Disrespect for authority
http://www.youtube.com/watch?v=yhD0MxacnIE&feature=endscreen&NR=1

FEYNMAN: Space Shuttle Challenger Investigation
http://www.youtube.com/watch?v=UCLgRyKvfp0&feature=topics

Richard Feynman on pseudosciences:
http://www.youtube.com/watch?v=HtMX_0jDsrw&feature=related

FEYNMAN: The importance of a father
http://www.youtube.com/watch?v=695Flhmjmg4&feature=related

FEYNMAN: EL PLACER DE DESCUBRIR
https://www.youtube.com/watch?v=1Nz7Pml4oPY

LA INCERTIDUMBRE DEL CONOCIMIENTO
https://www.youtube.com/watch?v=xjGjcNg9GQw

Feynman Idont like honours:Nobel Prize, Academies¡¡¡
http://www.youtube.com/watch?v=f61KMw5zVhg

FEYNMAN: Disrespect for authority
http://www.youtube.com/watch?v=yhD0MxacnIE&feature=endscreen&NR=1

Algunas aplicaciones –POTENCIALES- de los nanotubos

Nanoelectrónica

NANOMECÁNICA

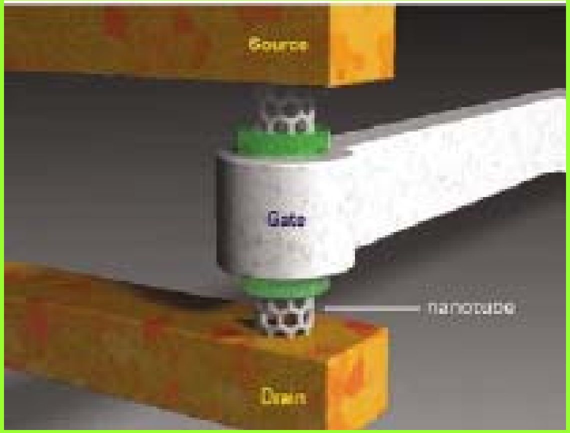
Catálisis

Sensores de gases

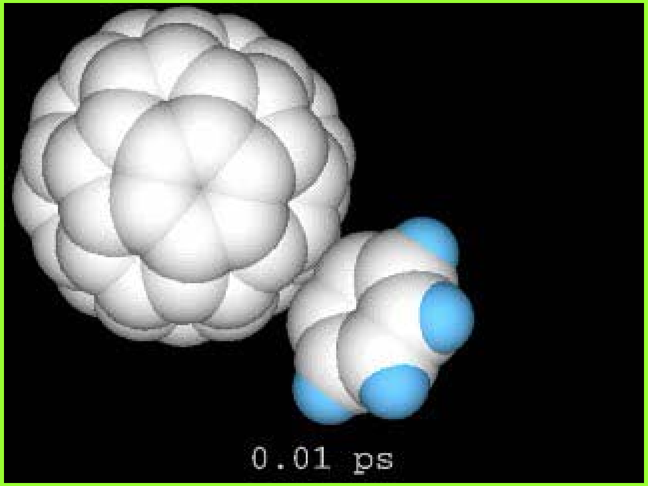
Cerámicas

Materiales compuestos

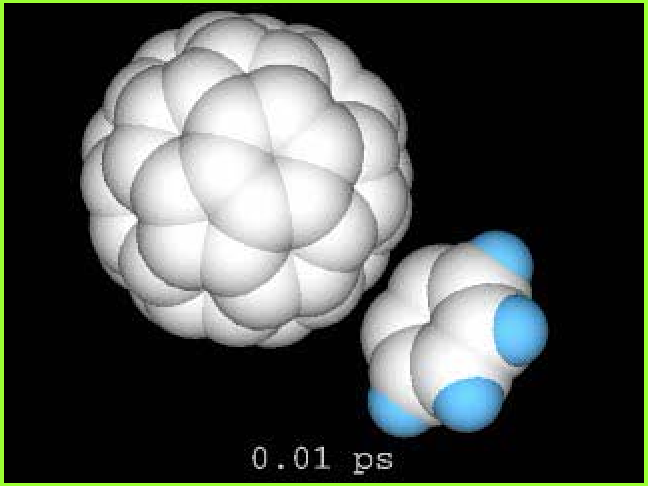
……

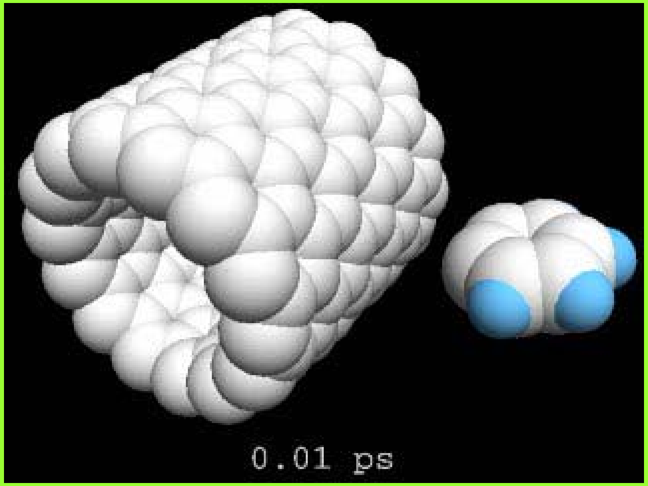


“Fabricación” de nanoengranajes

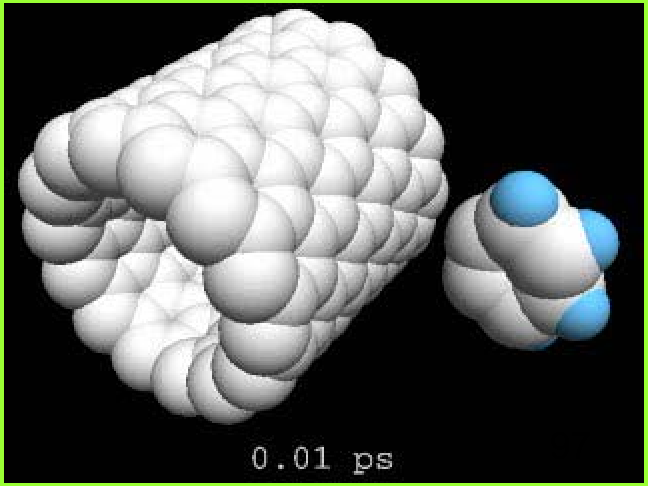


$C_{60} + C_6H_6$

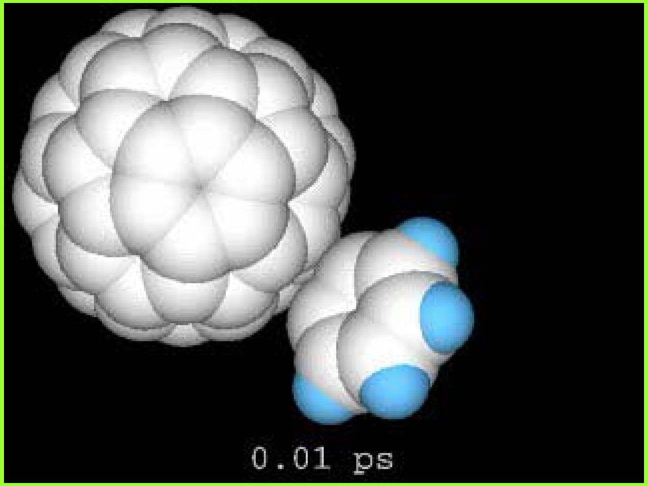




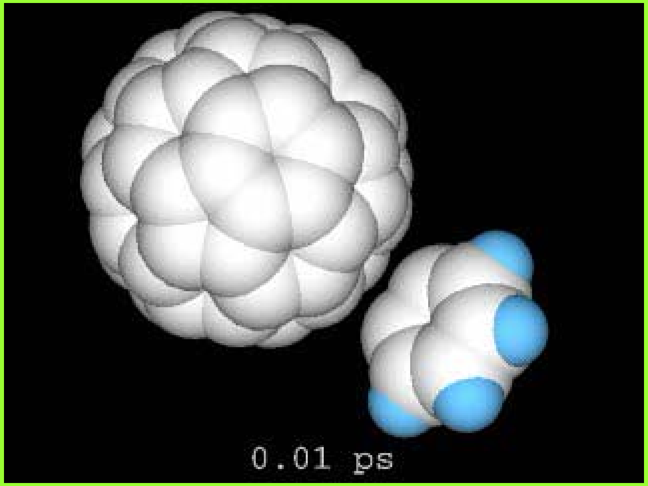
Nano + C_6H_6

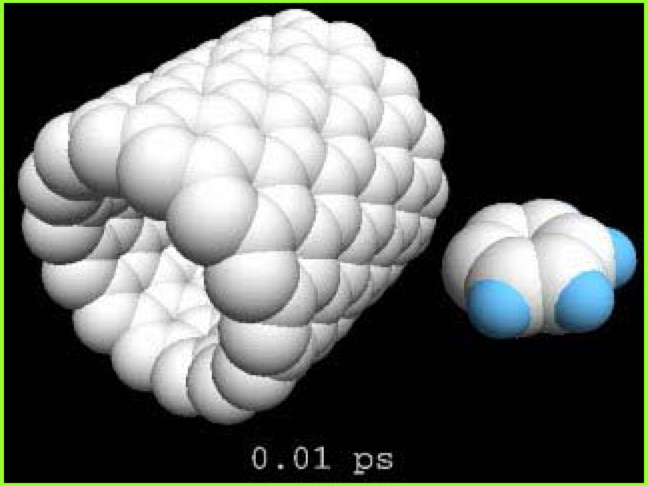


"Fabricación" de nanoengranajes

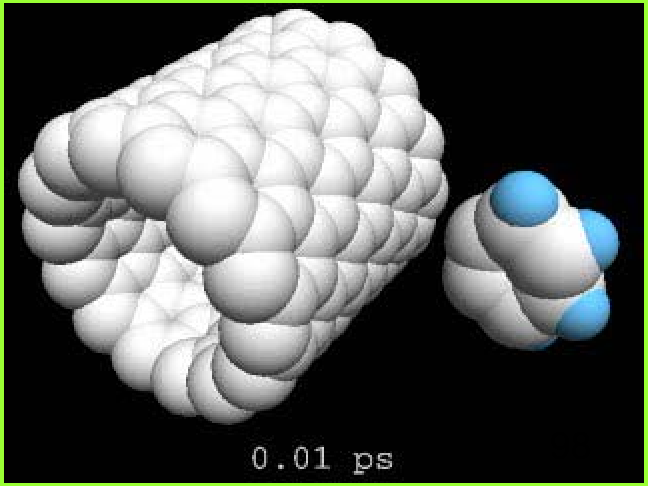


$C_{60} + C_6H_6$

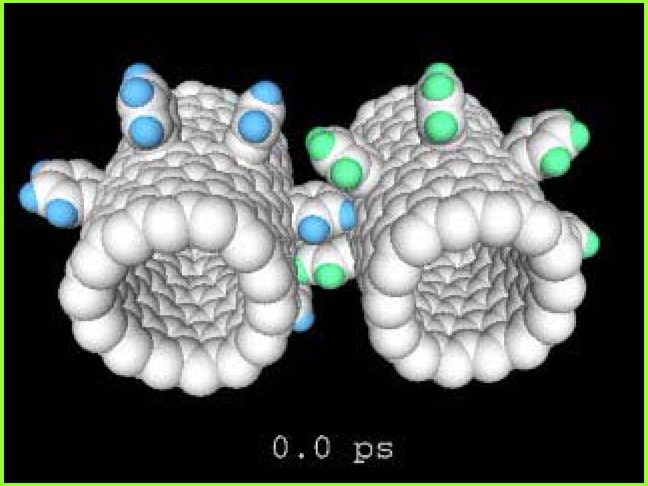


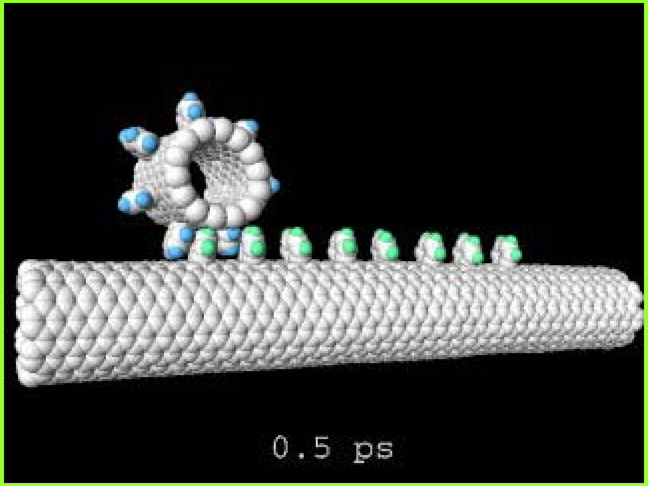


Nano + C_6H_6



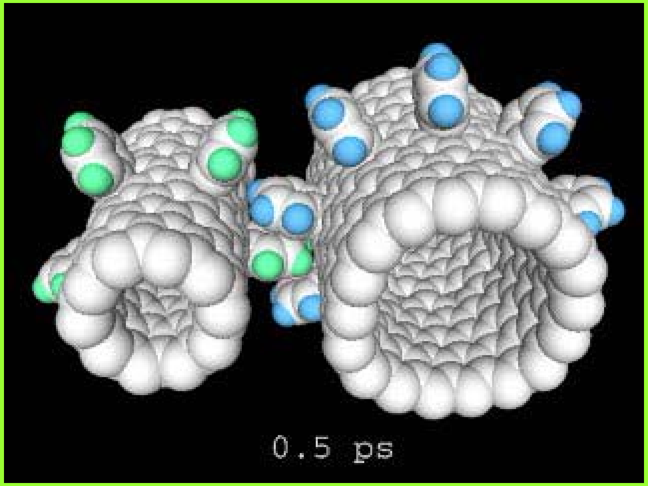
“Fabricación” de nanoengranajes

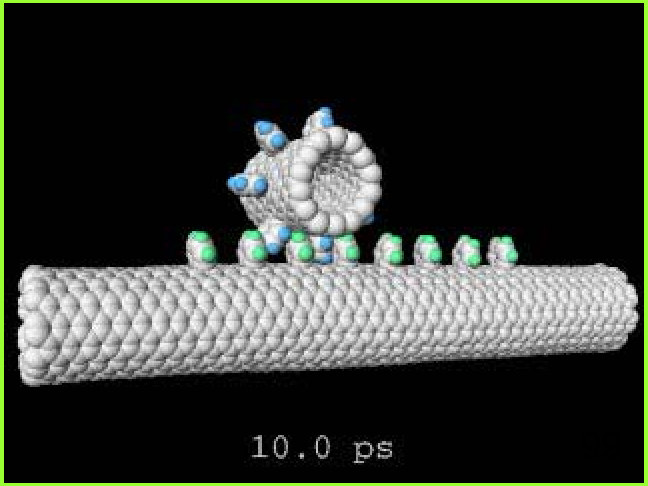




Transmisión en paralelo

Transmisión perpendicular





> "In Science the credit goes to the man who
> convinces the world, not to the man to
> whom the idea first occurs."
> Sir Francis Darwin.

The idea of a hollow carbon cage structure was first proposed by David E. H. Jones writing in the New Scientist under the name of 'Daedalus' (New Sci. 32, 245 1966). He suggested that it may be possible to create giant hollow molecules by distorting a plane hexagonal carbon net by the addition of impurity atoms. This, he claimed, could introduce curvature, and hence close the net into a spherical shell. He did not explain how this might be achieved.

In his book 'The Inventions of Daedalus' (Freeman 1982), Jones expands this idea, and even quotes from the work of Thompson. Anyone who has ever read 'Daedalus' will know that his 'inventions' lie somewhere in the hazy borderline between the feasable, and the fantastic, and as such are not to be taken too seriously. At least not until 1985!

Perhaps the first mention of the C60 molecule in the literature was in an article by E. Osawa (Kagaku 25, 854-863 1970). Osawa predicted that such a molecule would be stable, and expanded this in more detail in a book on aromatic molecules the following year (Z. Yoshida and E. Osawa 'Aromaticity' 1971). Both these articles are in Japanese.

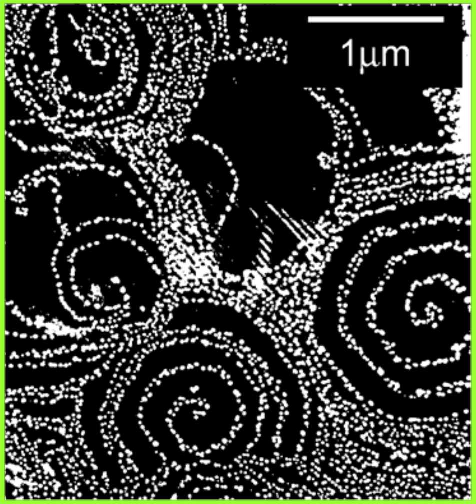
The photograph shows a copy of the paper model of C60 made by R.W.Henson at AERE Harwell in 1970

so in 1970, R. W. Henson , with no prior knowledge of aedalus', nor of Osawa's work, proposed the structure and de a model of Carbon 60. At the time he was a member of Graphite and Carbon Studies Group at the Atomic Energy search Establishment, Harwell, UK. studying radiation mage in the graphite moderator of nuclear reactors. The evidence for this new form of carbon was very weak and was not accepted, even by his colleagues! It was never published. The 'Carbon' journal contains a belated acknowledgement of Henson's work in an editorial by Dr.P.A.Thrower. Carbon Vol 37 No.11 1677-1678 (1999).

This new form of carbon was named after Richard Buckminster Fuller who was a pioneer in the design of the Geodesic dome often used in large building structures. A prime example of this was the dome for the 1967 Montreal World Exhibition. Fuller patented the geodesic dome in 1954!

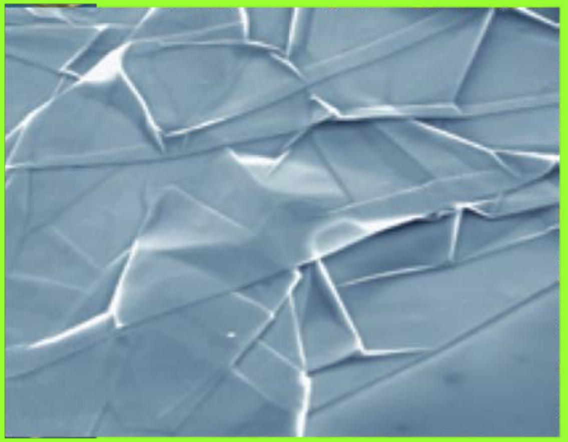
However, the first dome with this structure was built at the Carl Zeiss optical works at Jena in Germany in 1922 by Dr. Walter Bauersfeld. The design of the dome was almost incidental to his even more remarkable technical achievement: the invention of the 'Planetarium Projector'.

The history of this structure is long and varied, but one early and interesting study was by D'Arcy Wentworth Thompson. In his book 'On Growth and Form' (Cambridge University Press 1942) Thompson shows that a hexagonal grid, of any size, can be closed into a polyhedron by the inclusion of twelve pentagons in its network. It is interesting to note that C60 would be the smallest size of such a symmetric net. Thompson's interest was in the study of the skeletons of microscopic sea creatures

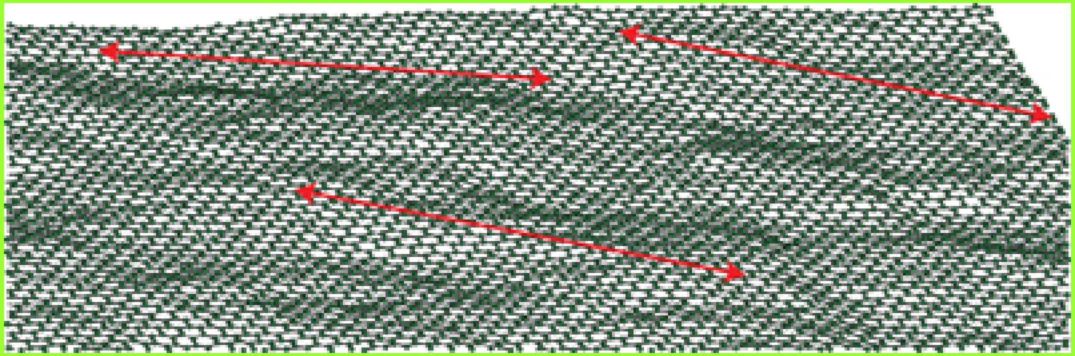


The occurrence of emergent screw dislocation (of opposite chirality) at the cleaved basal surface of graphite may be rendered visible by the gold-decoration technique, as described in refs. 2 and 66. The preferential growth of gold microcrystals enables step heights of 0.33 nm to be imaged.

John Meurig Thomas*ab and Paul A. Midgle. Chem Comm 2004



Micrografía electrónica
de barrido de una capa
arrugada de grafeno



A. Fasolino, J. H. Los & M. I. Katsnelson, Nature Materials 6, 858 - 861 (2007)

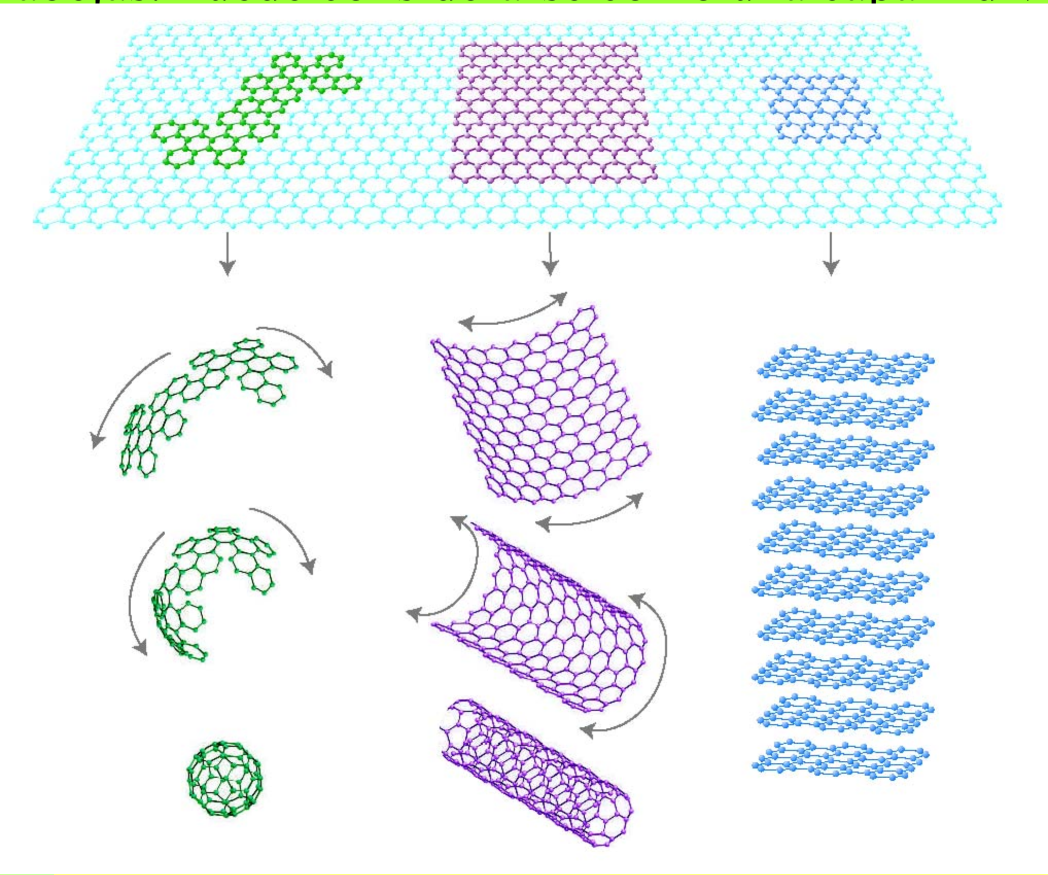
¿Qué es el GRAFENO? Es una forma alotrópica del carbono “bidimensional”(*) en la que cada átomo está unido a otros tres, por enlace covalente a través de orbitales híbridos sp^2, dando lugar a una estructura hexagonal, como en los panales de abejas. Puede considerarse como una capa individual de grafito.

(D estable con relación a otros

fu orma más estable por encima de

24 ictura arrugada, que es el estado

de



arbon. It is a transparent

unique features, not

e conducts electricity

naterial known,

stretched reversibly

nside behave in a

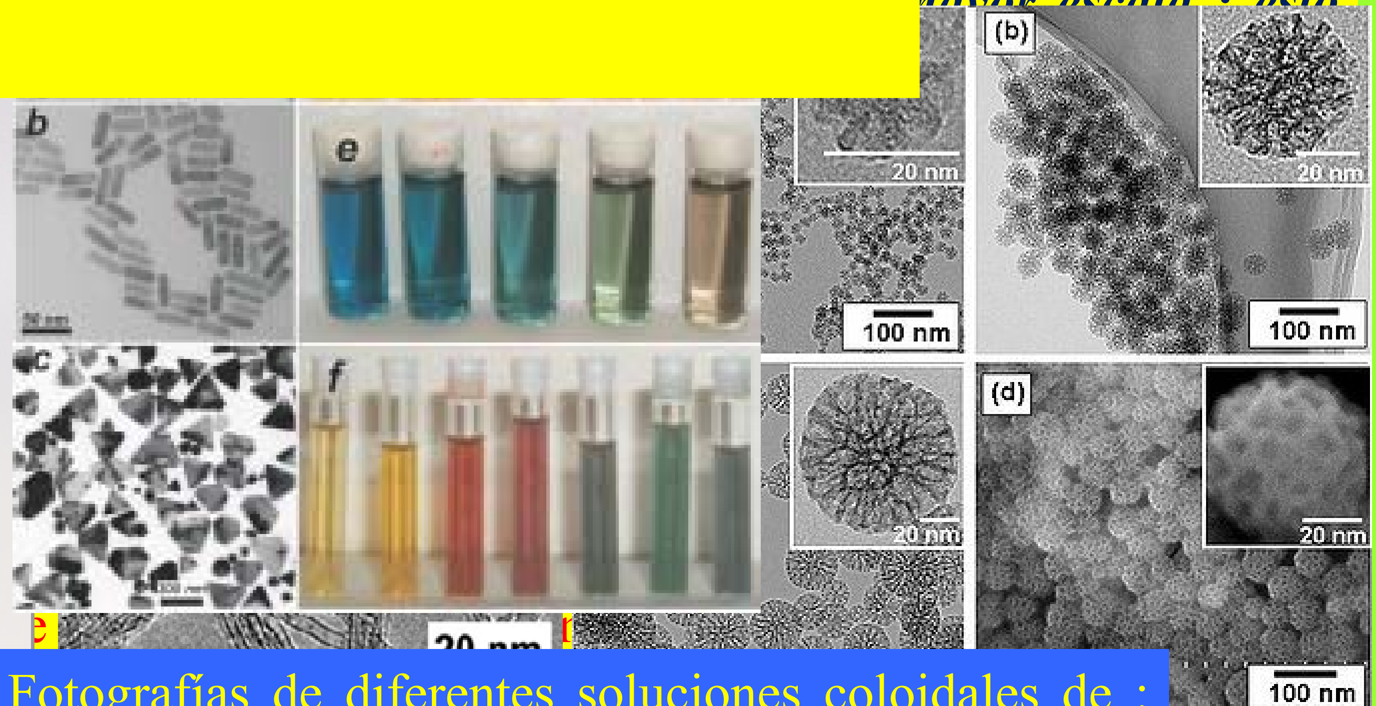
nentary particles, …

GRAFENO: UNA ACCIÓN MOVILIZADORA EN UN CAMPO EMERGENTE Acción complementaria MAT2010-12279-E

La influencia del Tamaño ROMPER EL CUBO¡http://www.youtube.com/watch?v=1uxmfsKsj3g

Las propieda... ...ones principales

En primer ... ***'a área superficial cuando se c*** ... ***mayor escala ; esto hace a los r***...



Fotografías de diferentes soluciones coloidales de : nanopartículas de una aleación AuAg de contenido creciente en Au (d). Nanovarillas de Au de relación acicular creciente (e), y nanoprismas de Ag de tamaño lateral creciente (f).

alcanza un punto en e...

Los...

una dimen...

dos dimensiones (por ejemplo, nanohilos y nanotubos)

las tres dimensiones (por ejemplo, nanopartículas).

En segundo lugar, los efectos cuanticos empiezan a controlar el comportamiento de la materia a la escala naométrica, particularmente a la más pequeña – afectando el comportamiento óptico, magnético, eléctrico, etc. de esos materiales .
Como as propiedades de un material resultan simplemente de promediar las fuerzas cuánticas que afectan a todos sus átomos, según se va disminuyendo el tamaño, se alcanza un punto en el que ya no sirve el promedio

Los Materiales pueden ser nanométricos en in :
una dimension (por ejemplo, recubrimientos muy delgados),
dos dimensiones (por ejemplo, nanohilos y nanotubos)
las tres dimensiones (por ejemplo, nanopartículas).

Las propiedades de los nanomateriales pueden ser diferentes por dos razones principales

En primer lugar, Los nanomateriales presentan una elevada área superficial cuando se compara con la del mismo material preparado a mayor escala ; esto hace a los materiales más reactivos y afecta a sus propiedades

http://www.youtube.com/watch?v=1uxmfsKsj3g

Por ejemplo, los metales con un tamaño de grano de unos 10 nanometros son hasta siete veces más duros y tenaces que sus equivalentes con tamaños de partíciula de cientos de nano-metros

En segundo lugar, los efectos cuanticos empiezan a controlar el comportamiento de la materia a la escala naométrica, particularmente a la más pequeña – afectando el comportamiento óptico, magnético, eléctrico, etc. de esos materiales . Como las propiedades de un material resultan simplemente de promediar las fuerzas cuánticas que afectan a todos sus átomos, según se va disminuyendo el tamaño, se alcanza un punto en el que ya no sirve el promedio

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una dimension (por ejemplo, recubrimientos muy delgados),
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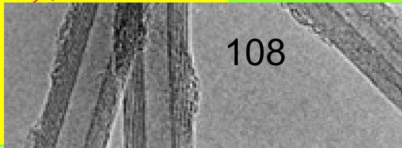
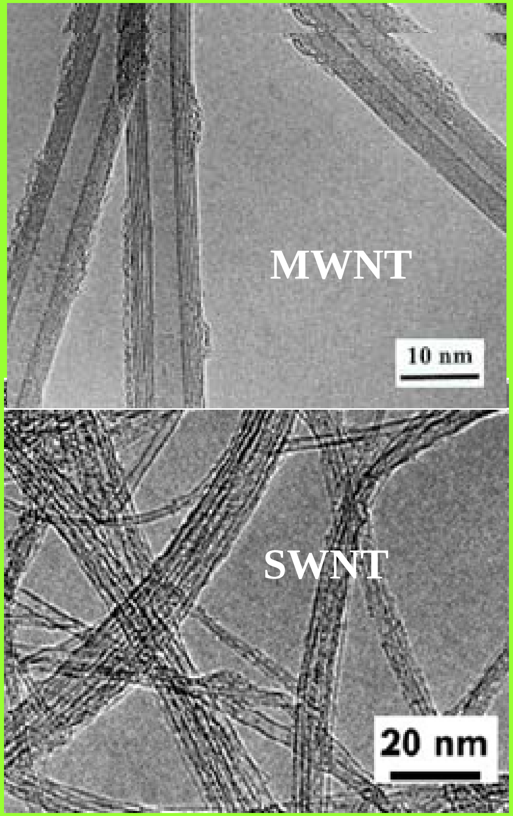
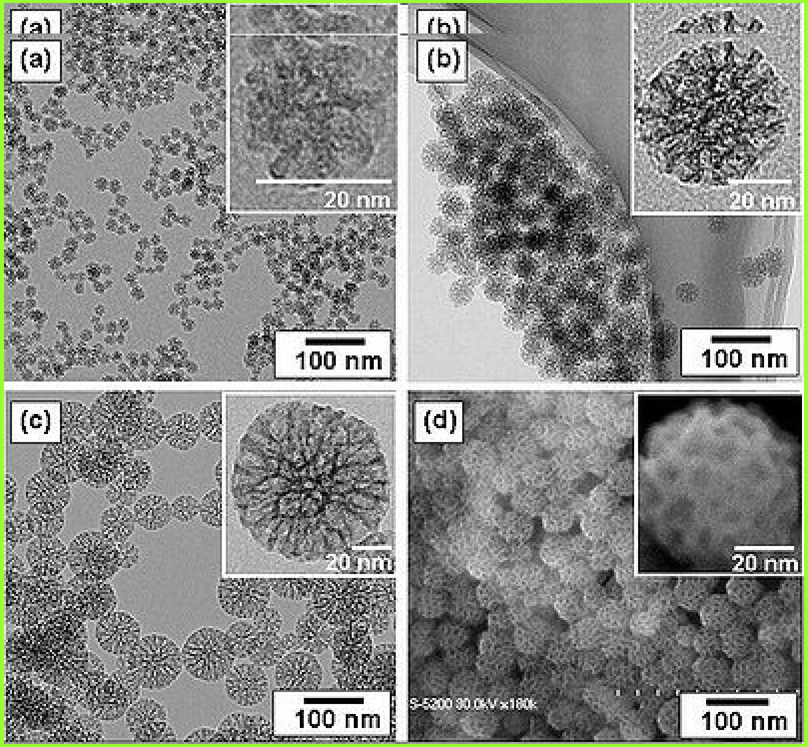
las tres dimensiones (por ejemplo, nanopartículas).




MWNT
10 nm
SWNT
20 nm


(a)
20 nm
100 nm
(b)
20 nm
100 nm
(c)
20 nm
100 nm
(d)
20 nm
100 nm