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Technological Center

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Generalitat de Catalunya

EUREKA WEEK

"El grafeno en el mundo industrial"

17-05-2017
Terrassa

Dr. David Amantia
Manager of Business Unit
Applied Chemistry and Materials

EL GRAFENO EN EL MUNDO INDUSTRIAL

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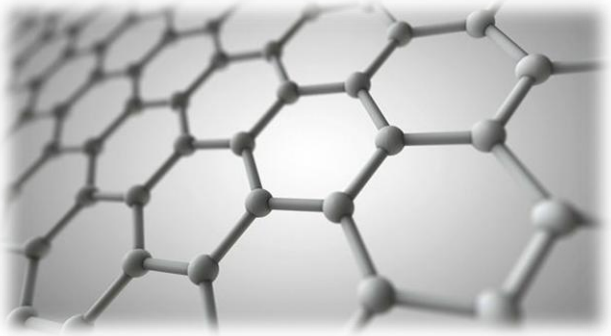


EL GRAFENO EN EL MUNDO INDUSTRIAL

1. Descripción general

RAZON DEL PREMIO

La investigación sobre el desarrollo del grafeno, representa la **innovación de un material bidimensional** que será útil para el desarrollo de **dispositivos electrónicos flexibles** y mas eficientes, como **ordenadores** y **pantallas táctiles** así como **paneles solares**. El grafeno ofrece propiedades excepcionales procedentes del mundo de la física cuántica.

The Nobel Prize in Physics 2010

Photo: U. Montan
Andre Geim
Prize share: 1/2

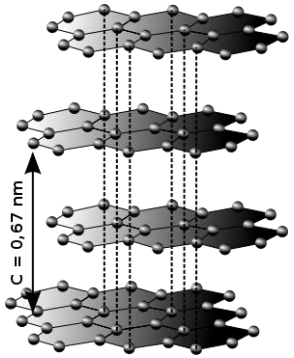
Photo: U. Montan
Konstantin Novoselov
Prize share: 1/2

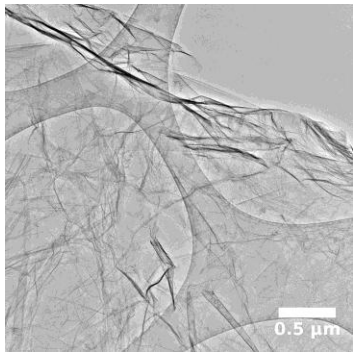
The Nobel Prize in Physics 2010 was awarded jointly to Andre Geim and Konstantin Novoselov *"for groundbreaking experiments regarding the two-dimensional material graphene"*

http://www.nobelprize.org/nobel_prizes/physics/laureates/2010/index.html

EL GRAFENO EN EL MUNDO INDUSTRIAL

1. Descripción general





El grafeno es una sustancia compuesta por **carbono puro**, con átomos dispuestos en un **patrón regular hexagonal** y es **similar al grafito**.

<u>Características mas destacables:</u>

Una hoja de un átomo es aproximadamente **200 veces más resistente** que el **acero** actual más fuerte.

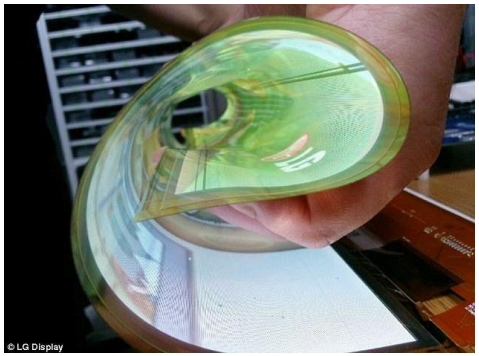
Su **densidad** es aproximadamente la **misma** que la de la **fibra de carbono**

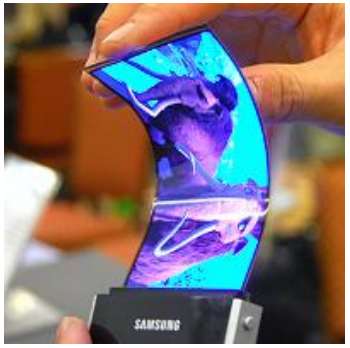
- Es **5 veces** más ligero que el **aluminio**
- Una lámina de **1 metro cuadrado** pesa tan solo **0,77 miligramos.**

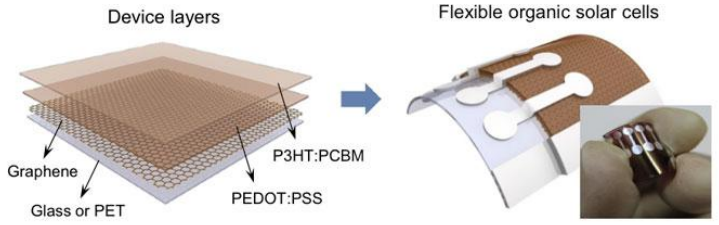
EL GRAFENO EN EL MUNDO INDUSTRIAL

1. Descripción general

Property	Graphene	Competing materials	Applications
High electron mobility (cm^2/Vas)	~200,000 cm2V-1s-1	Silicon 1400	• Applications in high speed transistors, spin devices, single electron transistors, semiconductor memory, QHRS (Quantum Hole Resistance Standard), RF, MEMS, silicon replacement
High electrical conductivity (S/m)	10^8	Silver 63x10^6	• Electrostatic discharge and EMI shielding composites
High strength	~1100 GPa modulus Fracture strength ~130 GPa	200 times stronger than steel	• Composite materials • Incredible rigidity lends themselves to nanoscale pressure sensors
Optical properties	97.7% Transmittance (monolayer)		• Transparent electrodes and laser materials
High curability for current density	Low density ~2 g/cm^3	~ 100 times copper	• Wiring materials
Thermal conductivity (W/mK)	5300	Silver: 420 Copper: 400	• Heat / energy storage, thermal management
High barrier material	Impermeable if defect-free)		• Coatings and films • Packaging



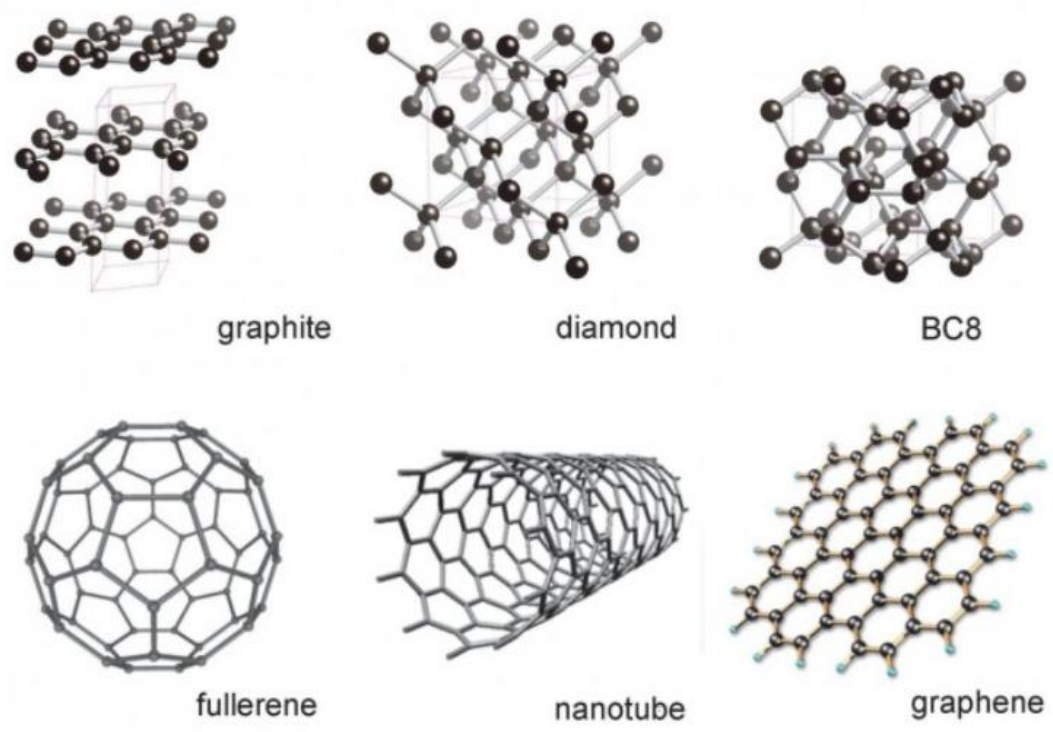




EL GRAFENO EN EL MUNDO INDUSTRIAL

1. Descripción general

Ejemplos de estructuras cristalinas del carbono



EL GRAFENO EN EL MUNDO INDUSTRIAL

2. Producción y precio

Graphene type	Carbon layers	Properties/Typical applications	Typical cost	Commercial availability
Epitaxial CVD graphene	1-2	*Conductive* • Electronics *Transparency* • ITO replacement • Flexible electronics	>$10,000 cm^2	Limited
Few layer graphene	3-10	*Conductive, flexible, high surface area* • Sensors.	$200-$2000/g	Commercially available (problems with consistency)
Graphene nanoplatelets	11-100	• Composites. • Inks. • Coatings. • Lubricants. • Printing.	$200-$2000/kg	Yes (with variable quality)
Graphene oxide	Various	• Insulator. • Semiconductors. • Hydrophilic-Dispersions.	$200-$3000/kg dry weight basis	Yes

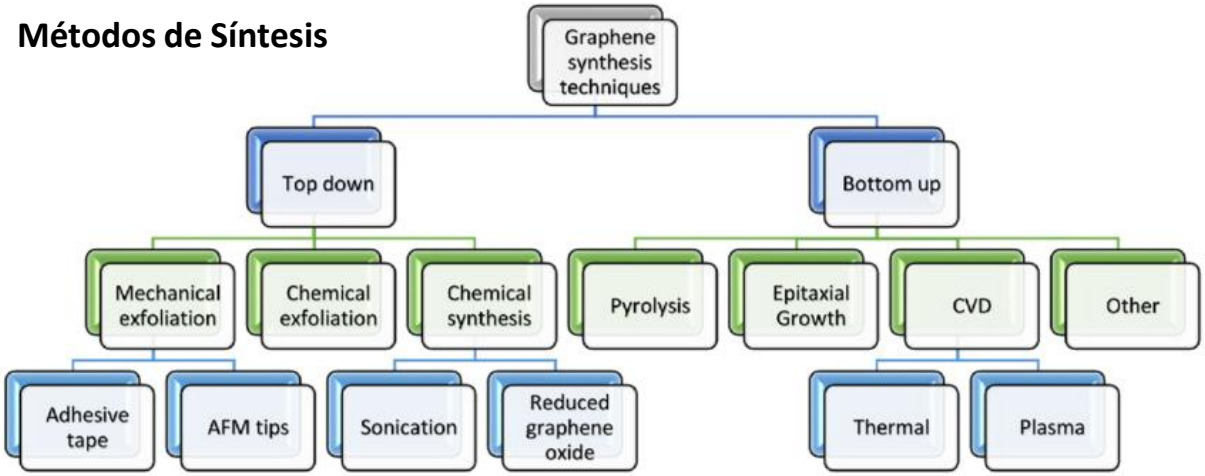
VARIAS FORMAS DE GRAFENO

- Multi-layer graphene.
- Few-layer graphene.
- Exfoliated graphene.
- Bilayer graphene.
- Trilayer graphene.
- Graphene nanoplatelets.
- Graphene nanoribbons.
- Graphene oxide (GO).
- Graphene foam.

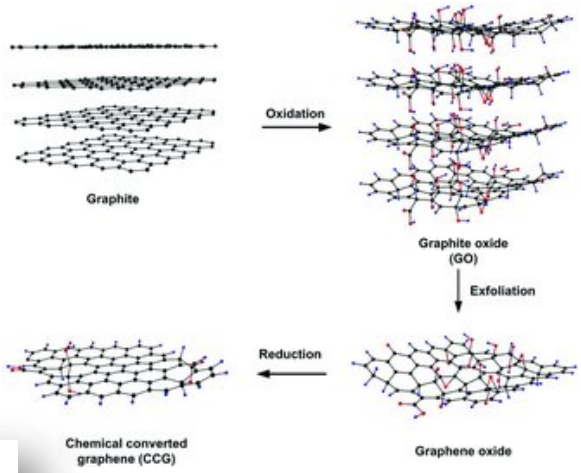
EL GRAFENO EN EL MUNDO INDUSTRIAL

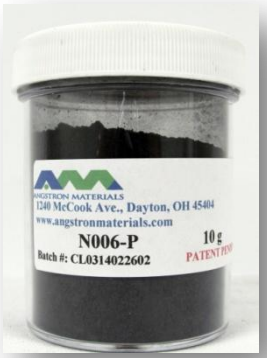
2. Producción y precio

Métodos de Síntesis



Síntesis típica (Top Down)





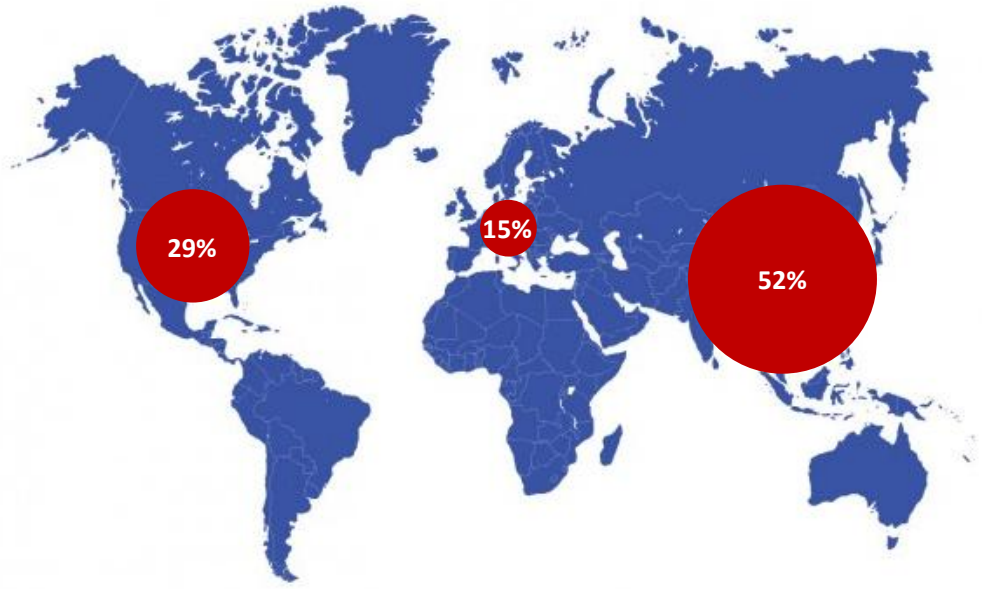
EL GRAFENO EN EL MUNDO INDUSTRIAL

2. Producción y precio

	Method	Typical dimension		Advantage	Disadvantage
		Thickness	Lateral		
BOTTOM UP	Confined self-assembly	Single layer	100's nm	Thickness control	Existence of defects
	CVD	Few layer	Very large (cm)	Large size; high quality	Small production scale
	Arc discharge	Single, bi and few layers	Few 100 nm to a few μ m	Can produce ~10 g/h of graphene	Low yield of graphene; carbonaceous impurities
	Epitaxial growth on SiC	Few layers	Up to cm size	Very large area of pure graphene	Very small scale
	Unzipping of carbon nanotubes	Multiple layers	few μ m long nano ribbons	Size controlled by selection of the starting nanotubes	Expensive starting material; oxidized graphene
	Reduction of CO	Multiple layers	Sub-μm	Un-oxidized sheets	Contamination with α-Al_2O_3 and α-Al_2S
TOP DOWN	Micromechanical exfoliation	Few layers	μm to cm	Large size and unmodified graphene sheets	Very small scale production
	Direct sonication of graphite	Single and multiple layers	μm or sub-μm	Unmodified graphene, inexpensive	Low yield; separation
	Electrochemical exfoliation/functionalization of graphene	Single and few layers	500–700 nm	Single step functionalization and exfoliation; high electrical conductivity of the functionalized graphene	Cost of ionic liquids
	Super acid dissolution of graphite	Mostly single layer	300–900 nm	Unmodified graphene; scalable	Use of hazardous chlorosulfonic acid; cost of acid removal

EL GRAFENO EN EL MUNDO INDUSTRIAL

2. Producción y precio



- 4% rest of the world

solan

BASF
We create chemistry

OSAKA GAS CHEMICALS

PERPETUUS
advanced materials

Graphenea

GPNT Graphene Nanotech

GrapheneTech
BECAUSE FUTURE IS NOW

graphenano
nanotechnologies

GRAnPH

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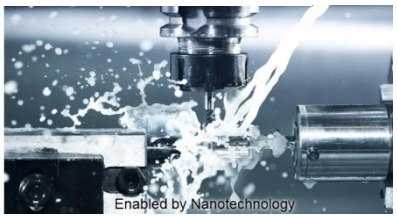
EL GRAFENO EN EL MUNDO INDUSTRIAL

3. Productos incorporando grafeno en el mercado

Graphene Nanochem

The future. Now.

Graphene Nanochem plc is a nanotechnology commercialisation company that designs, formulates, manufactures and markets a range of nano-enhanced solutions, from chemicals to performance materials with improved performance characteristics, focusing on the oil and gas sector.



http://www.graphenenanochem.com/

catlike

CARBON+GRAPHENE

New for 2015, Catlike has developed an amazing 100% carbon fiber sole that is infused with Graphene, a first for cycling shoes. Graphene is a super strong nano material that boosts strength without adding weight. The sole is super light and ergonomically curved to match the shape of your foot perfectly. The rear grip is replaceable as well. This is truly a Professional grade racing sole.

https://www.catlike.es/cy/en/innovation/shoes-technologies/carbon-graphene/

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Vorbeck Materials Debuts Flexible Battery Straps

Vorbeck Introduces Vor-flex™ Engineered HNBR Elastomer: Rubber Reinforced with Vor-x® Graphene

Advanced Elastomer Features Superlative Mechanical Strength, Temperature and Fatigue Resistance for Automotive, Petrochemical, Aerospace and Apparel Applications

September 29, 2016

Jessup, MD – Vorbeck Materials Corp., the leader in award-winning graphene technology, is announcing the introduction of Vor-flex™50, the first in a new family of graphene-enhanced, engineered elastomer products made using Vorbeck's proprietary Vor-x® technology.

Vor-x® provides Vor-flex™ 50's hydrogenated nitrile butadiene rubber (HNBR) with extreme strength at low deformation (high modulus) and the ability to withstand temperature spikes up to 200 °F above the rated working temperature of HNBR. Vor-flex™ 50 has a nominal tensile strength of 3500 psi and a Shore A hardness of 88.

"Vor-flex's high temperature stability allows it to serve in some of the most demanding environments, such as those found in automotive and petrochemical applications," said John Lettow, Ph.D., Founder and President of Vorbeck Materials. "Vor-flex is also an ideal choice for making custom gaskets to serve in severe applications as it provides a very tough seal, resistant to chemicals and fuels," said Lettow.

GRAPHENSTONE®

GRAPHENE INSIDE

Innovación a base de grafeno: mayor dureza, homogeneidad, resistencia, conductividad y flexibilidad

Las fibras de grafeno otorgan a las pinturas y recubrimientos Graphenstone propiedades innovadoras: conductividad térmica, gran dureza, homogeneidad, resistencia y flexibilidad. Este compuesto nanotecnológico actúa como una malla de soporte estructural a nivel molecular, lo que se traduce en mayor durabilidad y por consiguiente en un menor mantenimiento y un mayor ahorro.

Usamos la tecnología para conseguir materiales más eficientes, adaptados a las nuevas exigencias de un mercado cada vez más comprometido con modelos sostenibles de producción.

CUALIDADES ÚNICAS DEL GRAFENO

Alta adhesión. Film resistente.
Anticondensación. Reduce puntos fríos.
Producto lavable.
Flexible. No se cuartea.
Repele el agua. Anticapilaridad.
Fuerza y durabilidad.

PAINTS FOR THE *green* GENERATION

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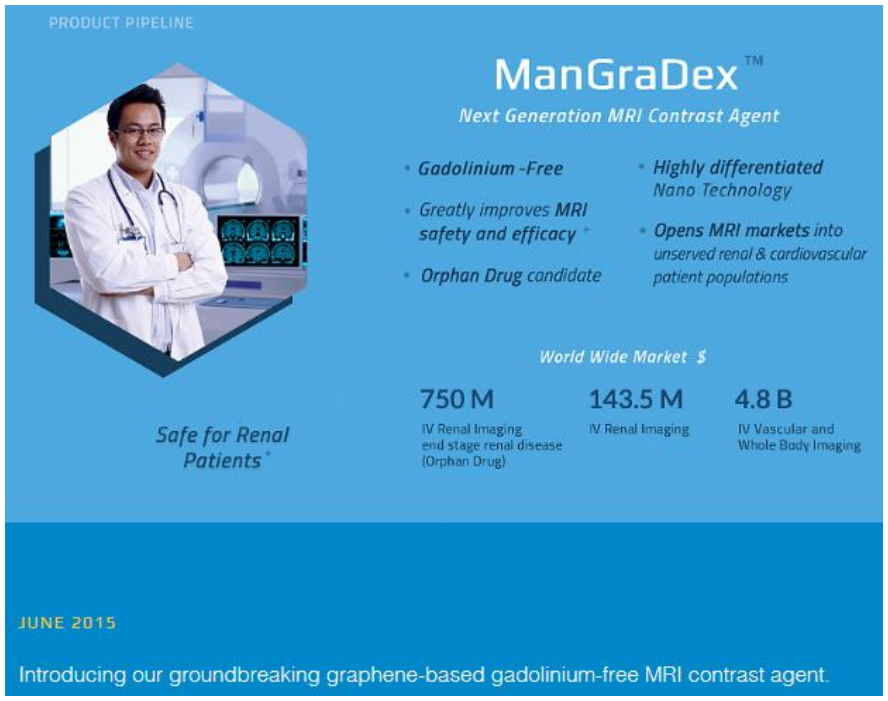
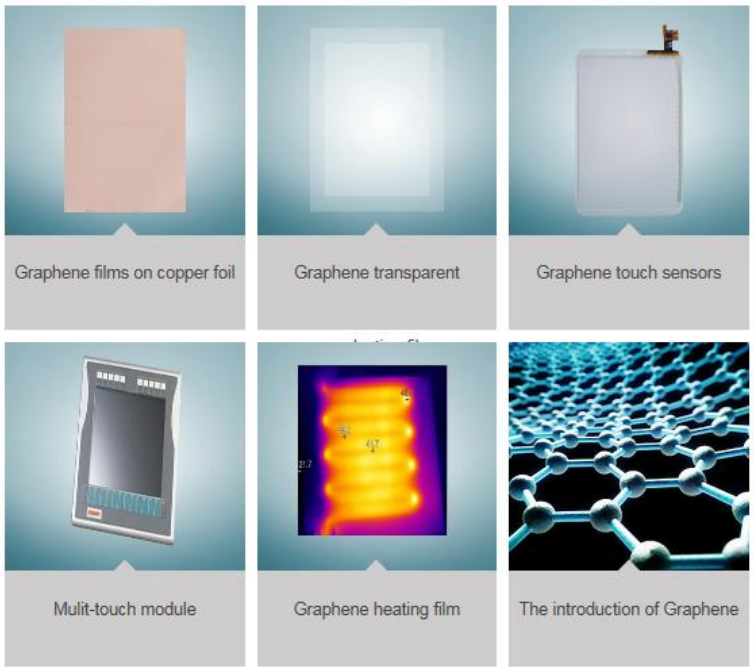
EL GRAFENO EN EL MUNDO INDUSTRIAL

3. Productos incorporando grafeno en el mercado

Theragnostic TECHNOLOGIES



第六元素旗下 无锡格菲电子薄膜科技有限公司 WUXI GRAPHENE FILM CO.,LTD



EL GRAFENO EN EL MUNDO INDUSTRIAL

3. Productos incorporando grafeno en el mercado

SKELE+ON TECHNOLOGIES

Skeleton Technologies is the only manufacturer covering the full value chain

"Curved graphene"

At the heart of our ultracapacitors' performance advantage is Skeleton's nanotechnology research into patented curved graphene. Curved graphene differs significantly from regular activated carbons, which are used by other ultracapacitor manufacturers. All competitors use organic pre-cursor materials, mostly carbon made from coconut, Skeleton is the only company to use an inorganic pre-cursor and has patented the synthesis process for the proprietary material. The use of curved graphene is one of the key factors in achieving the superior energy density of our ultracapacitors.

Skeleton Technologies has also achieved one of the lowest ESR (equivalent series resistance) levels on the market. This factor is crucial as it greatly increases the efficiency of the cells by reducing the amount of energy that is lost as heat. This is also an advantage because cooling systems can be downsized or removed altogether.

HEAD®

REDISTRIBUCIÓN DEL PESO

El peso se desplaza hacia la punta y el mango otorgando más maniobrabilidad y aumentando la inercia.

INTEGRACIÓN GRAPHENE

Graphene está integrado en el corazon de la raqueta haciéndolo más estable y logrando una redistribución optimizada del peso.

MÁS POTENCIA

Los jugadores generan con esta redistribución optimizada del peso de la raqueta más energía cinética al golpear la pelota. Se genera más energía con menos esfuerzo.

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EL GRAFENO EN EL MUNDO INDUSTRIAL

4. Ejemplos de aplicaciones en LEITAT

Journal of Materials Chemistry A

RSC Publishing

PAPER

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Improved power factor of polyaniline nanocomposites with exfoliated graphene nanoplatelets (GNPs)

Cite this: J. Mater. Chem. A, 2013, 1, 10450

Begoña Abad,[a] Irene Alda,[a] Pablo Díaz-Chao,[a] Hiroshi Kawakami,[b] Albert Almarza,[c] David Amantia,[c] David Gutierrez,[c] Laurent Aubouy[c] and Marisol Martín-González*[a]

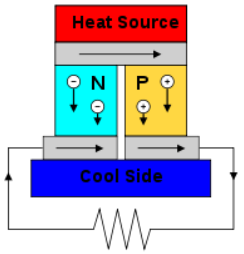
In this work, exfoliated graphene nanoplatelets (GNPs)/polyaniline (PANI) nanocomposites have been prepared by sequential processing comprising: (i) a first aniline oxidative polymerization step under acidic conditions and (ii) mechanical blending with GNPs at different percentages. Thermoelectric pellets of the hybrid materials have been obtained at suitable circular geometry by means of cold pressing. Thermoelectric parameters have been determined at room temperature (electrical conductivity, Seebeck coefficient and thermal conductivity). Thermoelectric measurements show a drastic enhancement in both electrical conductivity and Seebeck coefficient with the addition of GNPs. A respectable maximum power factor value of 14 $\mu W\ m^{-1}\ K^{-2}$ is reached for hybrid materials charged at 50 wt% GNP content, evidencing a 1000-fold enhancement with respect to the raw PANI polymer. The measured thermal conductivity is in the range of 0.5 $W\ m^{-1}\ K^{-1}$ for pure PANI to 3.3 $W\ m^{-1}\ K^{-1}$ for 50 wt% GNP content, which matches the parallel thermal resistor model for this nanocomposite.

Received 29th May 2013
Accepted 2nd July 2013

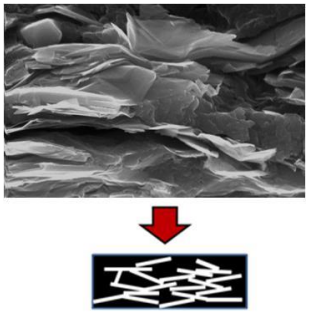
DOI: 10.1039/c3ta12105d

www.rsc.org/MaterialsA

TERMOELECTRICIDAD ORGÁNICA



$$ZT = \frac{\alpha^2 \sigma}{\kappa} T$$



EL GRAFENO EN EL MUNDO INDUSTRIAL

4. Ejemplos de aplicaciones en LEITAT

Sector de la automoción

- Composites de poliolefinas y ABS
- Refuerzo mecánico (modulo, dureza…)
- Reducción de peso

Sector del elastómero

- Mejora del proceso de vulcanización
- Transfer térmico
- Resistencia mecánica

Sector de la energía

-Fabricación de electrodos avanzados para batería de Li-ion
- Composites para intercambio termico

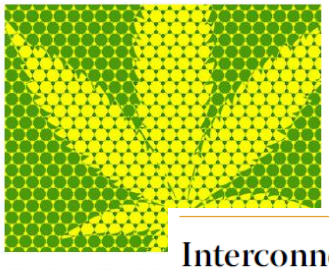
EL GRAFENO EN EL MUNDO INDUSTRIAL

4. Ejemplos de aplicaciones en LEITAT

Hemp Carbon Makes Supercapacitors Superfast

July 2013

by Mark Crawford, ASME.org



Most people don't understand the (*Cannabis sativa*). Cultures have for centuries for clothing, fabric, a for food, fuel, medicine, building r energy storage industry is starting Canadian research that shows su made from hemp-based carbon n supercapacitors by nearly 200%.

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106 47 Email Print

Energy-Storing Nanomaterial Made From Hemp

Electronics: Researchers turn agricultural waste into a carbon nanomaterial for high-power supercapacitors

By Katherine Bourzac

[+]Enlarge

Graphene might one day be used in batteries, solar cells, transparent electrodes, and a host of other electronic gadgets. But graphene is still quite expensive to make. Now researchers at the **University of Alberta** have demonstrated a low-cost process for **turning agricultural waste into graphenelike nanomaterials** for use in energy storage electronics (*ACS Nano* 2013, DOI: **0731g**).

:e area and conductivity, graphene is ideal
'odes in batteries and supercapacitors,
y storage devices that excel at providing
power. Supercapacitors charge and
than batteries can because they store
rm of fast-moving charges on the surfaces of

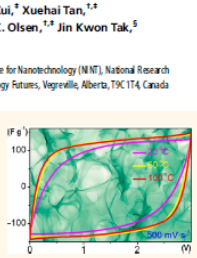
ARTICLE

Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy

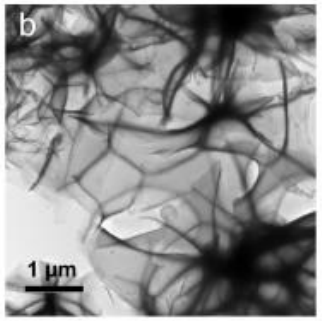
Huanlei Wang,[†,‡] Zhanwei Xu,[†,‡] Alireza Kohandehghan,[†,‡] Zhi Li,[†,‡,*] Kai Cui,[†] Xuehai Tan,[†,‡] Tyler James Stephenson,[†,‡] Cecil K. King'ondu,[†,‡] Chris M. B. Holt,[†,‡] Brian C. Olsen,[†,‡] Jin Kwon Tak,[§] Don Harfield,[§] Anthony O. Anyia,[§] and David Mitlin[†,‡,*]

[†]Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta T6G 2 V4, Canada, [‡]National Institute for Nanotechnology (NINT), National Research Council of Canada, Edmonton, Alberta T6G 2M9, Canada, and [§]Biorsource Technologies, Alberta Innovates-Technology Futures, Vegreville, Alberta, T9C 1T4, Canada

ABSTRACT We created unique interconnected partially graphitic carbon nanosheets (10—30 nm in thickness) with high specific surface area (up to 2287 $m^2 g^{-1}$), significant volume fraction of mesoporosity (up to 58%), and good electrical conductivity (211—226 S m^{-1}) from hemp bast fiber. The nanosheets are ideally suited for low (down to 0 °C) through high (100 °C) temperature ionic-liquid-based supercapacitor applications: At 0 °C and a current density of 10 A g^{-1}, the electrode maintains a remarkable capacitance of 106 F g^{-1}. At 20, 60, and 100 °C and an extreme current density of 100 A g^{-1}, there is excellent capacitance retention (72—92%) with the specific capacitances being 113, 144, and 142 F g^{-1}, respectively. These characteristics favorably place the materials on a Ragone chart providing among the best power—energy characteristics (on an active mass normalized basis) ever reported for an electrochemical capacitor: At a very high power density of 20 kW kg^{-1} and 20, 60, and 100 °C, the energy densities are 19, 34, and 40 Wh kg^{-1}, respectively. Moreover the assembled supercapacitor device yields a maximum energy density of 12 Wh kg^{-1}, which is higher than that of commercially available supercapacitors. By taking advantage of the complex multilayered structure of a hemp bast fiber precursor, such exquisite carbons were able to be achieved by simple hydrothermal carbonization combined with activation. This novel precursor-synthesis route presents a great potential for facile large-scale production of high-performance carbons for a variety of diverse applications including energy storage.



KEYWORDS: biomass · carbon nanosheets · ionic liquid · supercapacitor · energy storage



South Hemp
@South_Hemp
Seguir

Nuestros Directores Álvaro Gómez y Jorge Irarrazaval en visita técnica en el Headquarter de @Leitat en Barcelona.

RETWEETS 3 ME GUSTA 3

16:45 - 15 feb. 2017

David Mitlin's Group
http://www.mitlingroup.com/

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