CHEMWATCH

Bulletin Board

Contents

JAN. 30, 2026

(click on page numbers for links)

REGULATORY UPDATE

ASIA PACIFIC

AMERICA

EUROPE

REACH UPDATE

JANET'S CORNER

HAZARD ALERT

GOSSIP

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Contents

CURIOSITIES

TECHNICAL NOTES

Regulatory Update

ASIA PACIFIC

Toxic metals and carcinogens found in Australian tattoo inks

2026-01-20

A study led by UNSW Sydney and published today analysed the chemical composition of 15 black and coloured tattoo inks from major, established international tattoo ink brands that were purchased from Australian suppliers. While every ink tested failed current European Union (EU) safety regulations for tattoo inks, the authors say their findings aren’t cause for panic.

Instead, they say, Australia needs to introduce routine sampling and testing across brands and batches of inks.

“When we benchmarked these products against EU standards, every ink we tested failed on at least one regulated substance,” says the study’s corresponding author UNSW Professor William Alex Donald.

Tattoo ink is a complex mixture of pigments, solvents and additives. It is designed to remain in the body long term, injected into the thick layer of living tissue below the skin’s surface.

This method of ‘inking’ creates a permanent exposure pathway that bypasses many of the body’s natural protective barriers.

Since 2022, the EU has strictly enforced chemical limits for tattoo inks. Australia has no binding national regulatory framework that aligns with those standards and instead relies on voluntary compliance and the occasional government characterisation study.

Read More

Scimex, 20-01-26

https://www.scimex.org/newsfeed/toxic-metals-and-carcinogens-found-in-australian-tattoo-inks-new-study

Have your say: revisions to the Categorisation Guidelines in 2026

2026-01-26

What's this about?

As part of our annual update to the Industrial Chemicals Categorisation Guidelines (Guidelines), we have compiled all the upcoming changes to the Guidelines in September 2026, including some proposals that are open for public comments.

This consultation covers the following topics:

- Updates to the list of chemicals with high hazards for categorisation (for information only)
- High hazard salts and esters (open for comment)
- Single definition for 'chemical identity holder' (open for comment)
- Updated links and minor editorial changes (for information only)

Have your say

We invite your comments on the proposed Guideline changes by 28 January 2026.

Consultation closes: 28 January 2026

Updates to the list of chemicals with high hazards for categorisation (list) – for information only

This list is a downloadable resource that some importers and manufacturers may need to use when working out their introduction category. It is a list of chemicals that trusted national and international sources consider to be highly hazardous to human health or the environment. The information sources of the list are in Appendix 8.1 of the Guidelines.

Adding and updating chemicals on the list

We will add 294 chemicals to the list in September 2026:

- 81 of these are chemicals that AICIS has assessed or evaluated since the last update to the list.
- 215 of these are chemicals from other list sources.

- 2 of these chemicals are being added as a result of both an AICIS evaluation and their addition to another list source.

These chemicals have at least one hazard characteristic in:

- human health hazard band C, or
- environment hazard band C or D.

Therefore, most introductions of these chemicals will not be eligible for the exempted or reported categories at steps 4 and 5 of the categorisation process.

Read More

AICIS, 21-01-26

https://www.industrialchemicals.gov.au/consultations/have-your-say-revisions-categorisation-guidelines-2026

Guidance for health and safety representatives: asbestos

2026-01-22

This guide provides an overview of asbestos in the workplace to assist health and safety representatives (HSRs) exercise their powers and functions to represent workers in their work group. It is for HSRs in workplaces where the workers they represent may be at risk of exposure to asbestos, focused on the built environment. It does not cover the requirements for those involved in licensed asbestos removal or the management of naturally occurring asbestos.

As an HSR you can play an important role in representing members of your work group and bringing attention to issues such as the risk of exposure to asbestos. You are not expected to 'fix' the issue or be an expert on asbestos to exercise your HSR powers and functions.

Understanding more about asbestos can help you identify when things are not being managed well and when you might want to speak up.

Publication Date: 22 Jan 2026

Read More

Safe Work Australia, 22-01-26

https://www.safeworkaustralia.gov.au/doc/guidance-health-and-safety-representatives-asbestos

AMERICA

Notice of Virtual Public Hearing Announcement and Extension of Comment Period

2026-01-16

Updated Hazardous Waste Facility Permit Criteria for Additional Community Protections (SB 673 Track 2)

DTSC Reference Number: R-2021-07R

Office of Administrative Law Notice Reference Number: Z-2025-1110-05

Summary of the Proposal

The California Department of Toxic Substances Control (DTSC) proposes to amend regulations in California Code of Regulations, title 22, division 4.5, sections 66260.10 and 66270.14, and add sections 66271.22 and 66271.80. The proposed amendments and additions pertain to regulations that create new permit criteria for additional community protections.

To view the proposed regulatory text and all other rulemaking documents, visit DTSC's Proposed Regulations webpage.

Read More

US DTSC, 16-01-26

https://dtsc.ca.gov/dtsc-proposed-regulations/

EPA Issues Pesticide Stop Sale Orders in Houston, San Antonio Inspections Found Unregistered Cleaning Products

2026-01-12

In December, U.S. Environmental Protection Agency (EPA) Region 6 issued Stop Sale, Use, or Removal Orders (SSUROs) for unregistered pesticides to four companies following marketplace inspections in Houston and San Antonio, Texas. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), companies must register pesticides with EPA, including cleaning products that claim to kill bacteria and other microbes. The orders were issued to AK Wholesale LLC, C.T. Grocers dba La Abarrotera, Productos Bredy USA, and Border Cash & Carry.

"EPA is cracking down on companies that sell illegal pesticides to unsuspecting customers," said Regional Administrator Scott Mason. "When you go to the store to buy antibacterial cleaners, you expect them to be safe and not pose a danger to you and your family. This action demonstrates EPA's unwavering commitment to protecting American families from the sales of illegal pesticides."

The SSUROs addressed pesticidal products labelled as Ajax Pino, Ariel Matic, Axiom Polvo Superficies, Bed Bugs No More, Clorox Blanqueador (Concentrado), Clorox Ropa, Fabuloso Ultra Frescura/Frescura Activa (various), and Salvo Multiusos. These products, which were not registered with EPA, appear to have been made in Mexico, Pakistan, or Vietnam and are considered pesticides under FIFRA due in part to the pesticidal claims made on their labels.

Read More

US EPA, 12-01-26

https://www.epa.gov/newsreleases/epa-issues-pesticide-stop-sale-orders-houston-san-antonio-inspections-found

EPA Announces Intent to Regulate Dozens of Uses of Five Phthalate Chemicals to Protect Workers and Environment

2025-12-31

U.S. Environmental Protection Agency (EPA) announced today that it will move to regulate dozens of applications of five widely used phthalate chemicals to address environmental and workplace risks. This decision is based on final risk evaluations, released today, for each of these chemicals: Butyl Benzyl Phthalate (BBP), Dibutyl Phthalate (DBP), Dicyclohexyl Phthalate (DCHP), Diethylhexyl Phthalate (DEHP), and Diisobutyl Phthalate (DIBP), commonly used to make plastics more flexible in everything from building materials to industrial applications. EPA used gold standard science and tapped independent peer reviewers to reach its conclusions that all five chemicals it reviewed pose unreasonable risks to workers and to the environment. EPA's regulatory focus will target the specific uses that harm workers or threaten the environment.

"Our gold standard science delivered clear answers that these phthalates pose unreasonable risk to workers in specific industrial settings and to the environment," said Administrator Lee Zeldin. "We'll work directly with stakeholders to develop targeted protections that keep workers

safe and protect our environment. This is exactly what science-based environmental protection should look like."

Phthalates have the potential to cause human health abnormalities that EPA is seriously concerned with, including hormone deficiencies and endocrine disruption. It's also important to note that gold standard science also shows that these health impacts do not occur at all exposure levels. The key factor in determining risk is whether people are exposed to amounts above levels that could cause health problems. Under the Toxic Substances Control Act (TSCA) risk evaluation process, EPA focuses specifically on uses regulated under the federal chemical safety law. EPA's TSCA risk evaluation does not analyze exposures from food, food additives, food packaging, medical devices, cosmetics and other consumer products that are under the purview of the Food and Drug Administration or Consumer Product Safety Commission. For the consumer uses that are part of this TSCA risk evaluation, EPA found no products with exposure levels that are causing unreasonable risk to the general population. In pursuit of gold standard science, dermal modeling was enhanced based on peer review feedback and public comment, especially with the replacement of rodent data with actual human data.

Read More

US EPA, 31-12-25

https://www.epa.gov/newsreleases/epa-announces-intent-regulate-dozens-uses-five-phthalate-chemicals-protect-workers-and

Azoxystrobin; Pesticide Tolerances

2026-12-08

This regulation establishes a tolerance for residues of azoxystrobin in or on black pepper. Under the Federal Food, Drug, and Cosmetic Act (FFDCA), the American Spice Trade Association (ASTA) submitted a petition to EPA requesting that EPA establish a maximum permissible level for residues of this pesticide in or on the identified commodity.

DATES:

This regulation is effective December 8, 2025. Objections and requests for hearings must be received on or before February 6, 2026, and must be filed in accordance with the instructions provided in 40 CFR part 178 (see also Unit I.C. of this document.

ADDRESSES:

The docket for this action, identified by docket identification (ID) number EPA-HQ-OPP-2024-0460, is available at http://www.regulations.gov. Additional information about dockets generally, along with instructions for visiting the docket in person, is available at https://www.epa.gov/dockets.

Read More

US EPA, 08-12-25

https://www.federalregister.gov/documents/2025/12/08/2025-22174/azoxystrobin-pesticide-tolerances

2026 Proposed Perchlorate Rulemaking

2026-01-02

On January 2, 2026, the U.S. Environmental Protection Agency (EPA) signed a proposed National Primary Drinking Water Regulation (NPDWR) and Maximum Contaminant Level Goal (MCLG) for perchlorate as a result of the D.C. Circuit's May 2023 decision in NRDC v. Regan.

The EPA is proposing a health-based Maximum Contaminant Level Goal (MCLG) of 0.02 mg/L (20 µg/L). The EPA is co-proposing enforceable Maximum Contaminant Levels (MCLs) for perchlorate of 20 µg/L, 40 µg/L, or 80 µg/L.

The EPA will accept comments to the public docket identified by Docket ID No. EPA-HQ-OW-2024-0592 at http://www.regulations.gov by March 9, 2026. The EPA is also holding a public hearing on February 19, 2026 at 1-4 pm ET, at which time the public will be invited to provide the EPA with verbal comments. Information and registration for the public hearing is available here.

Read More

US EPA, 02-01-26

https://www.regulations.gov/docket/EPA-HQ-OW-2024-0592

FDA Records Access Authority for Cosmetic Products

2026-01-21

Draft Guidance for Industry

January 2026

Docket Number:

FDA-2025-D-2243

Issued by:

Office of Inspections and Investigations

The purpose of this document is to provide guidance to industry on FDA's authority to access and copy records related to cosmetic products under sections 605, 610, and 704 of the Federal Food, Drug, and Cosmetic Act (the FD&C Act or the Act). The guidance in this document is in the form of Questions and Answers and provides answers to common questions that might arise about these records access provisions and FDA's current thinking regarding their implementation.

Read More

FDA, 21-01-26

https://www.fda.gov/regulatory-information/search-fda-guidance-documents/fda-records-access-authority-cosmetic-products

EUROPE

What France's Forever Chemicals Ban Means for Manufacturers

2026-01-22

France is banning PFAS in textiles, cosmetics and more from January 2026, forcing brands and manufacturers to shift towards safer, sustainable alternatives

France is introducing some of Europe's most stringent regulations on 'forever chemicals', implementing rules to ban Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in a range of consumer products.

Beginning 1 January 2026, manufacturers, importers and brands selling products in the French market need to comply with new requirements across textiles, cosmetics, waxes, footwear and waterproofing agents.

Understanding forever chemicals

Forever chemicals, widely known as PFAS, are a group of more than 10,000 man-made substances that have been in widespread use since the 1950s.

The two regulated PFAS compounds are Perfluorooctanoic acid (PFOA) and Perfluorooctane sulfonate (PFOS).

Their characteristic feature is the carbon–fluorine bond, one of the strongest in chemistry, which makes PFAS exceptionally resistant to degradation.

Read More

Manufacturing Digital, 22-01-26

https://manufacturingdigital.com/news/what-frances-forever-chemicals-ban-means-for-manufacturers

Waste and recycling guidance refreshed and updated

2026-01-23

HSE has refreshed its guidance on the waste and recycling industry to make it easier to protect people and places in this sector.

Working in close consultation with the Waste Industry Safety and Health Forum (WISH), we have:

- removed outdated or duplicated information
- brought guidance up to date, so it reflects changes in the industry
- reduced the size of the site substantially, so it will be easier for you to find the advice you need

To find out how it can help you protect your workers and comply with the law, visit our updated waste management and recycling website.

Read More

HSE, 23-01-26

https://www.hse.gov.uk/waste/index.htm

Enforcing classification, labelling and packaging of hazardous mixtures

2026-01-21

During 2026, the national enforcement authorities in the EU will check how well hazardous mixtures comply with the Classification, Labelling and Packaging Regulation. Inspectors may also control whether mixtures comply with restrictions under the REACH and Persistent Organic Pollutants Regulations.

The checks will cover many product types including consumer products which are widely available on the market and known to contain hazardous mixtures.

Read More

ECHA, 21-01-26

Enforcing classification, labelling and packaging of hazardous mixtures

Call for evidence: restriction of certain non-polymeric aromatic brominated flame retardants

2026-01-21

We are looking for information on the expected socio-economic impacts of a potential REACH restriction of certain non-polymeric aromatic brominated flame retardants.

We want to hear how you would react to the restriction options, what the costs would be to comply with them, and how they could impact e.g. profitability, production processes, product quality, employment and trade.

We are also looking for information on the uses of non-polymeric aromatic brominated flame retardants and available alternatives, including the relevant technical and economic considerations.

Learn more about what type of information you are expected to submit in our webinar on 29 January 2026 at 11:00 Helsinki time.

Send your comments by 18 March 2026.

Your contributions will be used to prepare an Annex XV restriction proposal as requested by the European Commission.

Read More

ECHA, 21-01-26

Call for evidence: restriction of certain non-polymeric aromatic brominated flame retardants

Janet's Corner

Who Am I?

2026-01-30

I am a highly toxic, radioactive element named after a country in Eastern Europe. I was discovered by Marie Curie.

(Send in your answers and get a surprise Chemwatch merch from us for free)

I am a highly toxic, radioactive element named after a country in Eastern Europe.

Hazard Alert

2,3 Benzofuran

2026-01-30

2,3-Benzofuran is the heterocyclic compound consisting of fused benzene and furan rings with the molecular formula C_8H_6O.

It is a colourless, sweet-smelling, oily liquid that does not mix with water. 2,3- Benzofuran is made by processing coal into coal oil. It may also be formed during other uses of coal or oil. [1,2]

USES [2,3]

The part of the coal oil that contains 2,3-benzofuran is used to make a plastic called coumarone-indene resin. Coumarone-indene resin can then be used to make paint, varnish, glue, and floor tiles, and it is allowed on food products and packages.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

2,3-Benzofuran has been found in a few places in the air and water. In most instances, when it was found, the amount that was there was not measured. The levels of 2,3-benzofuran in soil, air, water, or food remain unknown. The reason that 2,3- benzofuran has not often been found could be that 2,3-benzofuran usually attaches to particles, and is not free in the air or water. It is unclear where 2,3-benzofuran comes from, except when it is found near fuel-processing factories. Workers who make coal oil or coumarone-indene resin might be exposed to 2,3-benzofuran. Cigarette smoke has some 2,3-benzofuran in it. Coumarone-indene resin is allowed in food packages and as a coating on oranges and grapefruit. It is unknown how often the resin is used or whether any 2,3-benzofuran in it gets into the food.

Routes of Exposure

Very little is known about how 2,3-benzofuran can enter and leave the body. Some 2,3-benzofuran can enter your body from the environment if it is in the water that you drink, the food that you eat, or the air that you breathe.

HEALTH EFFECTS [4]

Acute Health Effects

The effect of 2,3-benzofuran human health depends on how much is taken into the body. In general, the more taken in, the greater the chances that an effect will occur. No studies have been done to test the effects of 2,3-benzofuran on the health of humans. Studies in animals show that 2,3-benzofuran can damage the liver and kidneys if large amounts are given within a short time, and that very large amounts can kill. It is unknown whether exposure to 2,3-benzofuran can affect your ability to have children or can harm an unborn baby.

Studies in animals show that exposure to 2,3-benzofuran at moderate levels over a long time can damage the liver, kidneys, lungs, and stomach. The brain, muscles, and heart do not seem to be seriously damaged by long-term exposure. Some rats and mice that received 2,3-benzofuran for their whole lives developed cancer of the kidney, lung, liver, or stomach. However, no cases of cancer in humans have been linked to exposure to 2,3-benzofuran.

SAFETY

First Aid Measures [5]

If 2,3-benzofuran is ingested a physician should be consulted and a copy of the safety data sheet provided.

- **Inhalation:** Move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
- **Skin Contact:** Wash off with soap and plenty of water. Consult a physician.
- **Eye Contact:** Flush eyes with water as a precaution.
- **Ingestion:** Do not induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

Personal Protective Equipment [4]

- **Eye/face protection:** Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards.
- **Skin protection:** Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.
- **Body Protection:** Complete suit protecting against chemicals, Flame retardant antistatic protective clothing, the type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.
- **Respiratory protection:** Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards.

REGULATION

United States

No standards have been set for exposure to 2,3- benzofuran. The Food and Drug Administration specifies the quantity of coumarone-indene resin that may be used on food and in food packages.

REFERENCES

1. http://en.wikipedia.org/wiki/Benzofuran
2. http://www.atsdr.cdc.gov/phs/phs.asp?id=913&tid=187
3. http://www.atsdr.cdc.gov/toxprofiles/tp25.pdf
4. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=AU&language=en&productNumber=B8002&brand=ALDRICH&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Faldrich%2Fb8002%3Flang%3Den

New Material Changes Color and Texture Like an Octopus

2026-01-08

Octopus and cuttlefish are masters of disguise. Many species can rapidly change both the color and the texture of their skin – an ability that scientists have long sought to replicate with synthetic materials. In a paper published in Nature, researchers at Stanford have made a significant step towards that goal with a new flexible material that can swell into different textures and colors in a matter of seconds, creating patterns at resolutions finer than a human hair.

"Textures are crucial to the way we experience objects, both in how they look and how they feel," said Siddharth Doshi, a doctoral student in materials science and engineering at Stanford and first author on the paper. "These animals can physically change their bodies at close to the micron scale, and now we can dynamically control the topography of a material – and the visual properties linked to it – at this same scale."

The work could lead to more effective dynamic camouflage, both for humans and for robotic systems, and potentially help create flexible, color-changing displays for wearable technologies. It also opens up new opportunities in the field of nanophotonics, which uses the precise manipulation of light and optics for advancements in electronics, encryption, biology, and other areas.

"There's just no other system that can be this soft and swellable, and that you can pattern at the nanoscale," said Nicholas Melosh, a professor of materials science and engineering and a senior author on the paper. "You can imagine all kinds of different applications."

Precise, reversible patterns

To create dynamic textures in a flexible material, the researchers combined a patterning technique called electron-beam lithography, which is typically used in advanced semiconductor manufacturing, with a polymer film that swells as it absorbs water. By firing a beam of electrons at the film, they were able to adjust how much certain areas of the material would swell, creating detailed patterns that only revealed themselves when the film was wet.

The discovery that an electron beam could change the polymer's absorbency and create patterns of different colors and textures originally came as somewhat of a surprise. In an earlier project, Doshi had used a scanning electron microscope – which uses a focused beam of electrons to create a high-resolution image – to examine nanostructures the team had created on top of a polymer film. Typically, those samples would be discarded after imaging, but Doshi decided to reuse them instead of creating new ones. In the next set of tests, the regions of the film that had been imaged with the electron scanning microscope behaved differently and turned a different color.

"We realized that we could use these electron beams to control topography at very fine scales," Doshi said. "It was definitely serendipitous."

The electron-beam patterning is so precise that the team was able to create a nanoscale replica of Yosemite National Park's El Capitan rock formation. When dry, the film is perfectly flat, but as soon as water is added, the monolith's shape rises up from the surface. They also fashioned fine-scale textures that change how light is scattered depending on the amount of water added to the film. This allowed the researchers to create surface finishes ranging from glossy to matte, producing a more realistic appearance than smartphone or computer displays are currently capable of. All of the films are easily returned to their flat state by adding an alcohol-like solvent to remove the water.

The team demonstrated that the same technique can be used to design and reveal complex, switchable color patterns. The researchers put thin, metallic layers on each side of the patterned polymer film to create Fabry-Pérot resonators, which isolate specific wavelengths of light based on the distance between the metal layers. As the polymer films swell to different widths, they display a variety of colors. With the same electron-beam patterning and the right mix of water and solvent, the single-colored sheet becomes a riot of colorful spots and splotches.

"By dynamically controlling the thickness and topography of a polymer film, you can realize a very large variety of beautiful colors and textures," said Mark Brongersma, a professor of materials science and engineering and a senior author on the paper. "The introduction of soft materials that can expand, contract, and alter their shape opens up an entirely new toolbox in the world of optics to manipulate how things look."

Dynamic possibilities

When the researchers combined different films into a multilayer device, they were able to independently manipulate both color and texture at the same time, camouflaging with a background pattern nearly as adeptly as an octopus (although not without some trial and error).

Currently, getting the films to accurately match a background pattern requires the researchers to manually adjust the combination of water and solvent to get the right topography and colors. In the future, the team is hoping to integrate a computer vision system, which would be able to automatically adjust the level of swelling to make the films blend in with a variety of backgrounds.

“We want to be able to control this with neural networks – basically an AI-based system – that could compare the skin and its background, then automatically modulate it to match in real time, without human intervention,” Doshi said.

The researchers are also interested in applications beyond visual camouflage. Fine-scale changes in texture could, for example, be used to increase or decrease friction, which could help determine if a small robot will cling to a surface or slide past it. Nanoscale structures can change how cells respond, so there may be bioengineering uses for these techniques as well. They are even working with artists at Stanford to create an exhibit using these materials as an artistic medium.

“Small changes in the properties of soft materials over micron distances are finally possible, which will open up all sorts of possibilities,” Melosh said. “I think there are a lot of exciting things coming up.”

Technology Networks, 8 January 2026

https://technologynetworks.com

Scientists Find a Hidden State Inside Liquid Metal That Shouldn’t Exist

2026-01-25

Motionless atoms can trap liquid metal in a strange new state that shouldn’t exist.

Scientists have discovered that a liquid does not always behave the way it seems. Even when a material is fully molten, some of its atoms can remain fixed in place, no matter how hot it gets. These stationary atoms strongly influence how a liquid turns into a solid and can even give rise to an unusual state of matter known as a corralled supercooled liquid.

Why Solidification Matters

The process of solid formation underpins many natural phenomena, including mineralization, ice growth, and the folding of protein fibrils. It is also critical for a wide range of technologies. Pharmaceuticals rely on controlled solidification, as do metal-based industries such as aviation, construction, and electronics.

Watching Metal Freeze at the Atomic Scale

To investigate how liquids solidify, researchers from the University of Nottingham and the University of Ulm in Germany used transmission electron microscopy to observe molten metal nano droplets as they cooled. Their results were published in ACS Nano.

Professor Andrei Khlobystov, who led the research, said, “When we consider matter, we typically think of three states: gas, liquid, and solid. While the behavior of atoms in gases and solids is easier to understand and describe, liquids remain more mysterious.”

The Chaotic Motion of Liquid Atoms

Atoms inside a liquid move in a highly complex way, much like people pushing through a crowded space. They rush past one another while continuing to interact. Capturing this behavior is especially difficult during the moment when a liquid begins to freeze, even though this transition determines the final structure of the material and many of its practical properties.

Melting Nanoparticles on Graphene

Dr. Christopher Leist, who carried out the transmission electron microscopy experiments at Ulm using the low voltage SALVE instrument, said, “We began by melting metal nanoparticles, such as platinum, gold, and palladium, deposited on an atomically thin support—graphene. We used graphene as a sort of hob for this process to heat the particles, and as they melted, their atoms began to move rapidly, as expected. However, to our surprise, we found that some atoms remained stationary.”

Further investigation revealed that these immobile atoms were tightly bound to the support at specific defect sites. This strong attachment held even at extremely high temperatures. By focusing the electron beam, the researchers could create more defects and directly control how many atoms stayed pinned within the liquid.

Electron Beams and a New Phase of Matter

Professor Ute Kaiser, who established the SALVE center at Ulm University, said, “Our experiments have surprised us as we directly observe the wave-particle duality of electrons in the electron beam. We visualize the material using electrons as waves. At the same time, electrons behave like particles, delivering discrete bursts of momentum that can either move or, surprisingly, even fix atoms at the edge of a liquid metal. This remarkable observation has allowed us to discover a new phase of matter."

The team has previously used the same approach to record films of chemical reactions involving individual molecules, including the first time a chemical bond was seen breaking and reforming in real time. This technique allows scientists to observe chemistry one atom at a time.

How Stationary Atoms Change Freezing

In the new experiments, the researchers found that pinned atoms dramatically alter the way a liquid solidifies. When only a few atoms are stationary, crystals grow normally from the liquid until the entire particle becomes solid. When many atoms are fixed in place, however, this orderly process breaks down, and crystal formation is completely blocked.

Professor Andrei Khlobystov from the University of Nottingham said, "The effect is particularly striking when stationary atoms create a ring that surrounds the liquid. Once the liquid is trapped in this atomic corral, it can remain in a liquid state even at temperatures significantly below its freezing point, which for platinum can be as low as 350 degrees Celsius—that is more than 1,000 degrees below what is typically expected."

From Supercooled Liquid to Unstable Solid

When the temperature drops far enough, the trapped liquid eventually becomes solid. Instead of forming a crystal, it turns into an amorphous metal with no regular atomic pattern. This form is extremely unstable and exists only because the stationary atoms hold it in place. If that confinement is disturbed, the built-up tension is released, and the metal quickly rearranges into its normal crystalline structure.

Implications for Catalysts and Materials Science

Dr. Jesum Alves Fernandes, a catalysis expert at the University of Nottingham, said, "The discovery of a new hybrid state of metal is significant. Since platinum on carbon is one of the most widely used catalysts globally, finding a confined liquid state with non-classical phase behaviour could change our understanding of how catalysts work. This advancement may lead to the design of self-cleaning catalysts with improved activity and longevity."

Toward Atomically Corralled Matter

Until now, nanoscale corralling had only been demonstrated for photons and electrons. This study marks the first time atoms themselves have been corralled. Professor Andrei Khlobystov said, "Our achievement may herald a new form of matter combining characteristics of solids and liquids in the same material."

Looking ahead, the researchers aim to precisely control the placement of pinned atoms to build larger and more complex corrals. Such advances could enable more efficient use of rare metals in clean technologies, including energy conversion and storage.

Sci Tech Daily, 25 January 2026

https://scitechdaily.com

Scientists unlocked a superconductor mystery under crushing pressure

2025-12-21

The challenge is that superconductivity usually occurs only at very low temperatures, far below everyday conditions. This limitation has prevented widespread practical use. That picture began to change with the discovery of superconductivity in hydrogen-rich materials. Hydrogen sulfide ($H3S$) becomes superconducting at 203 Kelvin (-70°Celsius), while lanthanum decahydrid ($LaH10$) reaches superconductivity at 250 Kelvin (-23°Celsius). These temperatures are far higher than those of earlier superconductors and are above the boiling point of liquid nitrogen, which is why scientists classify them as high temperature superconductors. Their discovery marked a major step toward the long-standing goal of room-temperature superconductivity.

The Superconducting Gap and Why It Is Crucial

At the heart of superconductivity is a feature known as the superconducting gap. This property reveals how electrons join together to form the superconducting state and serves as a clear signature that distinguishes a superconductor from an ordinary metal.

Understanding the superconducting gap is essential because it directly reflects how electrons interact inside the material. Without measuring this gap, scientists cannot fully explain why a material becomes superconducting or what mechanism makes resistance disappear.

Why Measuring Hydrogen Superconductors Is So Difficult

Despite their importance, hydrogen-rich superconductors such as H3S have been extremely challenging to study. These materials can only be created under enormous pressures that exceed atmospheric pressure by more than a million times. Because of these extreme conditions, widely used techniques like scanning tunneling spectroscopy and angle-resolved photoemission spectroscopy cannot be applied.

As a result, the superconducting gap in these materials had remained unmeasured, leaving a major gap in scientists' understanding of how high-temperature superconductivity works in hydrogen-rich compounds.

A New Tunneling Technique Breaks the Barrier

To solve this problem, researchers at the Max Planck Institute in Mainz developed a planar electron tunneling spectroscopy method that can operate under these extreme pressures. This new approach made it possible to directly probe the superconducting gap in H3S for the first time.

With this technique, the team obtained a clear picture of the superconducting state in hydrogen-rich materials, overcoming a barrier that had limited progress in the field for years.

What the Measurements Revealed

The researchers found that H3S has a fully open superconducting gap of approximately 60 millielectronvolt (meV). They also studied its deuterium counterpart, D3S, which showed a smaller gap of about 44 meV. Deuterium is a hydrogen isotope and has one more neutron.

This difference is significant because it confirms that superconductivity in H3S is driven by interactions between electrons and phonons. Phonons are quantized vibrations of a material's atomic lattice. The results support long-standing theoretical predictions about the mechanism behind superconductivity in hydrogen-rich compounds.

Why This Breakthrough Matters

For the researchers in Mainz, the achievement goes beyond technical success. It provides a foundation for uncovering the fundamental origins of high-temperature superconductivity in hydrogen-based materials. "We hope that by extending this tunneling technique to other hydride superconductors, the key factors that enable superconductivity at even higher temperatures can be pinpointed. This should ultimately enable the development of new materials that can operate under more practical conditions," states Dr. Feng Du, first author of the now published study.

Dr. Mikhail Eremets, a leading figure in high-pressure superconductivity research who deceased in November 2024, described the study as "the most important work in the field of hydride superconductivity since the discovery of superconductivity in H3S in 2015." Vasily Minkov, project leader of High-Pressure Chemistry and Physics at the Max Planck Institute for Chemistry, added: "Mikhail´s vision of superconductors operating at room temperature and moderate pressures comes a step closer to reality through this work."

A Brief History of Superconductivity

Superconductivity refers to the ability of certain materials to conduct electrical current without resistance. It was first discovered in pure mercury in 1911 by Heike Kamerlingh Onnes. For many decades, scientists believed this phenomenon could only occur at temperatures near absolute zero (-273 °C).

That assumption changed in the late 1980s when Georg Bednorz and Karl Alexander Müller discovered copper-oxide superconductors, also known as cuprates, that exhibited high-temperature superconductivity under normal atmospheric pressure. This discovery sparked worldwide research efforts.

Over time, scientists reached critical temperatures (Tc) of about 133 K at ambient pressure and 164 K under high pressure. Progress then stalled until hydrogen-rich compounds entered the picture.

Hydrogen-Rich Materials Push the Limits

The discovery of superconductivity in H3S at megabar pressures, with a Tc = 203 K by the research group led by Dr. Mikhail Eremets, represented a turning point. Soon after, even higher critical temperatures were observed in hydrogen-rich metal hydrides such as YH9 (Tc ≈ 244 K) and LaH10 (Tc ≈ 250 K).

Current theoretical models now suggest that superconductivity above room temperature may be possible in several hydrogen-dominated systems when subjected to extreme pressure.

Cooper Pairs and the Meaning of the Superconducting Gap

In normal metals, electrons near the Fermi level can move freely. The Fermi level represents the highest energy level electrons can occupy in a solid at absolute zero. When a material becomes superconducting, electrons instead form paired states known as Cooper pairs and enter a collective quantum state.

In this state, paired electrons move together without scattering off phonons or impurities in the crystal lattice, which eliminates electrical resistance. This pairing creates an energy gap near the Fermi level called the superconducting gap. The gap represents the minimum energy required to break a Cooper pair and plays a protective role by stabilizing the superconducting state against disturbances.

The superconducting gap is a defining feature of superconductivity. Its size and symmetry provide critical insight into how electrons interact and pair, making it a key fingerprint of the underlying superconducting mechanism.

Science Daily, 21 December 2025

https://sciencedaily.com

Self-Healing Composites for Long-Lasting Aircraft Materials

2026-01-15

Researchers have created a self-healing composite that is tougher than materials currently used in aircraft wings, turbine blades and other applications - and can repair itself more than 1,000 times. The researchers estimate their self-healing strategy can extend the lifetime of conventional fiber-reinforced composite materials by centuries compared to the current decades-long design-life.

“This would significantly drive down costs and labor associated with replacing damaged composite components, and reduce the amount of energy consumed and waste produced by many industrial sectors - because they’ll have fewer broken parts to manually inspect, repair or throw away,” says Jason Patrick, corresponding author of the paper and an associate professor of civil, construction and environmental engineering at North Carolina State University.

At issue are fiber-reinforced polymer (FRP) composites, which are valued for their high strength-to-weight ratio and are commonly used in aircraft, automobiles, wind-turbines, spacecraft and other modern structural applications. FRP composites consist of layers of fibers, such as glass or carbon fiber, that are bonded together by a polymer matrix, often epoxy. The self-healing technique developed by the NC State researchers targets interlaminar delamination, which occurs when cracks within the composite form and cause the fiber layers to separate from the matrix.

“Delamination has been a challenge for FRP composites since the 1930s,” Patrick says. “We believe the self-healing technology that we’ve developed could be a long-term solution for delamination, allowing components to last for centuries. That’s far beyond the typical lifespan of conventional FRP composites, which ranges from 15-40 years.”

The self-healing material resembles conventional FRP composites, but with two additional features. First, the researchers 3D-print a thermoplastic healing agent onto the fiber reinforcement, creating a polymer-patterned interlayer that makes the laminate two to four times more resistant to delamination. Second, the researchers embed thin, carbon-based heater layers into the material that warm up when an electrical current is applied. The heat melts the healing agent, which then flows into cracks and microfractures and re-bonds delaminated interfaces – restoring structural performance.

To evaluate long-term healing performance, the team built an automated testing system that repeatedly applied tensile force to an FRP composite producing a 50 millimeter-long delamination, then triggered thermal remending. The experimental setup ran 1,000 fracture-and-heal cycles continuously over 40 days, measuring resistance to delamination after each repair. In other words, the researchers cracked the material in the exact same way, healed it, and then measured how much load the material could handle before delaminating again. And they did that 1,000 times, an order-of-magnitude beyond their prior record.

“We found the fracture resistance of the self-healing material starts out well above unmodified composites,” says Jack Turicek, lead author of the paper and a graduate student at NC State. “Because our composite starts off significantly tougher than conventional composites, this self-healing material resists cracking better than the laminated composites currently out there for at least 500 cycles. And while its interlaminar toughness does decline after repeated healing, it does so very slowly.”

In real-world scenarios, healing would only be triggered after the material is damaged by hail, bird strikes or other events, or during scheduled maintenance. The researchers estimate the material could last 125 years with quarterly healing or 500 years with annual healing.

"This provides obvious value for large-scale and expensive technologies such as aircraft and wind turbines," Patrick says. "But it could be exceptionally important for technologies such as spacecraft, which operate in largely inaccessible environments that would be difficult or impossible to repair via conventional methods on-site."

The study also shed light on why recovery slowly declines over time. With continued cycling, the brittle reinforcing fibers progressively fracture - creating micro-debris that limits rebonding sites. In addition, chemical reactions where the healing agent interfaces with the fibers and polymer matrix decline over time. Even so, modeling suggests the self-healing will remain viable over extremely long time scales.

"Despite the inherent chemo-physical mechanisms that slowly reduce healing efficacy, we have predicted that perpetual repair is possible through statistical modeling that is well suited for capturing such phenomena," says Kalyana Nakshatrala, co-author of the paper and the Carl F. Gauss Professor of Civil and Environmental Engineering at the University of Houston.

Patrick has patented and licensed the technology through his startup company, Structeryx Inc.

"We're excited to work with industry and government partners to explore how this self-healing approach could be incorporated into their technologies, which has been strategically designed to integrate with existing composite manufacturing processes," Patrick says.

Technology Networks, 15 January 2026

https://technologynetworks.com

Biodegradable bark–plastic composite lets engineers predict product lifetime from tensile tests

2026-01-29

Old trees are learning new tricks with the advent of composite materials. A "green composite" made from biodegradable polymers and the waste bark of the Yakushima Jisugi tree was developed by a research team at Tohoku University. When assessing the material, they found that simply testing its mechanical strength—in this case, its tensile strength or ability to resist pulling—could reliably predict the biodegradation process.

Traditionally, scientists chemically test how much of a material remains after time has passed, applying processes that are costly in time and money. Shifting assessment focus to how a material continues to safely function during the biodegradation process, the team said, could help better inform practical use of such products. They published their results on January 20, 2026, in npj Materials Degradation.

"Biodegradable materials are often discussed in terms of how fast they disappear, but in real use, what matters most is how long they remain strong and reliable," said Lovisa Rova, doctoral student in the Graduate School of Environmental Studies at Tohoku University and a Japan Science for the Promotion of Science (JSPS) Fellow. "By linking mechanical strength directly to biodegradation, our work provides a practical way to think about the usable lifetime of biodegradable materials."

Building a composite from tree bark

To develop their composite material, the researchers turned to polybutylene succinate (PBS), a type of polyester that can biodegrade in compost and other environments. It is readily available, but pricey and often composed—by more than half—of fossil fuel-based resources. The composite material contained about 40% PBS and 60% Yakushima Jisugi tree bark, a waste product of the lumber industry. The team then buried test samples of the material in compost and outdoor soil environments to simulate realistic degradation scenarios.

"At different stages of biodegradation, we measured the mechanical strength of the samples using tensile tests and compared these results with standard biodegradation indicators," Rova said. "We found that in both compost and soil, as the material biodegraded its tensile strength decreased in a clear and predictable exponential manner."

Tracking strength loss during degradation

In eight weeks of compost burial, the material degraded by 13%. In 30 weeks of outdoor soil burial, it degraded by 5%. Over six months, the researchers tracked the degradation and developed a simple model linking strength loss to the degradation process, which they said shows mechanical testing can be used to estimate biodegradation. They also confirmed that the composite material initially maintains sufficient electrical insulation performance, supporting its potential use in temporary products that need to electrically function prior to safely degrading.

According to the researchers, the material has "excellent" biodegradability, with potential applications in agriculture and in devices intended to selfdisintegrate. The electrical functioning, they said, also points to potential applications in biodegradable sensors or disposable electronic packaging.

“This research brings these two issues—plastic pollution and resource loss—together by focusing on how the mechanical strength of a biodegradable material changes as it degrades,” Rova said. “By connecting material strength with biodegradation progress, the study provides a more practical way to think about biodegradable products—not just as materials that eventually disappear, but as materials whose usable lifetime can be designed and predicted.”

Phys Org, 29 January 2026

https://phys.org

How smart polymer solutions transition to gels around body temperature

2026-01-28

In the world of modern medicine, most people focus on the active pharmaceutical ingredients, which are the chemicals that specifically fight a disease’s symptoms or causes. However, the unsung heroes of pharmacy are excipients—substances formulated alongside the active ingredients to ensure they reach the right part of the body at the right time. Simply put, excipients are as vital as the drugs themselves because they provide a controllable means of administration.

Why poloxamers matter in gels

A prominent example is thermoresponsive compounds that enable in situ gelling. These smart liquids, once administered to the body, transform into a solid gel in response to body heat, enabling the medication to stay exactly where it is put and providing a localized, steady release.

Poloxamers are polymeric materials that are among the most trusted tools for achieving in situ gelling and are widely used in topical creams, eye drops, and even oncological drug applications. Despite their popularity, working with these materials can be challenging; even the most researched variety, poloxamer 407 (P407), is notoriously finicky.

The exact temperature at which P407 turns from liquid to solid gel, called the sol–gel transition temperature, fluctuates depending on its concentration. This makes P407 difficult to ensure a formula that stays liquid in a cool syringe or vessel but solidifies reliably once it touches a warm human body.

Although P407 can be mixed with poloxamer 188 (P188) to finely tune its transition temperature, the underlying physics governing this behavior remain unclear.

Against this backdrop, a research team led by Associate Professor Kenjirou Higashi from the Graduate School of Pharmaceutical Sciences, Chiba University, Japan, conducted a deep dive into the structural evolution of P407/P188 mixtures.

Their paper, published in Journal of Colloid and Interface Science, explores the fine molecular and macroscopic changes that occur when these two polymers interact at different temperatures.

This work was co-authored by Dr. Prakasit Panyamao (a Ph.D. student at Chiba University and a lecturer at Chiang Mai University, Thailand), Dr. Chalermpong Saenjum from Chiang Mai University, and Dr. Keisuke Ueda and Dr. Kunikazu Moribe from Chiba University.

“Our research was motivated by repeated observations that small changes in poloxamer composition can cause unexpectedly large and inconsistent changes in gelation behavior. The lack of a clear mechanistic explanation prompted us to investigate how molecular self-assembly translates into macroscopic gelation, with the aim of moving beyond trial-and-error formulations,” explains Dr. Panyamao.

Peering into gelation at multiple scales

To achieve their goal, the team used a sophisticated three-pronged approach that revealed key properties at different scales. They used differential scanning calorimetry to measure heat changes at the molecular level, rheology to test the stiffness and sol–gel transition temperature of the gels, and in situ synchrotron small-angle X-ray scattering to determine their internal crystalline architecture as it formed.

Through detailed analysis, the team discovered that P188 at low concentrations essentially acts as a disruptor, preventing P407 molecules from packing together and thus raising the gelation temperature. However, at higher concentrations, P188 competes for water molecules with P407. This forces P407 to dehydrate faster and form a large number of tiny spherical structures called micelles.

These micelles become so tightly packed that the mixture turns into a gel at lower temperatures. Taken together, the results provide the first comprehensive map of how these poloxamers reorganize from a disordered solution state into highly organized, crystal-like lattices with distinct arrangements.

Implications for medicine and beyond

These insights into the gelation processes of P407/P188 mixtures are crucial for the pharmaceutical industry, as they will enable scientists to better customize the thickness and stability of thermoresponsive gels to suit specific medical needs.

"The findings in this study support the precise design of sustained-release formulations for localized therapies in ophthalmology, dermatology, and oncology, where controlled gelation can enhance drug retention and minimize side effects," highlights Dr. Panyamao.

Beyond clinical applications, the implications of this work reach into other industries that require materials to change shape or texture in response to temperature. "This research could not only help create safer, more predictable, and more accessible gel-based medicines, but also bolster the development of smarter materials in cosmetics, food, and technology," concludes Dr. Higashi.

Phys Org, 28 January 2026

https://phys.org

"Chemistry-Aware" AI Model Composes Nanomaterials With Optimal Properties

2026-01-15

LMU researcher Professor Alexander Urban and his team have developed a tool that could revolutionize the design of new materials. Synthesizer is a platform that combines automated chemical synthesis, high-throughput characterization, and data-driven modeling. The goal is to control the growth of nanocrystals with unprecedented precision, thereby creating materials with tailor-made optical properties. The results of their work, funded by the e-conversion Excellence Cluster, have now been published by the LMU team in Advanced Materials.

Unlike previous data-driven approaches, Synthesizer is the first platform to connect the entire chain from automated synthesis and optical high-throughput characterization to the AI-supported derivation of concrete design rules within an open and modular system. "Today, we can compose material properties almost like a melody, note by note, parameter by parameter," says Alexander Urban. That is exactly what Synthesizer enables.

Using the platform, variants of halide perovskites can be produced and characterized automatically, while an AI model learns which chemical combinations lead to specific colors, brightness levels or stabilities.

The optical properties of halide perovskites such as color, brightness or emission width determine their use in LEDs, solar cells or sensors. "Even the smallest differences in nanocrystal size, shape and structure can shift light emission," explains Nina Henke, first author and doctoral researcher in Urban's team. "Fine-tuning is therefore essential in order to develop materials that are precisely tailored to specific applications."

A turbo boost for the development of halide perovskites

What makes Synthesizer special is that the platform is open, flexible, and expandable. It was originally developed for halide perovskites but is, in principle, suitable for other material classes as well. In the future, researchers will be able to automate syntheses, systematically vary parameters and generate valuable data sets in a very short time. The AI model then translates this data into concrete design rules. In the journal article, the researchers not only present the concept but also release Synthesizer as a freely available and modularly adaptable platform.

"Our goal is to accelerate materials research and enable precise predictions," says Alexander Urban. "This makes it possible to create crystals with specifically tuned optical and physical properties and to further advance optoelectronics and photonics." The synthesizer platform is compatible with existing systems for automated synthesis. The LMU team is currently working on integrating its development into the laboratory routine.

Technology Networks, 15 January 2026

https://technologynetworks.com

Scientists Discover That Electric Fields Flip the Rules of Water Chemistry

2026-01-25

Hydrogen is expected to play a major role in future energy systems, which makes a clear understanding of electrolysis increasingly important. Scientists at the Max Planck Institute for Polymer Research and the Yusuf Hamied Department of Chemistry at the University of Cambridge have taken a closer look at a closely related phenomenon known as water autodissociation.

Although the basic chemistry of how water splits is well understood under normal conditions, far less is known about how this process unfolds in the intense electric fields found inside electrochemical devices.

Why water rarely splits on its own

In the natural world, systems of all sizes follow a small set of fundamental rules. Objects move in ways that lower their energy, such as falling downward under gravity. At the same time, the balance between order and disorder also plays a crucial role. Over time, systems tend to become more disordered, a tendency that applies even at the molecular scale and is described by the concept of "entropy".

Both energy and entropy shape how chemical reactions proceed. A process can occur spontaneously if it lowers energy or increases entropy, meaning greater disorder. Under everyday conditions, such as in a glass of water, water autodissociation is blocked on both fronts. It neither lowers energy nor increases disorder, which makes the reaction extremely rare. When strong electric fields are introduced, however, the situation changes and the reaction can speed up dramatically.

Electric fields flip the driving force

Researchers at the Max Planck Institute for Polymer Research and the Yusuf Hamied Department of Chemistry at the University of Cambridge have now identified an unexpected mechanism that controls water autodissociation under these powerful electric fields. Their results, published in the Journal of the American Chemical Society, challenge the long-held assumption that the reaction is governed mainly by energy alone.

"Water autodissociation has been extensively studied in bulk conditions, where it's understood to be energetically uphill and entropically hindered," says Yair Litman, group leader at the Max Planck Institute. "But under the strong electric fields typical of electrochemical environments, the reaction behaves very differently."

Using advanced molecular dynamics simulations, Litman and co-author Angelos Michaelides show that strong fields dramatically enhance water dissociation—not by making the reaction more energetically favorable, but by making it entropically favorable. The electric field initially orders water molecules into a highly structured network. When ions form, they disrupt this order, increasing the system's entropy—or disorder—which ultimately drives the reaction forward.

"It's a complete reversal of what happens at zero field," explains Litman. "Instead of entropy resisting the reaction, it now promotes it."

Rethinking water splitting under bias

The study also shows that under strong electric fields, the pH of water can drop from neutral (7) to highly acidic levels (as low as 3), with implications for how we understand and design electrochemical systems.

"These results point to a new paradigm," says Michaelides. "To understand and improve water-splitting devices, we need to consider not just energy, but entropy—and how electric fields reshape the molecular landscape of water."

The research highlights the need to rethink how reactivity is modeled in aqueous environments under bias and opens up new possibilities for catalyst design, particularly in electrochemical and "on-water" reactions.

Sci Tech Daily, 25 January 2026

https://scitechdaily.com

What are asteroids really made of? New analysis brings space mining closer to reality

2025-12-25

A research team led by the Institute of Space Sciences (ICE-CSIC) examined samples linked to C-type asteroids, carbon rich objects that are believed to be the original sources of carbonaceous chondrites. Their results, published in the Monthly Notices of the Royal Astronomical Society, strengthen the case that these asteroids could serve as important material reservoirs. The findings also help scientists identify where these meteorites came from and support planning for future space missions and resource extraction technologies.

Rare Meteorites From Ancient Asteroids

Carbonaceous chondrites arrive on Earth naturally, but they account for only about 5% of all meteorite falls. Many are extremely fragile and break apart before they can be recovered, which makes them especially rare. When they are found, it is often in desert environments such as the Sahara or Antarctica, where preservation conditions are favorable.

"The scientific interest in each of these meteorites is that they sample small, undifferentiated asteroids, and provide valuable information on the chemical composition and evolutionary history of the bodies from which they originate," says Josep M. Trigo-Rodríguez, the study's lead author and an astrophysicist at ICE-CSIC, affiliated to the Institute of Space Studies of Catalonia (IEEC).

Measuring the Building Blocks of Asteroids

To carry out the study, the ICE-CSIC team selected and carefully characterized asteroid related samples before sending them for detailed chemical analysis. The measurements were performed using mass spectrometry at the University of Castilla-La Mancha by Professor Jacinto Alonso-Azcárate. This work allowed the researchers to determine the precise chemical makeup of the six most common types of carbonaceous chondrites and assess whether extracting materials from their parent asteroids could one day be practical.

The Asteroids, Comets, and Meteorites research group at ICE-CSIC has spent more than a decade studying the physical and chemical properties of asteroid and comet surfaces. "At ICE-CSIC and IEEC, we specialize in developing experiments to better understand the properties of these asteroids and how the physical processes that occur in space affect their nature and mineralogy," Trigo-Rodríguez explains.

He also notes that ICE-CSIC serves as the international repository for NASA's Antarctic meteorite collection. Over the past ten years, he has helped select and request several of the carbonaceous chondrites used in this study and has designed multiple experiments around them. "The work now being published is the culmination of that team effort," he says.

Are Asteroid Resources Worth Extracting?

"Studying and selecting these types of meteorites in our clean room using other analytical techniques is fascinating, particularly because of the diversity of minerals and chemical elements they contain. However, most asteroids have relatively small abundances of precious elements, and therefore the objective of our study has been to understand to what extent their extraction would be viable," says Pau Grèbol Tomás, a predoctoral researcher at ICE-CSIC.

Jordi Ibáñez-Insa, a co-author of the study and researcher at Geosciences Barcelona (GEO3BCN-CSIC), points out that while many small asteroids are covered in loose surface material known as regolith, collecting small samples is very different from extracting resources at scale. "Although most small asteroids have surfaces covered in fragmented material called regolith -and it would facilitate the return of small amounts of samples-, developing large-scale collection systems to achieve clear benefits is a very different matter. In any case, it deserves to be explored because the search for resources in space could be susceptible to minimizing the impact of mining activities on terrestrial ecosystems," he says.

Choosing the Right Asteroids for the Future

The main asteroid belt contains an enormous range of objects, and understanding what resources they hold requires careful classification. According to Trigo-Rodríguez, asteroid composition varies widely due to their long and complex histories. "They are small and quite heterogeneous objects, heavily influenced by their evolutionary history, particularly collisions and close approaches to the Sun. If we are looking for water, there are certain asteroids from which hydrated carbonaceous chondrites originate, which, conversely, will have fewer metals in their native state. Let's not forget that, after 4.56 billion years since their formation, each asteroid has a different composition, as revealed by the study of chondritic meteorites."

One key conclusion of the research is that mining undifferentiated asteroids -- the primordial remnants of the solar system's formation considered the progenitor bodies of chondritic meteorites -- remains impractical for now. However, the team identifies a different class of relatively pristine asteroids that display olivine and spinel signatures as more promising mining targets.

To confidently identify such candidates, the researchers emphasize the importance of detailed chemical studies of carbonaceous chondrites combined with new sample return missions. These missions would help confirm which asteroids are truly linked to the meteorites studied on Earth.

Technology, Water, and Long Term Exploration

"Alongside the progress represented by sample return missions, companies capable of taking decisive steps in the technological development necessary to extract and collect these materials under low-gravity conditions are truly needed. The processing of these materials and the waste generated would also have a significant impact that should be quantified and properly mitigated," Trigo-Rodríguez adds.

The team expects progress in the near future, especially as in situ resource use becomes increasingly important for long duration missions to the

Moon and Mars. Using materials found in space could significantly reduce the need for supplies launched from Earth. If water is the primary target, the researchers stress that asteroids altered by water and rich in water bearing minerals should be prioritized.

Extracting resources in low gravity environments will require entirely new approaches. "It sounds like science fiction, but it also seemed like science fiction when the first sample return missions were being planned thirty years ago," says Pau Grèbol Tomàs.

From Planetary Defense to Space Resources

Globally, several concepts are already being discussed, including capturing small asteroids that pass close to Earth and placing them into circumlunar orbit for study and resource use. Trigo-Rodríguez highlights that water rich carbonaceous asteroids may be especially attractive targets. "For certain water-rich carbonaceous asteroids, extracting water for reuse seems more viable, either as fuel or as a primary resource for exploring other worlds. This could also provide science with greater knowledge about certain bodies that could one day threaten our very existence. In the long term, we could even mine and shrink potentially hazardous asteroids so that they cease to be dangerous," he explains.

Science Daily, 25 December 2025

https://sciencedaily.com

Self-powered composite material detects its own cracks

2026-01-29

A new multifunctional composite made of carbon fiber-reinforced polymers (CFRP) and piezoelectric materials can use vibrations to self-detect tiny cracks. This material could be used in the aerospace, automotive, and construction industries to monitor structural health without the need for an external power source. The technology was shared in a paper published in the International Journal of Smart and Nano Materials on January 9, 2026.

Why a smarter CFRP is needed

"CFRP is very strong and light. It's used in airplanes, wind turbines, and other large structures. However, it can fail suddenly when cracks grow inside. Finding these cracks early is difficult and many structures cannot easily use batteries or wired sensors. A self-powered sensing solution

is strongly needed," said assistant professor Zhenjin Wang of Tohoku University.

To make CFRP smarter, the researchers integrated a piezoelectric nanocomposite that converts mechanical energy into electrical energy. The piezoelectric nanocomposite is made of piezoelectric nanoparticles and epoxy, which helps balance electrical performance and mechanical strength. For practical use in aircraft and energy systems, the team used a lead-free piezoelectric material, potassium sodium niobate (KNN), instead of conventional lead-based ceramics. This supports safer and more environmentally friendly sensing technologies.

"Our material turns vibration into information. Crack growth can be reflected in the timing of the wireless signals, which enables fully autonomous structural monitoring to support safer aircraft and energy systems," said Wang.

How the composite senses damage

Researchers tested both the mechanical strength of the composite and its ability to generate electricity. Under vibration, the material produced an open-circuit voltage of up to 13.6 V. More importantly, when artificial cracks were introduced between the CFRP and the piezoelectric nanocomposite layers, the output voltage and resonant frequency decreased as the cracks became longer. This means the material does not only harvest energy, but it can also "sense" internal damage through changes in its electrical response.

Based on this behavior, the team proposes a new approach that combines energy harvesting, sensing, and structural health monitoring in a single material system. With the piezoelectric "brain," the CFRP can harvest electricity from vibration and use it to monitor key conditions such as acceleration and pressure, while sending the data wirelessly to a computer without any external power supply. In addition, internal damage such as delamination can be detected by analyzing changes in the timing of the received wireless signals.

"Today, inspections need sensors, wires, and power supplies. This new material works by itself. It reduces cost, weight, and maintenance, and improves safety in places where power is limited," said Wang. "In addition to supporting safer aircraft and energy systems, our research will help future smart materials research and advance battery-free sensor technology."

Looking ahead, researchers are thinking about the different ways this multifunctional composite could be used for next-generation self-powered structural health monitoring systems. Additional testing will be needed to confirm the durability and stability of the composite to determine its practical uses.

Phys Org, 29 January 2026

https://phys.org

Caffeine-Controlled CRISPR Could Transform Precision Medicine

2026-01-27

What if a cup of coffee could help treat cancer? Researchers at the Texas A&M Health Institute of Biosciences and Technology believe it's possible. By combining caffeine with the use of CRISPR — a gene-editing tool known as clustered regularly interspaced short palindromic repeats — scientists are unlocking new treatments for long term diseases, like cancer and diabetes, using a strategy known as chemogenetics.

Yubin Zhou, professor and director of the Center for Translational Cancer Research at the Institute of Biosciences and Technology, specializes in utilizing groundbreaking tools and technology to study medicine at the cellular, epigenetic and genetic levels. Throughout his career and over 180 publications, he has sought answers to medical questions by using highly advanced tools like CRISPR and chemogenetic control systems.

Chemogenetics refers to the ability to control cellular behavior using externally applied, small molecules — often drugs or dietary compounds — that activate genetically engineered switches inside cells. Unlike traditional drugs that broadly affect many tissues, chemogenetic approaches are designed to act only on cells that have been genetically programmed to respond.

Gene editing with a kick

Zhou's newest research builds on existing knowledge of genetic "switches" within cells by introducing a new chemogenetic approach that uses CRISPR and caffeine. The process begins with installing the cells in advance. Genes encoding the nanobody, its matching target protein and the CRISPR machinery are delivered using established gene-transfer methods, allowing cells to produce these components on their own. Once this molecular framework is in place, the process can be externally controlled. When a person later consumes a 20 mg dose of caffeine — such as from coffee, chocolate or a soda — it triggers a nanobody and its matching target protein to bind together, thereby activating CRISPR-driven gene modifications inside cells.

This method also allows scientists to activate T cells, something not possible with other gene-editing methods. T cells serve as the body's memory bank for past infections, storing blueprints that help fight future threats. Being able to manually activate these cells could give researchers a new way to direct the immune system against specific diseases.

In addition, the team found that certain drugs can reverse the process by causing the proteins to separate, stopping further gene changes and offering even more control over how the system is used, an important feature for safe and reversible chemogenetic therapies. For example, in a therapeutic setting, clinicians could temporarily pause gene-modifying activity to give patients a break from treatment-related stress or side effects, then re-activate the system when conditions are optimal — allowing gene control to be tuned over time rather than left permanently switched on.

"You can also engineer these antibody-like molecules to work with rapamycin-inducible systems, so by adding a different drug like rapamycin, you can achieve the opposite effect," Zhou said. "For example, if at first proteins A and B are separate, adding caffeine brings them together; conversely, if proteins A and B start out together, adding a drug like rapamycin can cause them to dissociate."

Rapamycin is a widely available immunosuppressant drug traditionally used as an anti-rejection regiment for organ transplant patients. The drug works by blocking white blood cells from attacking foreign entities in the body. The affordability and availability of the drug make it a prime candidate for applications like this one.

Percolating future possibilities

When an engineered nanobody protein can be switched on by caffeine, it's called a "caffebody." By harnessing the power of these caffebodies, Zhou says scientists may someday be able to treat a range of diseases. In the long term, he believes it may be possible to engineer cells that allow people with diabetes to boost insulin production simply by drinking a cup of coffee.

Beyond insulin, the technology can be adapted to control other important molecules, such as those that power T cells. In cancer therapy, for example, caffebodies could be built into T cells to give doctors chemogenetic control over when, where and how strongly the immune system attacks tumors.

In animal model lab studies, Zhou and his team have found that caffeine, as well as its metabolites — such as theobromine , which is abundantly available from chocolate or cocoa — could trigger the response and allows for editing with CRISPR. This form of treatment is accessible, easier to control and has fewer side effects than other treatments, he said.

While similar activation techniques have been observed before, this allows for much more control to open and close the circuit. When caffeine is introduced, the team has a few hours — or the metabolization time of caffeine — to control the involved physiological processes or gene editing. Then, rapamycin can be administered as a stop signal, driving protein dissociation and terminating the process. Few existing approaches offer this level of coordinated start-and-stop control, making the method particularly precise and well suited for both research and therapeutic applications.

"It's quite modular," Zhou said. "You can integrate it into CRISPR and chimeric antigen receptor T (CAR-T) cells, and also if you want to induce some therapeutic gene expression like insulin or other things, and this is fully tunable in a very precisely controlled manner."

Zhou and his team hope to advance the work into further preclinical studies and explore more ways to utilize caffebodies and CRISPR for treating a wide range of medical conditions, bringing everyday molecules one step closer to becoming tools for precision medicine.

"What excites us is the idea of repurposing well-known drugs and even commonly found food ingredients like caffeine to do entirely new tricks," Zhou said. "Instead of acting as therapies themselves, molecules like caffeine or rapamycin can serve as precise control signals for sophisticated cell and gene therapies. Because these compounds are already well understood, this approach opens a practical path toward translation. Our hope is that one day, clinicians could use simple, familiar inputs to finely tune powerful therapies in a safe and reversible way."

Technology Networks, 27 January 2026

https://technologynetwortks.com

Photocatalysis enables direct coupling of native sugars and N-heteroarene

2026-01-29

Researchers from the National University of Singapore (NUS) have developed a "capping-and-coupling" strategy to transform naturally occurring (native) sugars directly into compounds known as C-heteroaryl glycosides. This makes it easier to produce such molecules that are valuable for drug and vaccine development.

The research team was led by Associate Professor Koh Ming Joo from the NUS Department of Chemistry and Professor Chan Chun Yong Eric from the NUS Department of Pharmacy and Pharmaceutical Sciences. The research breakthrough was published in Nature Synthesis.

C-Heteroaryl glycosides are found in many medicinally relevant molecules with interesting biological activities and are used in the development of effective mRNA vaccines against COVID-19 and other diseases.

In their physiologically active forms, these compounds are densely functionalized with nitrogen-containing aromatic groups and numerous hydroxyl (-OH) groups. However, the chemical synthesis of C-heteroaryl glycosides is challenging and typically involves many steps, including hydroxyl protection and deprotection and the use of harsh reagents. This makes the process time-consuming, wasteful, and difficult to apply on a larger scale.

Directly linking native sugars and aromatics

Associate Professor Koh said, "The most appealing way to make C-heteroaryl glycosides and create new functional molecules is to merge naturally occurring native saccharides with N-heteroarenes, both of which are prevalent in nature, through direct carbon-carbon bond formation."

The researchers designed a "capping-and-coupling" concept that transforms native sugars into C-heteroaryl glycosides in one step. The approach works by temporarily "capping" the sugar at the anomeric (C1) position, which selectively activates it for further reaction.

This generates a bench-stable, redox-active intermediate that can then be joined to a nitrogen-containing aromatic group through light-driven (photocatalytic) carbon–carbon bond formation. Importantly, this reaction proceeds through a previously unexplored chemical pathway, distinct from existing photochemical methods used to activate sugars.

Potential for new therapeutic molecules

As a result, the method enables simple and efficient coupling of a wide range of single and multi-sugar molecules with diverse nitrogen-containing aromatics.

Beyond method development, the researchers also tested some of the resulting compounds and found one C-heteroaryl glycoside that strongly slows glycogen breakdown, about 114 times more potent than its parent

sugar scaffold. This highlights the compound's potential for metabolic and therapeutic applications.

"We believe that this new methodology offers a powerful avenue for late stage glycosylations of complex molecules and to build innovative, functional carbohydrates," added Assoc Prof Koh.

Studies are ongoing to extend the capping-and-coupling strategy to synthesize other important classes of carbohydrates for biological applications.

Phys Org, 29 January 2026

https://phys.org

Scientists Found a Platinum Alternative Hiding in Plain Sight

2026-01-28

A low-cost industrial metal just proved it can beat platinum at recycling plastic and powering cleaner chemistry

Many products people use every day, from plastics to detergents, depend on chemical reactions powered by catalysts made from precious metals such as platinum. While platinum is highly effective, it is also expensive and limited in supply. Scientists have spent years searching for alternatives that are both affordable and sustainable. One strong candidate is tungsten carbide, an Earth-abundant material already widely used in industrial machinery, cutting tools, and chisels.

Despite its promise, tungsten carbide has not been easy to apply in chemical manufacturing. Its unique properties have limited its effectiveness in the past. Recent research led by Marc Porosoff, an associate professor in the University of Rochester's Department of Chemical and Sustainability Engineering, has now addressed several of these challenges, bringing tungsten carbide closer to serving as a realistic substitute for platinum.

Why Atomic Arrangement Matters

According to Sinhara Perera, a chemical engineering PhD student in Porosoff's lab, one of the main obstacles lies in the way tungsten carbide atoms are arranged.

Part of what makes tungsten carbide difficult to use as a catalyst, she explains, is that its atoms can organize themselves into many different configurations, known as phases.

"There's been no clear understanding of the surface structure of tungsten carbide because it's really difficult to measure the catalytic surface inside the chambers where these chemical reactions take place," says Perera.

To overcome this limitation, the research team developed a way to control the material's structure while reactions were actively occurring. In a study published in ACS Catalysis, Porosoff, Perera, and chemical engineering undergraduate student Eva Ciuffetelli '27 carefully engineered tungsten carbide particles at the nanoscale inside a chemical reactor, where temperatures can exceed 700 degrees Celsius.

Using a method called temperature-programmed carburization, they created tungsten carbide catalysts in specific phases directly inside the reactor. The researchers then carried out chemical reactions and analyzed which versions delivered the best performance.

"Some of the phases are more thermodynamically stable, so that's where the catalyst inherently wants to end up," says Porosoff. "But other phases that are less thermodynamically stable are more effective as catalysts."

Through this process, the team identified a specific phase, β-W2C, that performed especially well in reactions that convert carbon dioxide into essential building blocks for fuels and other valuable chemicals. With further optimization by industry, Porosoff and his colleagues believe this phase could rival platinum while avoiding its high cost and limited availability.

Using Tungsten Carbide to Upcycle Plastic Waste

The researchers also examined how tungsten carbide could help address another major challenge: plastic waste. Porosoff and his collaborators studied its use as a catalyst for plastic upcycling, a process that transforms discarded plastics into higher-quality materials.

In a study published in the Journal of the American Chemical Society, led by Linxao Chen from the University of North Texas and supported by Porosoff and University of Rochester Assistant Professor Siddharth Deshpande, the team demonstrated how tungsten carbide can drive a chemical process known as hydrocracking.

Hydrocracking breaks large molecules into smaller ones that can be reused to make new products. In this case, the researchers focused on polypropylene, which is commonly used in water bottles and many other plastic items.

Although hydrocracking is widely used in oil and gas refining, applying it to plastic waste has been difficult. Most single-use plastics contain long polymer chains that are extremely stable, and contaminants in waste streams can quickly deactivate traditional catalysts. Platinum-based catalysts also rely on microporous supports that are too small for large polymer chains to access.

"Tungsten carbide, when made with the correct phase, has metallic and acidic properties that are good for breaking down the carbon chains in these polymers," says Porosoff. "These big bulky polymer chains can interact with the tungsten carbide much easier because they don't have micropores that cause limitations with typical platinum-based catalysts."

The results showed that tungsten carbide was not only significantly cheaper than platinum catalysts for hydrocracking, but also more than 10 times as efficient. The researchers say these findings could lead to better catalyst designs and new ways to convert plastic waste into valuable materials, supporting a circular economy.

Measuring Temperature With Greater Precision

Accurate temperature measurement plays a crucial role in developing efficient catalysts. Chemical reactions either absorb heat (endothermic) or release heat (exothermic), and controlling temperature at the catalyst surface allows scientists to coordinate multiple reactions more effectively.

However, traditional temperature measurements rely on bulk readings that average conditions across a reactor. These measurements often fail to capture the precise environment at the catalyst surface, making it difficult to study reactions accurately.

To solve this problem, the research team adopted optical measurement techniques developed in the lab of Andrea Pickel, a visiting professor in the Department of Mechanical Engineering. They described this new approach in a study published in EES Catalysis.

"We learned from this study that depending on the type of chemistry, the temperature measured with these bulk readings can be off by 10 to 100 degrees Celsius," says Porosoff. "That's a really significant difference in catalytic studies where you're trying to ensure that measurements are reproducible and that multiple reactions can be coupled."

Using this method, the team studied tandem catalyst systems in which heat released by one reaction is used to drive another reaction that requires heat input. Pairing these reactions more precisely can reduce wasted energy and improve overall efficiency in chemical processes.

Porosoff says this technique could also influence how catalysis research is conducted more broadly, leading to better measurements, stronger reproducibility, and more reliable results across the field.

Sci Tech Daily, 28 January 2026

https://scitechdaily.com

Researchers Develop "At-Home" Tooth-Whitening Powder

2026-01-28

Even with regular brushing, teeth can become stained from genetic factors or consuming foods and drinks like tomatoes and coffee. Chemical whiteners can help, but they can also damage teeth in the process. So, researchers reporting in ACS Nano have designed a prototype teeth-whitening powder that is activated by the vibrations from an electric toothbrush. The system both brightened and protected teeth in lab demonstrations.

"This work offers a safe, at-home teeth whitening strategy integrating whitening, enamel repair and microbiome balance for long-term oral health," says Min Xing, first author on the study.

Peroxide-based bleaching with strips, gels and mouth rinses is a popular option among consumers for whitening stained teeth. This type of chemical whitening generates reactive oxygen species (ROS), compounds that break apart stain-causing molecules. But in addition to removing stains, many whitening techniques can damage the tooth enamel, which might result in easier re-staining or other oral problems. Now, Xing, Wenhao Qian, Xuanyong Liu, Jiajun Qiu and colleagues are developing a tooth-whitening compound that generates ROS when activated by electric toothbrush vibrations while strengthening and repairing teeth at the same time.

The researchers combined strontium and calcium ions with barium titanate in a solution and then heated and formed it into a ceramic

powder, dubbed BSCT. When vibrated, the powder generates a small electric field — a phenomenon known as the piezoelectric effect — that causes ROS-generating chemical reactions.

In initial lab tests using human teeth artificially stained with tea and coffee, four hours of brushing with BSCT and an electric toothbrush caused visible whitening. After 12 hours of brushing, treated teeth were almost 50% whiter than the control group stained in the same way but brushed with saline. For teeth with damaged enamel and dentin, BSCT brushing regenerated these structural components because the strontium, calcium and barium ions included in the powder formed deposits on the tooth surface.

Next, researchers tested the powder on rats fed high-sugar diets. Daily brushing for one minute over four weeks using BSCT helped restore the rats' oral microbiome, killing periodontitis-causing Porphyromonas gingivalis and Staphylococcus aureus bacteria and reducing inflammation.

Though current tests haven't yet incorporated the BSCT powder into a toothpaste formula, researchers say that this study is a step toward a new effective, at-home treatment for safely whitening teeth and promoting oral health.

Technology Networks,28 January 2026

https://technologynetworks.com

New chemi-mechanical process removes pigments and restores properties in recycled plastics

2026-01-29

Researchers in Worcester Polytechnic Institute's Department of Chemical Engineering and at the University of Akron have published research in Chemical Engineering Journal about a new technology that seeks to solve long-standing challenges in plastic recycling that limit the overwhelming majority of plastics to a single use and contribute to the accumulation of plastic waste.

Currently, less than 20% of all plastics are recycled. Increasing that number will require solving several problems, including irreversible loss of properties during the recycling process, limited ability to blend plastic mixtures, discoloration, and carryover of toxic chemicals.

Mechanical recycling, which involves physically sorting materials and reprocessing them into materials for new production, is plagued by the aforementioned challenges. One proposed solution to these problems is chemical recycling, which uses heat and catalysts to break down plastics into substances that can be refined to become fuels or processed further for petrochemical production. Unfortunately, chemical recycling in its present form is energy-intensive and costly, requiring both breakdown of plastics and the rebuilding of broken chemical bonds.

A new chemi-mechanical approach

A team of researchers from Worcester Polytechnic Institute's Department of Chemical Engineering and the University of Akron partnered with the startup Seauciel to study a third approach proposed by the company, which it calls "aqueous chemi-mechanical recycling." The process relies on the properties of water heated beyond its normal boiling point to convert polymers found in plastics into a state at which they can blend with each other at the microscale. Tests of this approach show evidence of microscale mixing after the chemi-mechanical treatment.

Additionally, the research study found chemi-mechanical treatment resulted in a 96% reduction of the volatile organic compounds that are partially responsible for the "recycled plastic smell" compared with plastics processed using mechanical recycling. In addition, chemi-mechanical recycling removes pigments from polymers to restore recycled material closer to the color of virgin plastic.

The researchers found that carefully controlling the amount of time materials are exposed to the high temperatures in this treatment process minimized molecular weight loss of the polymers during processing—a major drawback of mechanical recycling—and used much less energy than chemical recycling.

The research team also reported that the process can deliver recycled plastics at a price similar to virgin-made and has a carbon footprint comparable to mechanical recycling and far smaller than incineration.

The team's future work is expected to include scaling the technology while conducting further research to provide a robust physical understanding of the key phenomena.

"With continued progress, this new technology could ultimately make single-use plastics a thing of the past," said Michael Timko, William B. Smith Professor of Chemical Engineering and head of the Department of Chemical Engineering at Worcester Polytechnic Institute and one of the authors of the report. "Large quantities of plastics are disposed

of in landfills or enter the ocean, causing environmental damage and representing lost potential for material reuse and energy capture."

Phys Org, 29 January 2026

https://phys.org

A breakthrough that turns exhaust CO2 into useful materials

2026-01-29

"This work shows that carbon capture and conversion do not need to be treated as separate steps. By integrating both functions into a single electrode, we demonstrate a simpler pathway for CO2 utilization under realistic gas conditions," explains Wonyong Choi, a corresponding author on the study.

Why CO2 Conversion Has Been So Difficult

Pulling carbon dioxide out of the air may seem straightforward, especially since plants do it naturally. The greater challenge lies in transforming that captured gas into something useful, a step that is essential if carbon capture technologies are to be widely adopted. In real industrial exhaust, CO2 is usually mixed with other gases, including nitrogen and oxygen. Most existing conversion systems only work efficiently when carbon dioxide has already been separated and concentrated, which limits their practicality.

To overcome this obstacle, Donglai Pan, Myoung Hwan Oh, Wonyong Choi, and their colleagues set out to build a system that could operate under realistic conditions. Their goal was to create a device capable of handling flue gas as it is actually produced and converting even small amounts of captured CO2 into a valuable product.

Inside the Three Layer Electrode

The research team designed an electrode that allows gas to pass through it, trap carbon dioxide, and convert it at the same time. The device is made up of three layers: a material that captures CO2, a sheet of gas permeable carbon paper, and a catalytic layer of tin(IV) oxide. Together, these components enable the direct conversion of carbon dioxide gas into formic acid.

Formic acid is an important chemical used in a range of applications, including fuel cells and other industrial processes. Producing it directly from exhaust gases could make carbon reuse more practical and cost effective.

Strong Results Under Real World Conditions

When tested with pure CO2 gas, the new electrode showed about 40% higher efficiency than existing carbon conversion electrodes under similar laboratory conditions. The advantage became even clearer when researchers used a simulated flue gas containing 15% CO2, 8% oxygen gas, and 77% nitrogen gas. Under these conditions, the new system continued to generate substantial amounts of formic acid, while other technologies produced very little.

The electrode also proved capable of capturing carbon dioxide at concentrations similar to those found in the atmosphere, showing that it can function in ambient air. According to the researchers, this approach offers a promising path toward integrating carbon capture into real industrial applications. They also suggest that similar designs could eventually be adapted to capture and convert other greenhouse gases, including methane.

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Science Daily, 29 January 2026

https://sciencedaily.com

A revolution in how we do chemistry: Best ideas of the century

2026-01-19

Chemistry can be a messy, sluggish business, frequently involving cocktails of chemicals in round-bottomed flasks that must later be painstakingly separated. But in 2001, K. Barry Sharpless and his colleagues outlined an idea they called click chemistry that broke the mould. The snappy name, which was Sharpless's wife Janet Dueser's idea, summed it up well: a new set of reactions that worked quickly, cleanly and consistently.

If it seems like a simple idea, it is – and therein lies its brilliance. Sharpless and his colleagues Hartmuth C. Kolb and M. G. Finn described their new reactions as "spring-loaded". The idea was that you could apply them to a plethora of different starting chemicals, snapping them together almost like Lego bricks, and so quickly build a huge range of new and useful molecules – it was medicines that Sharpless mostly had in mind.

The unifying thought behind these reactions was that they shied away from forming carbon-carbon bonds, as was the orthodoxy among chemists at the time, and instead formed bonds between carbon and what chemists call "heteroatoms", principally oxygen and nitrogen. The best-known click reaction snaps together two reactants to form a triazole, a ring of carbon and nitrogen atoms. This chemical motif tends to be good at sticking to large biological molecules like proteins, making it useful in creating drug molecules. Sharpless unveiled this particular reaction independently, but at the same time as chemist Morten Meldal at the University of Copenhagen, and it has since been used to make, among other things, the anticonvulsant drug rufinamide.

This reaction, says chemist Tom Brown at the University of Oxford, was easy, highly specific and worked in almost any solvent. "I think you can say this was just a great idea," he says.

A few years later, chemist Carolyn Bertozzi at Stanford University in California developed a click-style reaction that works without any toxic catalysts, meaning it could be used inside cells without disrupting them.

For chemist Alison Hulme at the University of Edinburgh, UK, it was this work that elevated click chemistry from a good idea to a truly great one. It enabled biologists to peg together proteins and other bits of biological machinery at will, and to label them with fluorescent tags to investigate what happened. "It's just so simple and straightforward," says Hulme. "It brought small molecule chemistry to biologists in a way that doesn't require a chemistry degree."

Bertozzi, Meldal and Sharpless shared the 2022 Nobel prize in chemistry for their work – to the surprise of no one.

New Scientist, 10 January 2026

https://newscientist.com

Biodegradable polymers used to develop eco-friendly, high-performance gas sensors

2026-01-29

Air pollutants like nitrogen dioxide (NO2), primarily produced during fossil fuel combustion, pose a serious concern for human health, contributing to respiratory diseases like pulmonary edema, bronchitis, and asthma. Effective air-quality monitoring therefore requires portable gas sensors that offer high sensitivity, selectivity, and long-term stability. Among existing technologies, organic field-effect transistors (OFETs) are promising for highly sensitive portable sensors with their lightweight, flexible, and simple-to-fabricate structure.

However, a critical challenge for their practical application is the limited lifetime of organic semiconductors, which are vulnerable to degradation caused by moisture and oxygen. This leads to a gradual decline in device performance and ultimately contributes to growing electronic waste and environmental pollution.

Addressing this issue, a research team led by Professor Yeong-Don Park from the Department of Energy and Chemical Engineering at Incheon National University in South Korea has developed novel eco-friendly OFET gas sensors. These sensors utilize blended polymer films combining poly(3-hexylthiophene) (P3HT), a widely used organic semiconductor, and poly(butylene succinate) (PBS).

“Using PBS, a well-known biodegradable polymer, and effective solvent engineering, we demonstrated that high sustainability and device performance can be achieved simultaneously,” says Prof. Park. Their study was published in the Chemical Engineering Journal on November 1, 2025.

To fabricate the sensors, the researchers prepared blended solutions of P3HT and PBS using either chloroform (CF) or a mixture of chloroform and dichlorobenzene (CF:DCB) as solvents. These blended solutions were deposited onto silicon substrates and fitted with gold electrodes to form OFET-based gas sensors. This yielded two distinct sensor types.

The choice of solvent played a crucial role in determining the internal structure of the active polymer layer and, consequently, the device performance. Specifically, CF-processed films exhibited a horizontal phase separation of P3HT and PBS, producing an uneven surface structure. In contrast, the CF:DCB-processed films demonstrated a uniform surface structure across all compositions owing to vertical phase separation.

Although the electrical performance of both sensors decreased with increasing PBS content, the sensor with the CF-processed film stopped functioning when PBS content exceeded 50%. In contrast, the CF:DCB-processed sensor retained a stable performance even with up to 90% PBS content.

Beyond electrical stability, the researchers also evaluated the devices’ gas-sensing capabilities. These tests revealed that the sensitivity of both devices to nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon dioxide

(CO_2) increased with higher PBS content. Notably, the CF-processed films demonstrated higher sensitivity, while the CF:DCB-processed films displayed excellent, stable sensitivity even with 90% PBS content. The devices also showed significantly higher sensitivity for NO2 over SO2 and CO2. Increasing PBS content enhanced flexibility of the films and both devices were found to be biodegradable in seawater.

“Our eco-friendly and resource-efficient sensors open up new possibilities for environmentally sustainable gas sensing technologies suitable for large-scale or disposable applications,” concludes Prof. Park. “In the long term, biodegradable organic sensors could significantly reduce electronic waste, especially for sensors deployed in natural or marine environments.”

Phys Org, 29 January 2026

https://phys.org

Thomas Edison May Have Created a Miracle Material Before Physics Knew It Existed

2026-01-27

A modern materials study suggests that Thomas Edison’s early light bulb experiments may have unknowingly produced graphene decades before the material was formally theorized or isolated.

Thomas Edison never heard the word “graphene,” yet researchers at Rice University think his work may still brush up against it. In a recent paper from chemist James Tour’s lab, the team points to graphene as an unexpected thread connecting Edison to Konstantin Novoselov and Andre Geim, the 2010 Nobel Prize in Physics winners who isolated and studied the material.

Edison died nearly two decades before physicist P.R. Wallace proposed that graphene might exist, and almost 80 years before the Nobel committee recognized its experimental discovery.

Graphene is a one-atom-thick form of carbon that is both transparent and remarkably strong, with growing importance in modern devices such as semiconductors. The Rice researchers focus on a variant called turbostratic graphene, which can form when a resistive carbon material is hit with an electrical voltage and heated extremely quickly to about 2,000 to 3,000 degrees Celsius.

A 19th-Century Precursor to Flash Joule Heating

Today, that rapid electrical heating approach is known as flash Joule heating. In 1879, Edison could create similar conditions in a far more familiar way: by switching on one of his newly patented light bulbs. Early incandescent designs often relied on carbon filaments, including Japanese bamboo, rather than tungsten.

When current flowed, the filament heated rapidly and produced light, and under the right circumstances, it may have done more than glow. It may have briefly entered the temperature range where graphene can emerge.

"I was developing ways to mass produce graphene with readily available and affordable materials," explains Lucas Eddy, first author on the paper and a former Rice graduate student in Tour's lab. "I was looking at everything from arc welders, which were more efficient than anything I'd ever built, to lightning struck trees, which were complete dead ends." But then, as his lab mate put it, he had a light bulb moment. "I was trying to figure out the smallest, easiest piece of equipment you could use for flash Joule heating, and I remembered that early light bulbs often used carbon-based filaments."

Edison's bulbs were not chosen for nostalgia. His patented design could drive a carbon filament to roughly 2,000 degrees Celsius, a temperature range considered essential for the kind of rapid carbon transformations the team wanted to test. Another practical advantage was documentation: Edison's 1879 patent offered Eddy a detailed reference point for rebuilding the setup as closely as possible.

Recreating a Historic Experiment

Finding a truly comparable bulb took trial and error. Eddy initially bought Edison style bulbs advertised as having "carbon" filaments, only to discover the filaments were actually tungsten.

"You can't fool a chemist," laughs Eddy. "But I finally found a small art store in New York City selling artisan Edison-style light bulbs." The artisan light bulbs were exactly like Edison's, down to the Japanese bamboo filaments. Even the diameters of the filaments were close with Eddy's filaments measuring only 5 micrometers larger than Edison's.

Just like Edison, Eddy attached the light bulb to a 110-volt DC electricity source. He flipped the switch on for only 20 seconds. Longer periods of heating, he explains, can result in graphite forming rather than graphene.

When the filament was examined under an optical microscope, its appearance had clearly changed. The carbon had shifted from a dull dark gray to what Eddy described as a "lustrous silver." A transformation had likely occurred, but to what?

To characterize the change, Eddy reached for a technique developed in the 1930s: Raman spectroscopy. This technique uses lasers to identify the substances through their atomic signatures, like reading a barcode. Advances over the last century allow it to do so with rather extreme precision. The spectroscopy confirmed what Eddy had hoped — parts of the filament had turned into turbostratic graphene. Edison, in his quest to develop a practical light bulb that could be used in everyday life, may just have produced a substance that is quickly becoming key to the technology-dependent 21st century.

Revisiting the Past With Modern Tools

Of course, there is no way to know what really happened with Edison's long-ago experiment. Even if the original light bulb Edison used was available to analyze, any graphene produced likely would have turned to graphite during its first 13-hour test.

"To reproduce what Thomas Edison did, with the tools and knowledge we have now, is very exciting," said Tour, the T.T. and W.F. Chao Professor of Chemistry and corresponding author on the paper. "Finding that he could have produced graphene inspires curiosity about what other information lies buried in historical experiments. What questions would our scientific forefathers ask if they could join us in the lab today? What questions can we answer when we revisit their work through a modern lens?"

Sci Tech Daily, 27 January 2026

https://scitechdaily.com

Built-in fire extinguishers can prevent battery explosion

2025-07-14

Batteries enhanced with a polymer material that releases fire-suppressing chemicals at high temperatures are significantly less likely to explode into flames. This technique could boost the safety of battery-reliant machines, like electric cars and medical devices.

"Our approach enhances safety within mainstream liquid lithium batteries," says Ying Zhang at the Institute of Chemistry, Chinese Academy of

Sciences. "It's like popping open a safety valve – these chemicals smother flammable gases before they can explode, helping prevent fires."

Zhang and her colleagues created and tested the flame-retardant polymer material in a prototype lithium metal battery. Such batteries are currently in limited use, but next-generation versions are candidates to replace the batteries in electric cars and portable electronic devices. That is because lithium metal can store 10 times as much energy as popular lithium-ion batteries by using pure lithium, rather than graphite, in the negative electrode.

The researchers exposed the prototype battery and a standard lithium metal battery to gradually hotter temperatures, starting from 50°C. When external temperatures rose above 100°C, both batteries experienced overheating – but the prototype's special polymer material began breaking down automatically, releasing chemicals that act like "microscopic fire extinguishers", says Zhang.

Beyond 120°C, the standard battery without safety features overheated to 1000°C within 13 minutes and burst into flames. But under the same conditions, the prototype battery's peak temperature only reached 220°C, without any resulting fire or explosion.

This "innovative material science approach" can reduce the risk of battery fires or overheating, not only in lithium metal batteries but also in certain lithium-ion batteries and lithium-sulphur batteries, says Jagjit Nanda at the SLAC National Accelerator Laboratory in California. It could lead to safer batteries, in particular for electric vehicles or even electric aircraft, he says.

The fire-suppressing technology would integrate well into existing battery manufacturing as a "near-term safety upgrade, while the industry pursues long-term solutions" involving alternative battery designs and chemistries, says Zhang. Still, injecting the polymer material into batteries would require some retuning of manufacturing processes, she says.

New Scientist, 14 July 2025

https://newscientist.com

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OCCUPATIONAL

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