CHEMWATCH

Bulletin Board

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Regulatory Update

ASIA PACIFIC

Guidance on using reference products to satisfy the statutory criteria

2025-12-11

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has published new guidance on how to use reference products to satisfy the statutory criteria. This clarifies how applicants can nominate reference products as part of an application, and how the APVMA considers reference products and other information against our statutory criteria. We are updating our web pages that set out requirements for applications relying on reference products. The new guidance sets out the requirements in one place while this update is underway.

A reference product is an agvet chemical product described on our register, with associated data items that have been relied upon during its assessment to determine that the product met the statutory safety, efficacy and trade criteria. Nominating reference products creates a streamlined pathway for applicants, reducing the need to generate new data.

Read More

APVMA, 11-12-25

https://www.apvma.gov.au/news-and-publications/news/update-application-requirements-closely-similar-item-6-and-7-applications

AMERICA

Prohibition of Certain Toxic Substances Regulations, 2025

2026-01-10

The Prohibition of Certain Toxic Substances Regulations, 2012 (the 2012 Regulations) will be repealed and replaced by the Prohibition of Certain Toxic Substances Regulations, 2025 (the 2025 Regulations) when the 2025 Regulations comes into force on June 30, 2026. Both these Regulations are made under the authority of the Canadian Environmental Protection Act, 1999.

The Regulations prohibit the manufacture, use, sale, and import of certain toxic substances, as well as products containing them, with a limited number of exemptions.

The 2025 Regulations further restrict the manufacture, use, sale and import of perfluorooctane sulfonate, its salts and its precursors (PFOS), perfluorooctanoic acid, its salts and its precursors (PFOA), long-chain perfluorocarboxylic acids, their salts and their precursors (LC-PFCAs), hexabromocyclododecane (HBCD), and polybrominated diphenyl ethers (PBDEs), and products containing them, by removing certain exemptions or limiting specific activities which were allowed under the 2012 Regulations.

The 2025 Regulations also prohibit two additional flame retardants, Dechlorane Plus (DP) and decabromodiphenyl ethane (DBDPE), and products containing them, with a limited number of exemptions.

In addition, the 2025 Regulations simplify the current Regulations by consolidating substance-specific requirements.

Read More

Government of Canada, 10-01-26

https://pollution-waste.canada.ca/environmental-protection-registry/regulations/view?Id=2175

Report on the Use of PFAS in Cosmetic Products and Associated Risks

2025-12-15

Prepared by: U.S. Food and Drug Administration Office of the Chief Scientist Office of Cosmetics and Colors December 2025

PFAS are a diverse group of synthetic chemicals used in a wide range of consumer and industrial products for their water- and oil-repellent properties, as well as their resistance to heat and chemical degradation (Gluge, Scheringer et al. 2020). There is currently neither a consensus definition of PFAS internationally nor a federal definition in the U.S. (Hammel, Webster et al. 2022, Gaines, Sinclair et al. 2023, NSTC 2023). The U.S. Congress did not define the term "PFAS" in Sec. 3506 of the MoCRA requirement for a PFAS report either. Regulators from various jurisdictions such as the European Union (EU) and the U.S. have proposed different definitions based on chemical structures. While the exact PFAS definition is still under discussion and evolving, this report uses a definition proposed by the Organization for Economic Co-operation and Development (OECD) in 2021 (OECD 2021) that is currently accepted widely. OECD defines PFAS as "fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it), i.e., with a few noted exceptions, any chemical with at least a perfluorinated methyl group (–CF3) or a perfluorinated methylene group (–CF2–) is a PFAS." The "noted exceptions" refer to a carbon atom with a H/Cl/Br/I atom attached to it (Wang, Buser et al. 2021). This OECD definition broadens the scope of PFAS initially introduced by Buck et al. (2011) who defined PFAS as highly fluorinated aliphatic substances that contain the perfluoroalkyl moiety CnF2n+1.

As scientific understanding and regulations regarding PFAS evolve, PFAS definitions may continue to change according to specific needs in the future regulatory landscape. Chemically, the PFAS family encompasses a wide range of chemical compounds characterized by a very strong fluorine-carbon bond, with variations in chain length, functional groups, molecular structural features, and thus properties. Therefore, individual PFAS can be very different in their physicochemical and toxicological properties, and the safety of PFAS should be assessed taking these differences into consideration. In general, PFAS are classified into two primary categories: nonpolymers and polymers. Further, nonpolymer PFAS encompass two major subclasses including perfluoroalkyl substances and polyfluoroalkyl substances, each further divided into many groups and subgroups. Polymer PFAS include fluoropolymers, polymeric perfluoropolyethers, and side-chain fluorinated polymers (Buck, Franklin et al. 2011). Polymeric PFAS usually have distinct physicochemical and toxicological profiles compared with nonpolymer PFAS due to their large molecular weight and complex molecular structures.

Read More

US FDA, 15-12-25

https://www.fda.gov/media/190319/download?attachment

Hazardous chemicals pile up in K–12 science labs

2026-01-12

As US teachers discover more and more legacy chemicals in schools, funding for cleanup is hard to find. Educators, nonprofits, and local governments are stepping in to help

Key Insights

- Teachers in K–12 schools across the US are discovering hazardous and unlabeled chemicals in their classroom laboratories.
- With small education budgets, they face challenges evaluating and paying to remove those chemicals without harming students or themselves.
- Nonprofits and some state governments offer training on how to maintain a lab as well as funding for chemical removal.

When Maria Giesler, then a high school science teacher, opened the chemical cabinet in her classroom laboratory for the first time in 2020, she felt a chill down her spine. Giesler saw before her rows and rows of corroding and spilled chemicals stacked all the way from the bottom of the wooden shelves to the ceiling.

“This is not safe, and I don’t want to be in here,” she remembers thinking. “Those things shouldn’t be next to each other.”

Read More

c&en, 12-01-26

https://cen.acs.org/education/k-12-education/Hazardous-chemicals-pile-K12-science/

National Primary Drinking Water Regulation for Perchlorate

2025-01-06

A Proposed Rule by the Environmental Protection Agency on 01/06/2026

The U.S. Environmental Protection Agency (“EPA” or the “Agency”) is proposing a National Primary Drinking Water Regulation (NPDWR) for perchlorate and a health-based Maximum Contaminant Level Goal (MCLG) under the Safe Drinking Water Act (SDWA). In this action, the EPA is proposing to set the perchlorate MCLG at 0.02 mg/L (20 µg/L). The EPA is also proposing and taking comment on setting an enforceable Maximum Contaminant Level (MCL) for perchlorate at 0.02 mg/L (20 µg/L), 0.04 mg/L (40 µg/L), or 0.08 mg/L (80 µg/L). The EPA is also proposing requirements for water systems to conduct monitoring for perchlorate in drinking water, take mitigation actions if the level exceeds the MCL, provide information about perchlorate to their consumers through public notification and consumer confidence reports, and report to their respective primacy agency. The Administrator has determined that the benefits of this regulation would not justify the costs; however, the EPA is required to

issue an NPDWR and MCLG for perchlorate in response to the D.C. Circuit’s decision in NRDC v. Regan.

DATES:

Comments must be received on or before March 9, 2026. Comments on the information collection provisions of the proposed rule under the Paperwork Reduction Act (PRA) must be received by the Office of Management and Budget’s Office of Information and Regulatory Affairs (OMB-OIRA) on or before February 5, 2026. Please refer to the PRA section under “Statutory and Executive Order Reviews” in this preamble for specific instructions. Public hearing: The EPA will hold a virtual public hearing on February 19, 2026, at https://www.epa.gov/sdwa/perchlorate-drinking-water. Please refer to the

SUPPLEMENTARY INFORMATION section for additional information on the public hearing.

Read More

US FDA, 06-01-26

https://www.federalregister.gov/documents/2026/01/06/2026-00021/national-primary-drinking-water-regulation-for-perchlorate

EUROPE

EU Adopts New Regulation to Strengthen Toy Safety Across Europe

2025-12-15

On 12 December 2025, the European Union officially adopted Regulation (EU) 2025/2509, a law aimed at ensuring a higher level of safety for toys and protecting children from potential hazards. The new regulation, published today in the Official Journal of the European Union, repeals the previous Directive 2009/48/EC and introduces stricter requirements for manufacturers, importers, and distributors.

The regulation addresses growing concerns about harmful chemicals, digital risks, and emerging technologies in toys. It introduces generic prohibitions on hazardous substances, including carcinogenic, mutagenic, and endocrine-disrupting chemicals, as well as PFAS and certain bisphenols. Manufacturers will now be required to conduct comprehensive safety assessments and comply with updated chemical limits to protect children's health.

In addition to chemical safety, the regulation sets out essential safety requirements covering physical, mechanical, flammability, electrical, hygiene, and radioactivity hazards. It also tackles new challenges posed by digitally connected toys, requiring compliance with cybersecurity and privacy standards under related EU legislation

Read More

Eurofins, 15-12-25

https://www.eurofins.com/toys-hardlines/resources/industry-newsletter/tech-watch-eu-adopts-new-regulation-to-strengthen-toy-safety-across-europe/

Active substances approved for use in pesticides

2025-01-06

The GB approvals register

An active substance must be included in the statutory GB Pesticides Approvals Register before it can be included in any PPP authorised for use in Great Britain.

The GB Pesticides Approvals Register provides a full list of approved active substances which can be included in plant protection products in Great Britain, together with details on the specific conditions of approval.

Download the GB approvals register (.xlsx)

Many active substances are approved as a result of EU legislation being adopted into GB law. EU pesticides legislation often provides further explanation of certain conditions of approval or specific provisions in a separate review report.

For approvals transferred from EU decisions taken before EU exit, you may need to read the relevant EU review report for further explanation of some points relating to the approvals.

You can find the review reports for specific active substances on the EU Pesticides database (Europa website).

Read More

HSE UK, 06-01-25

https://www.hse.gov.uk/pesticides/active-substances/register.htm

EU active substance expiry dates postponed

2025-01-13

Active substance expiry dates postponed whilst the renewal evaluations are completed in the EU.

For reasons beyond the control of the applicants, the approvals of the active substance/product type combinations listed were likely to expire before a decision could be taken on their renewal under the EU Biocidal Products Regulation (EU BPR).

To allow sufficient time for the renewal evaluation to be completed, a decision has been taken to postpone the expiry dates of the following approvals. This affects NI:

From 31 December 2025 to 31 December 2026

- (3β,5Z,7E)-9,10-secocholesta-5,7,10(19)-trien-3-ol (cholecalciferol) (CAS 67-97-0 EC 200-673-2) in product type 14

From 31 January 2026 to 31 July 2027

- magnesium phosphide releasing phosphine (trimagnesium diphosphide) (CAS 12057-74-8 EC 235-023-7) in product type 18
- aluminium phosphide releasing phosphine (CAS 20859-73-8 EC 244-088-0) in product types 14, 18 and 20

From 31 March 2026 to 31 March 2028

- Bacillus thuringiensis subsp. israelensis serotype H14, strain AM65-52 (CAS N/A EC N/A) in product type 18
- (S)-α-cyano-3-phenoxybenzyl (1R,3R)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylate (deltamethrin) (CAS 52918-63-5 EC 258-256-6) in product type 18

From 31 March 2026 to 30 September 2028

- reaction mass of (R)-α-cyano- 3-phenoxybenzyl (1S,3S)-3-[(Z)-2- chloro-3,3,3-trifluoropro- penyl]-2,2-dimethylcyclopropanecarboxylate and (S)-α-cyano-3-phenoxybenzyl (1R,3R)-3-[(Z)-2-chloro-3,3,3-trifluoropropenyl]-2,2- dimethylcyclopropanecarboxylate (1:1) (lambda-cyhalothrin) (CAS 91465-08-6 EC 415-130-7) in product type 18

If you want to supply new biocidal products containing these active substances, you can still apply for EU BPR product authorisation. New products (including new trade names) must not be supplied in NI until product authorisation is granted.

HSE will provide separate updates on the renewal decisions when relevant.

Read More

UK HSE, 13-01-26

https://www.hse.gov.uk/

Publication of GB mandatory classification and labelling (GB MCL) technical reports

2026-01-16

The next GB MCL technical report is now available.

A GB MCL technical report is an independent scientific evaluation of the information submitted under the stand-alone GB MCL process or as part of the EU harmonised classification and labelling process.

It sets out whether there is adequate scientific evidence to support a new or revised GB MCL of a substance and what that GB MCL should be.

Download the next technical report at the end of the GB MCL publication table.

This GB MCL technical report relates to a substance for which the Committee for Risk Assessment (RAC) published a RAC Opinion under Article 37(4) of EU CLP during 2025, based on information submitted under the EU CLP Regulation. The scientific information supporting the RAC Opinion is evaluated under the GB MCL system.

At the time of publication, the classification and labelling proposed in this technical report has not been agreed and/or adopted in GB.

For information on the next steps in the process, please see our webpage on the GB MCL system.

We expect to publish the next batch of technical reports in March 2026. CLP ebulletin alerts will be issued when technical reports are published on the HSE website.

Read More

HSE, 16-01-26

https://www.hse.gov.uk/chemical-classification/classification/publication-template.htm

Highlights from December RAC and SEAC meetings

2025-12-17

The Committees for Risk Assessment (RAC) and for Socio-Economic Analysis (SEAC) progressed their evaluation of the proposed restriction on PFAS. RAC is expected to adopt its opinion in March 2026 while SEAC will agree its draft opinion for further consultation.

RAC also adopted its first harmonised classification and labelling opinion on a new hazard class: very persistent, very bioaccumulative (vPvB).

Read More

ECHA, 17-12-25

https://echa.europa.eu/-/highlights-from-december-2025-rac-and-seac-meetings

PFAS draft opinion consultation: guidance for respondents and detailed mapping of uses

2025-12-17

This document will help you prepare for the upcoming consultation on the draft opinion of our Committee for Socio-Economic Analysis (SEAC) on the PFAS restriction proposal. It explains the consultation structure and question types, and provides technical instructions for submitting responses. You will also find the questions of the consultation in the guidance.

The updated draft mapping of PFAS uses, published as an annex to this guidance, describes in detail the uses and applications evaluated by SEAC. The questions and use mapping will be updated reflecting any revisions made to the SEAC draft opinion when the consultation begins.

The 60-day consultation is expected to start shortly after the draft opinion is agreed at SEAC's March 2026 meeting.

Read More

ECHA, 17-12-25

https://echa.europa.eu/hot-topics/perfluoroalkyl-chemicals-pfas

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ECHA observes a fall in hazardous chemicals trade in 2024

2025-12-15

Based on the annual data reported by Member States to the European Chemicals Agency (ECHA) under the Prior Informed Consent (PIC) Regulation, the decline is mainly due to reduced volumes of exports and imports of substances containing benzene.

Helsinki, 15 December 2025 – ECHA's annual report on exports and imports of chemicals that are banned or severely restricted in the EU shows that substances containing benzene accounted for approximately 51% (1.1 million tonnes) of total exports and 99% (30 million tonnes) of total imports of PIC chemicals in 2024. In 2023, 64 million tonnes of substances containing benzene were exported, with imports reaching 65 million tonnes. The decrease in their trade has led to a 97% reduction in overall export volumes and a 53% reduction in overall import volumes.

If substances containing benzene are excluded from the data, the report shows a slight increase in hazardous substance trade. Exports of other PIC chemicals increased by 7% from approximately 1.03 million tonnes in 2023 to 1.1 million tonnes in 2024. Imports of other PIC chemicals rose by 2% from approximately 378 000 tonnes in 2023 to 387 000 tonnes in 2024.

The top traded chemicals were largely similar to previous years, with substances containing benzene, benzene itself and ethylene dichloride (1,2-dichloroethane) dominating both exports and imports.

In 2024, pesticide exports increased by 34% (from approximately 173 000 to 232 000 tonnes), after two consecutive years of decline. The main contributor to this increase was chlorate, which accounted for 24% of the overall rise.

Background

Exports – 553 companies from 24 EU countries provided data to ECHA on the exports of PIC chemicals from the EU in 2024. Three EU countries (Cyprus, Luxembourg and Malta) and the United Kingdom (Northern Ireland) declared that they had not exported PIC chemicals.

Imports – 226 companies from 23 EU countries submitted data on imports of PIC chemicals into the EU in 2024. Four EU countries (Cyprus, Lithuania, Luxembourg and Malta) and the United Kingdom (Northern Ireland) declared that they had not imported PIC chemicals.

REACH Update

Article 10 of the PIC Regulation requires importers and exporters to give information about the annual trade of chemicals listed in Annex I to the regulation to their designated national authorities by 31 March of the following year. Each EU country must then provide the aggregated information to ECHA so that it can be summarised at EU level and non-confidential information can be made publicly available.

Read More

ECHA, 15-12-25

https://echa.europa.eu/-/echa-observes-a-fall-in-hazardous-chemicals-trade-in-2024

Janet’s Corner

Who Am I?

2026-01-23

I am a shiny, yellow, ductile, and malleable metal, highly prized for my beauty and resistance to corrosion. I am an excellent conductor of electricity and heat, but my rarity makes me more valuable for jewelry and currency than for industrial applications. Historically, my discovery has driven empires and explorations. Who am I?

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

I am a shiny, yellow, ductile, and malleable metal, highly prized for my beauty and resistance to corrosion.

Cyclohexane

2026-01-23

USES [2,3]

This compound is used as a solvent to dissolve cellulose ethers, lacquers, resins, fats, waxes, oils, bitumen and crude rubber. It is also used in perfume manufacturing, during surface coating operations (lacquers), in synthesis of adipic acid for production of nylon 66 and engineering plastics, during synthesis of caprolactam in nylon 6, paint and varnish remover, in the extraction of essential oils, in analytical chemistry for molecular weight determinations, in the manufacturing of adipic acid, benzene, cyclohexyl chloride, nitrocyclohexane, cyclohexanol and cyclohexanone, in the manufacturing of solid fuel for camp stoves, in fungicidal formulations (possesses slight fungicidal action) in the industrial recrystallising of steroids, organic synthesis, recrystallising medium glass substitutes, solid fuels, in analytical chemistry and in manufacturing of adhesives.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

- **Industry sources:** The primary point sources are petroleum refining, automotive repair shops, and commercial printing and publishing.
- **Diffuse sources:** Sub-threshold facilities.
- **Natural sources:** Cyclohexane is a natural constituent of crude petroleum. It also occurs naturally as a plant volatile and can be released from volcanoes.
- **Transport sources:** Cyclohexane has been detected in motor vehicle exhaust.
- **Consumer products:** Cyclohexane is used as a solvent, oil extractant, paint and varnish remover, and in solid fuels.

Routes of Exposure

Exposure to cyclohexane can occur through inhalation, ingestion, and eye or skin contact. Cyclohexane enters the body when breathed in with contaminated air or when consumed with contaminated food or water. It can also be absorbed through skin contact. Cyclohexane is not likely to remain in the body due to its breakdown and removal in exhaled air and in urine.

Cyclohexane is a cycloalkane with the molecular formula $C6H12$. [1] It is a colourless flammable liquid with a mild, sweet odour resembling that of chloroform or benzene that occurs naturally in crude oil, volcanic gases, and cigarette smoke but is also produced synthetically to be used as a solvent in numerous industries. [1,2]

HEALTH EFFECTS [4]

Acute Health Effects

The effects of cyclohexane on human health depend on how much of the chemical is present and the length and frequency of exposure. Effects also depend on the health of a person when exposure occurs. Breathing large amounts of cyclohexane for short periods of time adversely affects the human nervous system. Effects range from headaches to anaesthesia, tremors, and convulsions. Contact with cyclohexane liquid or vapour can damage the eyes. These effects are not likely to occur at levels of cyclohexane that are normally found in the environment. Human health effects associated with breathing or otherwise consuming smaller amounts of cyclohexane over long periods of time are not known. Information about cyclohexane's potential to cause cancer, developmental effects, or reproductive effects either does not exist or is not adequate. Studies show that repeat exposure to large amounts of cyclohexane in air causes nervous system effects, eye damage, and respiratory effects in animals. The cyclohexane industry is now studying how its chemical affects the reproductive system and the development of the foetus of animals.

SAFETY

First Aid Measures [5]

- **Eye Contact:** Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Get medical attention.
- **Skin Contact:** In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.
- **Serious Skin Contact:** Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.
- **Inhalation:** If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
- **Serious Inhalation:** Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If

breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

- **Ingestion:** If swallowed, do NOT induce vomiting. Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Aspiration hazard if swallowed- can enter lungs and cause damage. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention. Get medical attention if symptoms appear.

Workplace Controls & Practices [4]

When handling cyclohexane, exhaust ventilation or other engineering controls should be used to keep the airborne concentrations of vapours below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protective Equipment [5]

The following personal protective equipment should be used when handling cyclohexane:

- Splash goggles;
- Lab coat;
- Vapour respirator (be sure to use an approved/certified respirator or equivalent);
- Gloves

Personal Protection in Case of a Large Spill:

- Splash goggles; Full suit;
- Vapour respirator;
- Boots;
- Gloves;
- A self contained breathing apparatus should be used to avoid inhalation of the product.
- Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATION

United States

- OSHA: The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for cyclohexane is 300 ppm (1050 milligrams per cubic metre (mg/m3) as an 8-hour time-weighted average (TWA) concentration [29 CFR 1910.1000, Table Z-1].
- NIOSH: The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for cyclohexane of 300 ppm (1050 mg/m3) as a TWA for up to a 10-hour workday and a 40-hour workweek [NIOSH 1992].
- ACGIH: The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned cyclohexane a threshold limit value (TLV) of 300 ppm (1030 mg/m3) as a TWA for a normal 8-hour workday and a 40-hour workweek [ACGIH 1994, p. 17].

REFERENCES

1. http://en.wikipedia.org/wiki/Cyclohexane
2. http://www.osha.gov/SLTC/healthguidelines/cyclohexane/recognition.html
3. http://toxipedia.org/display/toxipedia/Cyclohexane
4. http://www.npi.gov.au/substances/cyclohexane/index.html
5. http://www.epa.gov/chemfact/f_cycloh.txt
6. http://www.sciencelab.com/msds.php?msdsId=9927145
7. http://www.safeworkaustralia.gov.au/sites/swa/search/results?k=cyclohexane

Tuning color through molecular stacking: A new strategy for smarter pressure sensors

2026-01-22

Piezofluorochromism, the phenomenon of materials reversibly changing their fluorescent color when pressure is applied, is used to create the pressure sensors used in automotive and medical industries. By monitoring color changes, researchers can visually recognize phenomena, such as chemical changes, that actually take place. However, as devices get increasingly complicated, there is an increasing demand for ways to produce more sensitive sensors.

A research group led by Project Assistant Professor Takuya Ogaki, Associate Professor Yasunori Matsui, and Professor Hiroshi Ikeda at the Graduate School of Engineering, Osaka Metropolitan University, has identified a new way to produce fluorescence, by finding that an initially stacked benzene layer (cyclophane moiety) increased its fluorescent color change drastically when exposed to pressure.

The findings are published in Journal of Materials Chemistry C.

Challenges in designing color-changing crystals

Professor Ogaki explained the background to the research. "It is difficult to rationally design organic crystals that exhibit the desired color change," he said. "Even a slight change in the structure of organic molecules yields a completely different crystal structure."

The researchers focused on two closely related crystalline organoboron compounds containing a special structural unit called [2.2]paracyclophane (pCP). When exposed to very high pressure, such materials show a shift in fluorescence toward longer wavelengths, resulting in them glowing red. Using X-ray crystallography, they found that the reason for this color change differed between the two crystals.

Comparing two organoboron crystals

In one crystal, called pCP-H, the electron clouds naturally form pairs in stacked layers known as π-stacked dimer layers. Pressure pushes these pairs even closer together, strengthening the weak electron forces between neighboring molecules and causing a pronounced change in the fluorescent color.

In the other crystal, pCP-iPr, molecules do not form these stacked layers, so the color change mainly comes from subtle changes within the individual molecules making up the crystal, resulting in a much smaller shift and a less intense color.

Implications for future material design

"Under ultra-high-pressure conditions, we discovered that cyclophanes, such as [2.2]paracyclophane, act like springs, expanding and contracting to alter the luminescent color through changes in molecular interactions," Professor Matsui explained.

Together, these results reveal that molecular pairing and the internal molecular structure affect how materials respond to pressure, providing valuable guidance for designing future pressure-sensitive materials.

Professor Ikeda concluded: "As materials function not only in molecular assemblies, like crystalline states, but also in monolayers, understanding both these processes is expected to become a new molecular design strategy."

Phys Org, 22 January 2026

https://phys.org

A simple chemistry trick could end forever plastic

2026-01-04

Yuwei Gu was walking through Bear Mountain State Park in New York when an unexpected sight caught his attention. Plastic bottles were scattered along the trail, with more drifting across a nearby lake. Seeing plastic waste in such a natural setting stopped the Rutgers chemist in his tracks and set his mind racing.

Gu began thinking about polymers, long chainlike molecules that make up both natural materials and modern plastics. DNA and RNA are polymers, and so are proteins and cellulose. The difference is that nature's polymers eventually break down, while synthetic plastics often remain in the environment for decades or longer.

"Biology uses polymers everywhere, such as proteins, DNA, RNA and cellulose, yet nature never faces the kind of long-term accumulation problems we see with synthetic plastics," said Gu, an assistant professor in the Department of Chemistry and Chemical Biology in the Rutgers School of Arts and Sciences.

Standing there in the woods, the reason suddenly became clear to him.

“The difference has to lie in chemistry,” he said.

Copying Nature’s Built-In Exit Strategy

Gu realized that if natural polymers can perform their function and then disappear, human-made plastics might be able to do the same. He already knew that biological polymers contain small built-in chemical features that help their bonds break apart at the right moment.

“I thought, what if we copy that structural trick?” he said. “Could we make human-made plastics behave the same way?”

That question led to a breakthrough. In a study published in Nature Chemistry, Gu and his Rutgers colleagues showed that using this nature-inspired approach allows plastics to break down under everyday conditions, without requiring high heat or harsh chemicals.

“We wanted to tackle one of the biggest challenges of modern plastics,” Gu said. “Our goal was to find a new chemical strategy that would allow plastics to degrade naturally under everyday conditions without the need for special treatments.”

How Polymers and Chemical Bonds Work

Polymers are made of many repeating units linked together, much like beads on a string. Plastics fall into this category, as do DNA, RNA and proteins. DNA and RNA consist of chains of smaller units known as nucleotides, while proteins are built from amino acids.

What holds these units together are chemical bonds, which act like glue at the molecular level. In polymers, these bonds connect one building block to the next. Strong bonds give plastics their durability, but they also make them difficult to break down once discarded. Gu’s research focused on designing bonds that stay strong during use but become easier to break later when degradation is desired.

Programmable Plastics With Built-In Weak Points

This research does more than make plastics degradable. It makes their breakdown programmable.

The key discovery involved carefully arranging parts of the plastic’s chemical structure so they sit in just the right positions to begin breaking apart when triggered. Gu compares the idea to folding a piece of paper so it tears easily along a crease. By effectively “pre-folding” the structure at a molecular level, the plastic can fall apart thousands of times faster than usual.

Despite this built-in vulnerability, the plastic’s overall chemical composition remains unchanged. That means it stays strong and useful until the moment degradation is activated.

“Most importantly, we found that the exact spatial arrangement of these neighboring groups dramatically changes how fast the polymer degrades,” Gu said. “By controlling their orientation and positioning, we can engineer the same plastic to break down over days, months or even years.”

Matching Plastic Lifetimes to Real-World Uses

This level of control allows plastics to be designed with lifespans that fit their purpose. Food packaging might only need to last a single day, while automotive components must hold up for many years. The researchers showed that degradation can be built in from the start or activated later using ultraviolet light or metal ions.

The potential applications extend well beyond reducing plastic pollution. Gu said the same chemistry could lead to timed drug delivery capsules or coatings that erase themselves after a set period.

“This research not only opens the door to more environmentally responsible plastics but also broadens the toolbox for designing smart, responsive polymer-based materials across many fields,” he said.

Safety Testing and the Road Ahead

For Gu, the long-term vision is simple. Plastics should do their job and then disappear.

“Our strategy provides a practical, chemistry-based way to redesign these materials so they can still perform well during use but then break down naturally afterward,” he said.

Early laboratory tests indicate that the liquid produced when the plastics break down is not toxic, though Gu emphasized that further testing is needed to confirm long-term safety.

Looking back, Gu said he was surprised that an idea sparked during a quiet hike actually worked.

“It was a simple thought, to copy nature’s structure to accomplish the same goal,” he said. “But seeing it succeed was incredible.”

Expanding the Research

Gu and his team are now pushing the research further. They are closely examining whether the small fragments left behind after plastic breakdown pose any risk to living organisms or ecosystems, ensuring safety across the entire life cycle of the material.

They are also exploring how their chemical approach could be applied to conventional plastics and integrated into existing manufacturing processes. At the same time, they are testing whether the method can be used to create capsules that release medication at carefully controlled times.

While technical challenges remain, Gu believes that continued development, along with collaboration with plastic manufacturers focused on sustainability, could bring this chemistry into everyday products.

Other Rutgers scientists who contributed to the study included: Shaozhen Yin, a doctoral student in the Gu lab who is first author on the paper; Lu Wang, an associate professor in the Department of Chemistry and Chemical Biology; Rui Zhang, a doctoral student in Wang's lab; N. Sanjeeva Murthy, a research associate professor at the Laboratory for Biomaterials Research; and Ruihao Zhou, a former visiting undergraduate student.

Science Daily, 4 January 2026

https://sciencedaily.com

New Brain Drugs Mimic Psychedelics Without the Hallucinations

2026-01-19

UC Davis scientists have created a light-based technique that converts amino acids — the building blocks of proteins — into new molecules with psychedelic-like shapes and brain activity.

These compounds can switch on the brain's serotonin 5-HT2A receptors, which are linked to cortical neuron growth, making them potential leads for conditions such as depression, substance-use disorder and PTSD. In animal models, though, the molecules did not produce a key behavioral sign typically associated with hallucinogenic drugs.

The research was recently published in the Journal of the American Chemical Society.

"The question that we were trying to answer was, 'Is there whole new class of drugs in this field that hasn't been discovered?" said study author Joseph Beckett, a Ph.D. student working with Professor Mark Mascal, UC Davis Department of Chemistry, and an affiliate of the UC Davis Institute for Psychedelics and Neurotherapeutics (IPN). "The answer in the end was, 'Yes.'"

The findings point to a simpler, more environmentally friendly path for discovering serotonin-targeting medicines that may deliver psychedelic-like benefits without strongly altering perception.

"In medicinal chemistry, it's very typical to take an existing scaffold and make modifications that just tweak the pharmacology a little bit one way or another," said study author Trey Brasher, also a Ph.D. student in the Mascal Lab and an affiliate of IPN. "But especially in the psychedelic field, completely new scaffolds are incredibly rare. And this is the discovery of a brand-new therapeutic scaffold."

Discovering a new therapeutic scaffold

To build their collection of candidate molecules, the team paired different amino acids with tryptamine, a metabolite of the essential amino acid tryptophan. Next, they exposed these combined molecules to ultraviolet light, reshaping them into new compounds with potential medicinal usefulness.

Computer simulations were used to test the binding affinity of 100 of these compounds at the 5-HT2A receptor.

From that set, five compounds were chosen for additional laboratory tests of efficacy and potency. The selected candidates showed efficacies ranging from 61% to 93%, with 93% indicating a full agonist — a compound capable of producing the maximum biological response from the 5-HT2A system.

The team labeled the full agonist in the group as D5. They expected that administering the compound to mouse models would induce head twitch responses, a hallmark of hallucinogenic-like behaviors.

However, that wasn't the case. Despite fully activating the same receptor as psychedelics, D5 didn't induce head twitch responses.

"Laboratory and computational studies showed that these molecules can partially or fully activate serotonin signaling pathways linked to both brain plasticity and hallucinations, while experiments in mice demonstrated suppression of psychedelic-like responses rather than their induction," Beckett and Brasher said.

Next steps: why no hallucinations?

The team plans to conduct follow-up studies to better understand if other serotonin receptors in the brain modulate or suppress the hallucinogenic-like effects of D5.

"We determined that the scaffold itself possesses a range of activity," Brasher said. "But now it's about elucidating that activity and understanding why D5 and similar molecules are non-hallucinogenic when they're full agonists."

Sci Tech Daily, 19 January 2026

https://scitechdaily.com

Study reveals why light-driven chemical reactions often lose energy before bond-breaking

2026-01-22

Florida State University researchers have discovered a pathway within a certain type of molecule that limits chemical reactions by redirecting light energy. The study could enable development of more efficient reactions for pharmaceuticals and other products.

The researchers examined ligand-to-metal photocatalysts. Ligands are a molecule bound to a larger molecule; in this case, to a metal. Photocatalysts are materials that use light to accelerate a chemical reaction. Theoretically, these molecules should be readily able to harness light energy toward chemical reactivity. But in experiments, chemists only found inefficient reactions.

The FSU research, published in the Journal of the American Chemical Society, shows why: The molecule quickly moves into a less energetic state before the absorbed energy can break chemical bonds. The energy is drained too quickly into the wrong place, so bond-breaking is limited.

"Even though the molecule is absorbing the light and it's getting the energy, it doesn't always do the thing that you want it to do, which is to rip itself in half and catalyze some photochemical reaction," said co-author Bryan Kudisch, an assistant professor in the Department of Chemistry and Biochemistry.

When molecules absorb energy from light, that energy has to go somewhere. Sometimes it causes a chemical reaction. In other cases, it dissipates as heat or radiates light back; that is, it glows.

But ligand-to-metal charge transfer molecules didn't behave as expected. When combined with other reactive materials and exposed to light, they produced chemical reactions, but at much lower efficiency than expected. They also didn't radiate much heat or light. That posed a mystery: Where was the energy from that light going?

The answer: The electron configuration within the material was moving. Instead of breaking chemical bonds, the electrons rearranged to move to a lower energy state.

"Whenever you give something a lot of energy, the thing that it wants to do is get rid of it," said co-author Rachel Weiss, a graduate researcher. "The two ways that this system has are to either break the bond or rearrange its electrons, and it just tends to go in the rearranging pathway much more often."

In the examples the researchers examined, molecules rearranged their electrons in about 85% of cases.

The electron-rearrangement pathway doesn't directly allow for more efficient reactions in applied settings such as manufacturing. But understanding how this reaction works is crucial for future research that could lead to more efficient chemical processing.

"Right now, we don't know what determines the path these molecules use, but it implies we can make these reactions five or ten times faster," Kudisch said.

In the context of pharmaceutical manufacturing, for example, in which companies are producing millions of doses of medicine for patients, cutting the time for a single reaction represents a major increase in efficiency.

"The economics of making a molecule depends on how much time is needed for a reaction to occur," he said. "The faster your reactions are, the more products you can make."

Phys Org, 22 January 2026

https://phys.org

The toxic chemistry behind skin bleaching products

2026-01-19

The global skin-lightening market is worth over $10 billion and growing, but the unregulated products driving it contain dangerous chemicals linked to serious health risks. Zahra Khan speaks to the scientists and advocates trying to fix the problem

The skin is the body's largest organ, and humans have evolved to acquire skin colour as a balance between UV protection and vitamin D synthesis. The anatomy of colour remains a relatively under-researched area of medicine, but what is known is there is a strong desire to lighten skin tone in certain communities. Skin bleaching refers to the intentional whitening of someone's skin colour for cosmetic purposes using products such as soaps, creams and washes – and in some cases, through injections. While evening out skin tone under strict medical guidance happens, the misuse of chemicals in a highly unregulated market is driving an epidemic in some countries. This essentially alters the biochemistry of the skin.

The use of products containing harmful chemicals is on the rise, and with the global skin-lightening market valued at around $10.22 billion in 2025 (£7.5 billion) and projected to exceed $16 billion by 2032, the industry is only thriving. These chemicals have been linked to severe health conditions such as neurological damage and kidney problems, creating a major public-health concern. This demonstrates why scientists, policymakers and the public must unite to stop this harmful practice. Cultural norms, regulatory gaps and industry ethics all contribute to the problem – and beyond biology, this is colonial colourism rendered in chemical form.

How melanin is produced

'Your skin colour is naturally preset to be a certain colour,' says Roopal Kundu, a dermatologist at Northwestern University in Illionois, US. Skin colour comes from melanin – the pigment that gives skin, hair and eyes their colours. The enzyme tyrosinase acts as the molecular on-switch for pigment production. Melanin synthesis begins with the amino acid tyrosine, which is converted into DOPA (3,4-dihydroxyphenylalanine) and then into DOPAquinone by the copper-containing enzyme tyrosinase, explains Bianca Tod, a dermatologist in Cape Town, South Africa. These reactions take place inside specialised cells called melanocytes, found in the basal layer of the epidermis – the layer that constantly sheds and renews itself.

From there, DOPAquinone follows one of two pathways, producing either eumelanin (a dark brown to black pigment) or pheomelanin (red to yellow). These pigments are packaged into tiny organelles called melanosomes, which are transported through dendrites into surrounding keratinocytes, the main cells that make up the epidermis. As keratinocytes mature, they carry those melanin granules upwards towards the skin's surface, where the colour becomes visible.

'For every one melanocyte, it's feeding into multiple other keratinocytes,' says Kundu, describing how a single pigment cell supplies colour to many surface cells – what she calls a 'melanin unit.'

The visible pigmentation of the skin – this intricate melanin unit – depends on the balance between eumelanin and pheomelanin, and on the number, size and distribution of melanosomes. Darker skin produces more melanin, predominantly eumelanin, contained in larger, individually dispersed melanosomes. In lighter skin, less melanin is produced, with more pheomelanin and smaller, clustered melanosomes. The final skin tone is ultimately determined by how much melanin each keratinocyte receives – nature's own calibration of colour and protection.

Each melanin granule sits over the nucleus of a keratinocyte – 'it's like a hat protecting the cell's nucleus from UV', says Kundu. Melanin absorbs and scatters UV radiation before it can damage DNA, meaning that skin cancers are less common in people with more pigmentation. Melanin, therefore, represents a finely tuned evolutionary adaptation, not a cosmetic feature. 'Melanin is not a flaw – it's a function. It's your body's built-in sunscreen,' says Kandu.

Melanin absorbs ultraviolet light and protects DNA from UV-induced damage, but this also means that darker skin is less efficient at synthesising vitamin D. 'This balance between UV protection and vitamin D production is one of the evolutionary reasons for the range of human skin tones,' says Tod. Darker skin evolved to protect against DNA damage whereas people in low UV regions like Europe have lighter skin to maximise vitamin D production. The biological advantage of melanin is UV protection – but there is a cost to that protection. There is reduced UV penetration to the deeper layers of the skin, where 7-dehydrocholesterol is converted into vitamin D_3. And crucially, this biochemical balance cannot be changed by bleaching. Lightening the skin doesn't increase vitamin D production – it simply removes the body's natural shield, leaving it more vulnerable to UV damage without providing any evolutionary benefit.

Why people bleach their skin

‘Everyone believes that a fairer or white skin complexion means being elite, beautiful and more accepted,’ says public health PhD researcher Rashidat Owulabi. Bleaching is less a cosmetic choice than a social contract: lighter skin is coded as status and safety, a legacy of colonial aesthetics. Women who lighten their skin are often praised for being clean or presentable, while darker skin individuals are often told to ‘tone up.’

‘40% of African women bleach … 77% in Nigeria, 59% in Togo. Skin bleaching is a multi-billion-dollar business,’ says Dellasie, a Ghanaian advocate and artist. The phenomenon extends beyond Africa – it’s common in the diaspora, and across Latin America and Asia, too.

The norm is amplified by advertising and influencers. ‘Education on skin health in Africa is minimal,’ Dellasie explains, leaving communities vulnerable to colourist messaging and unsafe products. ‘Before-and-after pictures and influencer promotions make people believe it’s safe – they become embedded ambassadors,’ adds Owulabi. The media continues to fuel the idea that lighter skin signals opportunity, desirability and employability. Branding has also evolved, moving away from explicit bleaching labels toward euphemisms like brightening, anti-ageing or anti-wrinkle – even though lab tests continue to find illegal mercury in many of these products.

Seeing the scale of the problem, Amira Adawe, founder of Beautywell, channelled her energy into advocacy. Her NGO partners with labs to test products, then simplifies and translates the findings into multiple languages so that communities can understand what’s really inside their creams. What she’s finding is alarming. ‘If you look at the global threshold [of mercury], according to the Minamata Convention, they changed in 2023 to zero parts per million. Any level of mercury is toxic,’ Adawe explains. Yet her team routinely finds products with 55,000ppm of mercury, and even those on the lower end contain around 150ppm – still far beyond legal limits. Though bans exist on paper, these products are everywhere – in corner stores, imported shipments, even rural towns with limited healthcare – and the consequences are devastating.

‘Neurological damage from heavy metal exposure does not appear for years – making the products seem harmless in the short term,’ adds Owulabi. The health effects are often invisible, making consumers underestimate the danger. Mercury in creams can even be transferred to infants through breast milk, carrying silent, long-term health risks. ‘A woman in Minnesota lost her vision … in California another was in a coma for six months. In East Africa I’ve seen women on dialysis because

mercury levels … were extremely high,’ says Adawe. Mercury is cheap and fast – it suppresses melanin more, meaning the skin colour change is faster and more visible compared to hydroquinone and steroids. The impact of mercury extends to learning disabilities and speech delays.

A growing public health problem

‘The rate of kidney problems in my country is increasing by the day because of skin bleaching,’ says Joy Ikegulu, public health education research fellow and advocate in Nigeria. Studies confirm that these products can overload the liver and kidneys. Once mercury and hydroquinone enter the bloodstream, the body relies on the renal system to remove and excrete them. Public-health agencies warn that mercury-based creams can cause irreversible renal damage, presenting with swelling around the eyes, high blood pressure and rapid weight gain. Chronic use – months of daily application – allows mercury to bioaccumulate, eventually leading to proteinuric kidney disease. Symptoms often appear only after prolonged exposure, making the danger harder to detect.

It’s no longer just a single demographic that’s vulnerable – the entire population is at risk, with mothers even buying bleaching products for their children due to family and societal pressure for acceptance. Women remain the largest user base, but male use is steadily rising, and children are being exposed through parental choices. Young girls are targeted early, scrolling through social media feeds filled with celebrities and influencers endorsing lighter skin. Ikegulu has even seen pregnant women purchasing these products in the false hope of changing their unborn baby’s complexion – a scientifically inaccurate belief that can damage the baby’s developing brain and nervous system.

Skin bleaching has become normalised and multigenerational, rooted in low self-esteem and internalised discomfort with one’s natural skin tone. ‘Everyone wants to look like a white person,’ Joy says – a disastrous remnant of colonial beauty ideals that continues to echo across generations.

Chronic users also face an unexpected side effect: a sharp, pungent body odour. ‘It’s the first thing you notice,’ says Ikegulu. When the renal system is strained, metabolic waste containing sulfur-rich amino acids is released through sweat. Meanwhile, hydroquinone oxidises into quinones and phenolic compounds – giving off a harsh chemical smell, especially in humid climates. The visible skin blotching and odour that follow can trigger anxiety, depression and isolation, compounding the harm.

‘Many countries banned mercury and hydroquinone, but enforcement is almost zero,’ says Adawe. Loose policy allows anyone to mix a cocktail of harmful chemicals, and people will buy it. Imports and online sales persist, even in regions where other essentials are scarce. The products are easy to find – and until that changes, so will the damage.

How skin bleaching agents work

Bleaching agents work by blocking or slowing down tyrosinase – the key enzyme responsible for melanin production. ‘Creams can be absorbed … into the top layer of skin, the epidermis,’ explains Kundu. On a microscopic scale, chronic bleaching can reduce melanin synthesis permanently by damaging melanocytes, the pigment-producing cells. These products target different stages of the pigment pathway – during melanin synthesis, melanosome formation and transfer, or epidermal turnover, where they accelerate the shedding of pigmented skin cells.

‘There are several skin-lightening agents on the market. They work at different points in the production of pigmentation,’ says Tod. The most common ingredients – hydroquinone, kojic acid and thiamidol – all interfere with tyrosinase, effectively switching off the body’s natural pigment factory and disrupting the very process that gives skin its colour and protection.

Hydroquinone acts as a structural analogue of tyrosine, effectively tricking the enzyme into producing toxic quinones that damage the melanocyte itself. It can act aggressively and permanently, causing serious side effects. Long-term misuse leads to exogenous ochronosis – an irreversible dermal pigmentation disorder. ‘The skin turns a very unusual pinkish colour … with caviar-like stippling,’ explains Kundu.

Mercury salts replace the copper cofactor in tyrosinase, shutting down its activity and halting melanin synthesis. But mercury is far more than a pigment inhibitor – it is a potent neurotoxin that is systemically absorbed, damaging the kidneys and nervous system. ‘Mercury is readily absorbed by the skin and is particularly toxic to the kidneys, nervous system and developing foetuses,’ says Tod. Mercury exposure also increases UV vulnerability, leaving the skin photosensitive and more prone to cancer.

Topical steroids are another cause for concern. They aren’t true depigmenters, but long-term use thins the skin, destroying collagen and elastin, leading to fragile, prematurely aged skin, stretch marks, acne and easy bruising. Other agents, such as retinoids, increase cell turnover, causing pigmented keratinocytes to shed faster and making

the skin appear lighter temporarily. Retinoids themselves aren’t systemic toxins, but in unlabelled combinations, they amplify irritation and barrier damage.

Clinically treating pigment problems

There are, however, several naturally occurring pigment disorders that dermatologists treat medically rather than cosmetically. Melasma – driven by UV exposure and hormones – causes patchy overproduction of melanin, often on the face. Vitiligo is the opposite, a depigmentation condition caused by loss of melanocytes. Post-inflammatory hyperpigmentation (PIH) develops after acne, eczema or bites, when, as Kundu explains, ‘trauma pushes melanin to the wrong places’.

Treatment for these conditions focuses on repair, regulation and protection – not erasure. Daily high-SPF photoprotection is ‘the most critical step’, says Adawe. Dermatologists often prescribe time-limited cycles (around three months) of hydroquinone with retinoids and mild corticosteroids for melasma or PIH, followed by a rotation to alternatives to avoid the risks of long-term exposure. These substances are safe only when treating disease, not for lightening normal skin, and must be supervised.

‘Tretinoin … helps the skin turn over, so you’re sloughing off some extra melanin that’s moved up in the skin,’ Kundu explains. Tretinoin – also known as retinoic acid – is one of the most prescribed topical agents in the world, bridging pigment control and skin repair by stimulating collagen renewal. Dermatologists also prefer reversible, cosmetic-level inhibitors such as Thiamidol, which act on human tyrosinase without permanently altering melanocytes.

Thiamidol, marketed as a safer alternative, works by selectively inhibiting human tyrosinase – the key enzyme in melanin production – with reversible action. ‘It does not induce lightening of the entire skin. It targets areas with excessive melanin production,’ says Ludger Kolbe, chief scientist for photobiology at skin care company Beiersdorf.

Beiersdorf positions Thiamidol as a targeted hyperpigmentation active ingredient, not a whole-skin lightener – a clear statement that the company is not pro-bleaching but focused on medical-grade pigment care. ‘Its mechanism differs from bleaching agents such as hydroquinone,’ Kolbe explains. He describes Thiamidol as the first and only inhibitor designed specifically for and tested on human tyrosinase, capable of reducing existing pigment spots while helping to prevent new ones.

Crucially, he adds, 'the mode of action is reversible … melanocytes will restart melanin production after discontinuation'.

Dermatologists like Kundu agree that these medications can be used safely under medical supervision, but she cautions that misuse or combining multiple actives can overwhelm the skin barrier, leading to a range of problems. 'When melanin is suppressed, the skin loses part of its protective structure. You see more inflammation, more infections and, paradoxically, more pigment problems later,' Kundu warns. Melanin, she reminds us, 'is a living system, not a pigment you can safely switch off indefinitely'.

The cost of beauty?

The biggest issue lies in accessibility – these products are everywhere: on the shelves of corner stores, in open-air markets and easily available online. Availability drives use. Many of the creams sold in local markets are spiked with steroids and mercury, and clinicians consistently warn against over-the-counter 'lighteners'. Adawe's team has tested products sourced from both the US and East Africa and found almost identical formulations across regions – many also contain other heavy metals such as lead and arsenic. Worse still, mercury can contaminate household air, lingering even after use stops and affecting other family members.

Governments are finally beginning to act. Regulators are far more engaged than a decade ago. Adawe now trains border and customs teams, urging for stronger legislation and continuous enforcement. 'If there's not enforcement, policy is not active.' Some countries are beginning to see progress – Rwanda, for example, has stricter compliance, meaning fewer products reach the shelves and, as Owulabi notes, 'has lower prevalence' of the associated problems.

Retail platforms like Amazon and eBay are also starting to respond. After Adawe's petitions, 'some listings were removed, though others have never listened', she says of major online retailers where many of these products can still be found and purchased with ease.

At the community level, Ikegulu continues to advocate for natural methods, urging people to stop trying to change their baseline skin colour. She preaches the benefits of natural remedies like cocoa butter, especially for melanin-rich skin, which can repair the skin barrier, soothe irritation, and help maintain an even tone by preventing secondary inflammation. However, Owulabi insists that telling people to stop must come with safer alternatives. 'When you have people stop something, you must create a better alternative … health promotion and public health awareness are key.'

Alternatives already exist – but only when the goal is treating disease, not altering natural colour. A major part of that education is differentiating medicine from bleach. Treating clinical conditions chemically should never be conflated with whole-skin lightening. There also needs to be greater ingredient transparency to curb vague 'brightening' claims that allow unsafe products to slip through regulation. Demand persists, but Kundu believes it can be redirected: 'reframing toward safe medical treatment redirects patients', says Kundu.

There is no silver bullet for pigmentation. 'The sheer number of depigmenting agents tells you that nothing is a wonder cure. Prevention is the most critical step, in the form of sun protection,' says Tod. No single ingredient is inherently safe; its safety hinges on supervised, time-limited regimens and strict photoprotection.

Ultimately, lasting change will only come from acceptance and pride in natural skin colour. As Dellassie argues, we must confront a 'toxic and outdated psychology' that equates lightness with value. That means campaigns, particularly on social media, to challenge colourist narratives so that young people aren't influenced by damaging messages about skin tone. There are signs of hope – mentorship programmes, youth groups, and community interventions are slowly shifting attitudes – but, as Adawe warns, 'we will continue to see skin lightening products until we dismantle colourism and redefine beauty standards'.

Chemistry World, 19 January 2026

https://chemistryworld.com

Beyond silicon: These shape-shifting molecules could be the future of AI hardware

2026-01-03

At the same time, neuromorphic computing, hardware inspired by the brain, has pursued a similar goal. The aim is to find a material that can store information, perform computation, and adapt within the same physical structure and do so in real time. However, today's leading neuromorphic systems, often based on oxide materials and filamentary switching, still function like carefully engineered machines that imitate learning rather than materials that naturally contain it.

Two Paths Begin to Converge

A new study from the Indian Institute of Science (IISc) suggests these two long-standing efforts may finally be coming together.

In a collaboration bringing together chemistry, physics, and electrical engineering, a team led by Sreetosh Goswami, Assistant Professor at the Centre for Nano Science and Engineering (CeNSE), developed tiny molecular devices whose behavior can be tuned in multiple ways. Depending on how they are stimulated, the same device can act as a memory element, a logic gate, a selector, an analog processor, or an electronic synapse. "It is rare to see adaptability at this level in electronic materials," says Sreetosh Goswami. "Here, chemical design meets computation, not as an analogy, but as a working principle."

How Chemistry Enables Multiple Functions

This flexibility comes from the specific chemistry used to construct and adjust the devices. The researchers synthesized 17 carefully designed ruthenium complexes and studied how small changes in molecular shape and the surrounding ionic environment influence electron behavior. By adjusting the ligands and ions arranged around the ruthenium molecules, they demonstrated that a single device can display many different dynamic responses. These include shifts between digital and analog operation across a wide range of conductance values.

The molecular synthesis was carried out by Pradip Ghosh, Ramanujan Fellow, and Santi Prasad Rath, former PhD student at CeNSE. Device fabrication was led by Pallavi Gaur, first author and PhD student at CeNSE. "What surprised me was how much versatility was hidden in the same system," says Gaur. "With the right molecular chemistry and environment, a single device can store information, compute with it, or even learn and unlearn. That's not something you expect from solid-state electronics."

A Theory That Explains and Predicts Behavior

To understand why these devices behave this way, the team needed something that has often been missing in molecular electronics: a solid theoretical framework. They developed a transport model based on many-body physics and quantum chemistry that can predict device behavior directly from molecular structure. Using this framework, the researchers traced how electrons move through the molecular film, how individual molecules undergo oxidation and reduction, and how counterions shift within the molecular matrix. Together, these processes determine switching behavior, relaxation dynamics, and the stability of each molecular state.

Toward Learning Built Into Materials

The key result is that the unusual adaptability of these complexes makes it possible to combine memory and computation within the same material. This opens the door to neuromorphic hardware in which learning is encoded directly into the material itself. The team is already working to integrate these molecular systems onto silicon chips, with the goal of creating future AI hardware that is both energy efficient and inherently intelligent.

"This work shows that chemistry can be an architect of computation, not just its supplier," says Sreebrata Goswami, Visiting Scientist at CeNSE and co-author on the study who led the chemical design.

Science Daily, 3 January 2026

https://sciencedaily.com

Lead, Arsenic, and Other Toxic Metals Discovered in Australian Tattoo Inks

2026-01-20

A study by UNSW Sydney 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.

Using advanced analytical techniques, the researchers detected multiple regulated toxic substances across the 15 samples, including eight metals restricted under EU law: antimony, arsenic, cadmium, chromium, copper, lead, selenium and tin. These metals were found in amounts that exceeded the limits set under EU Commission Regulation 2020/2081 and the Council of Europe Resolution ResAP (2008) in at least one ink.

A cause for alarm?

Surveys estimate more than 20% of Australian adults have at least one tattoo.

However, the researchers say their findings should not be interpreted as evidence that tattoos directly cause harm.

This is because the study measured the chemical composition of inks – not health outcomes. The study also did not assess how much of these substances are absorbed by the body or what effects they could have over time.

“We need further targeted studies to confirm the specific chemical forms of some regulated substances,” Prof. Donald says.

“This means examining how inks behave once injected into the skin,” he says.

“It also means understanding how factors such as ageing, sunlight exposure and tattoo removal might influence long-term exposure.

“So the results are best seen as a signal for closer scrutiny, rather than a verdict on the safety of tattooing itself.”

Lead author Dr Jake Violi, also from UNSW, says people with tattoos are not automatically at risk.

“We are not saying people should not get tattoos,” Dr Violi says.

“We are saying the chemical content of inks matters – and there is very little routine checking of what is actually sold in Australia.”

If you are thinking about getting a tattoo, the Cancer Council suggests asking if the inks used comply with the European standards (updated to

EU Commission Regulation 2020/2081), which set the requirements and criteria for the safety of tattoos.

A curious start

The project began as a high school science question. Coauthor Bianca Tasevski initiated the work as part of a senior research project while completing her final year of school.

“Bianca asked a straightforward question of ‘What is actually in the tattoo inks sold in Australia?’,” Dr Violi says.

“And so we worked with her to test this.”

Dr Violi says the study combined two complementary standard chemical analysis techniques.

One was inductively coupled plasma mass spectrometry, to show which metals were present at what concentrations.

The second was untargeted liquid chromatography tandem mass spectrometry, which screened for organic compounds. Toluidine, a carcinogenic aromatic amine, was found in three of the 15 inks. Sulphanilic acid – which is not typically suitable for human consumption or therapeutic use – was detected in nine inks. Both substances are banned under EU tattoo-ink regulations.

The researchers found bright coloured inks had additional toxic compounds not currently restricted under tattoo-ink legislation, including high levels of pigment-associated metals.

“Titanium was detected at concentrations of up to about 10,000 parts per million in a light-blue ink,” Dr Violi says.

“Aluminium and zirconium were also present at very high levels.

“These metals are commonly associated with pigments that are used to improve colour and stability.”

While not currently restricted under EU tattoo-ink regulations, Dr Violi says their presence at such high concentrations raises important toxicological questions because tattoo pigments can persist in the skin and migrate to lymph nodes.

Inking the future

Australia's only government survey of tattoo inks was conducted in 2016, with an update in 2018. The resulting report found most inks tested would not meet European guidelines. It also had limited methodological detail and predated the EU's current, legally binding rules.

Across the world, investigations document widespread non-compliance with EU standards. This indicates tattoo inks remain a significant and under-regulated source of toxic metal exposure.

In the United States, only 11% of inks were labelled accurately. In Sweden, more than 90% of inks failed labelling requirements and concentrations of metals above regulatory thresholds were found across multiple samples. In Turkey, most inks breached the EU limits for metals, with several products demonstrating cytotoxic effects in the lab.

The researchers say European standards for tattoo inks were only introduced recently, so it would only be a matter of time before the rest of the world adopts safety regulations. This needs a lot more focused work to both identify and measure specific regulated chemicals, especially where safety rules depend on the type of chemical, not how much of it is present.

"Australia has limited publicly available testing data," Prof. Donald says. "The chemical composition of inks currently sold here remains largely unknown.

"Because tattooing is now a mainstream form of body art, regular monitoring and aligning Australia's standards with international best practice just makes sense."

Technology Networks, 20 January 2026

https://technologynetworks.com

Rye pollen's cancer-fighting structure revealed for first time

2026-01-21

Nearly three decades ago, scientists found that a pair of molecules in rye pollen exhibited an unusual ability to slow tumor growth in animal models of cancer. But progress stalled for one seemingly simple reason: No one knew exactly what the molecules looked like.

Now, Northwestern University chemists have finally cracked the case. In a recent study, the team definitively determined the three-dimensional structures of both molecules—secalosides A and B—by building them from scratch.

With the correct blueprint now in hand, scientists can finally investigate how specific components of pollen from rye—a staple cereal crop grown for its grain—interact with the immune system and whether it could inspire new strategies for cancer treatment.

The study is published in the Journal of the American Chemical Society.

"In preliminary studies, other researchers found that rye pollen could help different animal models clear tumors through some unknown, non-toxic mechanism," said Northwestern's Karl A. Scheidt, who led the study. "Now that we have confirmed the structure of these molecules, we can find the active ingredient—or what part of the molecule is doing the work. This is an exciting starting point to make better versions of these molecules that could possibly inform approaches to cancer therapy."

Scheidt is a professor of chemistry at Northwestern's Weinberg College of Arts and Sciences and a professor of pharmacology (by courtesy) at Northwestern University Feinberg School of Medicine. He also is a member of the Chemistry of Life Processes Institute and of the Robert H. Lurie Comprehensive Cancer Center of Northwestern University.

Nature as inspiration for medicine

Throughout history, researchers, biologists and health care workers have looked to nature as an inspiration for new treatments. Some of the most powerful drugs in modern medicine originated not in the lab but in tree bark, microbes and flowers. Morphine, the gold standard for relieving severe pain, is derived from the opium poppy. Taxol, a widely used and effective cancer treatment, was originally isolated from the Pacific yew tree. And statins, which lower cholesterol to prevent heart disease, can trace their origins back to fungi.

"Natural products aren't necessarily effective drugs on their own, but they are great leads," Scheidt said. "We can find inspiration in natural products and use chemistry to make better versions that are orally available, survive the metabolism and hit the right targets."

Eventually, rye pollen potentially could join these ranks. Many consumers around the world already ingest rye pollen extract in supplement form to protect prostate health. But scientists haven't yet optimized it for use as a pharmaceutical drug. Understanding how it works required knowing the molecules' precise three-dimensional shape—information that proved elusive.

A molecular mystery

Using traditional techniques, such as advanced nuclear magnetic resonance spectroscopy, scientists could not fully reveal the orientation of the molecules' key parts. As a result, two competing structural models persisted for decades.

Those two proposed structures had the same atoms, same connections and same overall shape. But a central part of the molecules are mirror images of each other. That subtle distinction can change how the molecule fits into a biological target and determine whether a molecule is biologically active or inert.

"It's like your hands," Scheidt said. "They are mirror images of each other, but you need a different glove for each. If you had two left-handed gloves, it wouldn't work because your hands can't be superimposed on top of one another."

Building from scratch

To settle the question once and for all, the Northwestern team turned to total synthesis, or the step-by-step process of constructing a natural molecule in the laboratory. The approach was incredibly complicated and challenging. At their cores, secalosides A and B contain an extremely rare and highly strained feature: a tightly compressed, 10-membered ring that is notoriously difficult to build.

Scheidt and his team devised a clever workaround. They first built a larger, more flexible ring and then triggered a reaction that snapped it into a smaller, strained shape in a single step. After synthesizing both competing structural versions of the secalosides, the scientists compared them to samples isolated from rye pollen. Only one version matched perfectly, finally revealing the true molecular structure.

"We've demonstrated we can make the core of this natural product," Scheidt said. "Now, we're trying to find potential collaborators in immunology who could help us translate this to a possible clinical endpoint."

Phys Org, 21 January 2026

https://phys.org

Algae's Secret Sun Shield Could Revolutionize Solar Energy

2026-01-20

A hidden pigment helps ocean algae harness sunlight without getting burned—and it may hold clues for better solar tech.

Too much sunlight can spoil a beach day, and it can also damage photosynthesis, the process plants and algae use to turn light into energy. Excessive exposure can overwhelm this system, harming organisms that depend on sunlight to survive. Under the ocean surface, however, some algae have developed an effective defense.

Researchers from Osaka Metropolitan University and their collaborators found that a pigment called siphonein helps marine green algae continue photosynthesis smoothly, even under intense light.

How Photosynthesis Can Go Wrong in Strong Light

Photosynthetic organisms rely on sensitive structures known as light-harvesting complexes (LHCs) to absorb sunlight. When chlorophyll captures light, it briefly enters an excited singlet state and passes that energy to reaction centers that drive chemical processes. Under normal conditions, this transfer is efficient and safe. When light levels become too high, though, chlorophyll can shift into a harmful "triplet" state. This state can produce reactive oxygen species that cause oxidative damage to cells.

"Organisms use carotenoids to quickly dissipate excess energy, or quench these triplet states, through a process called triplet-triplet energy transfer (TTET)," said Ritsuko Fujii, lead author and associate professor at the Graduate School of Science and Research Center for Artificial Photosynthesis at Osaka Metropolitan University.

Despite its importance, the basic rules behind this protective process have remained unclear.

Why Scientists Turned to Marine Algae

To better understand how this protection works, the research team studied Codium fragile, a species of marine green algae. Like land plants, it has a light-harvesting antenna called LHCII, but it also contains unusual carotenoids, including siphonein and siphonaxanthin. These pigments allow the algae to make use of green light, which is more common underwater.

"The key to the quenching mechanism lies in how quickly and efficiently the triplet states can be deactivated," said Alessandro Agostini, a researcher at the University of Padua in Italy and co-lead author of the study.

Measuring Algae's Natural Sun Protection

The researchers used electron paramagnetic resonance (EPR) spectroscopy, a technique that can directly detect triplet excited states, to compare spinach plants with Codium fragile. In spinach, faint signals from chlorophyll triplet states were still present. In Codium fragile, those signals disappeared entirely. This showed that carotenoids in the algae were fully neutralizing the harmful states.

"Our research has revealed that the antenna structure of photosynthetic green algae has an excellent photoprotective function," Agostini said.

Siphonein's Role in Shielding Algae

By combining EPR results with quantum chemical simulations, the team identified siphonein as the main pigment responsible for this protection. The pigment sits at a crucial binding site within the LHCII complex. The analysis also explained how siphonein's electronic structure and precise location make it especially effective at dispersing excess energy before it can cause damage.

These results show that marine algae have evolved specialized pigments not only to absorb the blue-green light available underwater but also to survive intense sunlight.

Implications for Future Solar Technology

Beyond shedding light on photosynthesis, the findings could help inspire bio-inspired solar technologies that include built-in protection against energy overload. Such designs could lead to renewable energy systems that are both more durable and more efficient.

"We hope to further clarify the structural characteristics of carotenoids that increase quenching efficiency, ultimately enabling the molecular design of pigments that optimize photosynthetic antennae," Fujii said.

The study was published in Cell Reports Physical Science.

Sci Tech Daily, 20 January 2026

https://scitechdaily.com
~tProlonged Exposure to Air Pollution Increases ALS Risk

2026-01-20

Prolonged exposure to air pollution can be linked to an elevated risk for serious neurodegenerative diseases like ALS and seems to speed up the pathological process, report researchers from Karolinska Institutet in Sweden. The study is published in the journal JAMA Neurology.

We can see a clear association, despite the fact that levels of air pollution in Sweden are lower than in many other countries," says Jing Wu, researcher at the Institute of Environmental Medicine, Karolinska Institutet. "This underlines the importance of improving air quality."

Motor neuron diseases (MNDs) are serious neurological diseases in which the nerve cells that govern voluntary movement become so degraded that they stop working, leading to muscle atrophy and paralysis. Amyotrophic Lateral Sclerosis (ALS) is the most common type, accounting for around 85 to 90 per cent of cases.

Environmental factors thought to play a part

The causes of these diseases are largely unknown, but environmental factors have long been suspected of playing a part. The new study shows that air pollution can be one such factor.

The study included 1,463 participants in Sweden with recently diagnosed MND, who were compared with 1,768 siblings and over 7,000 matched controls from the general population. The researchers analysed levels of particles (PM2.5, PM2.5-10, PM10) and nitrogen dioxide at their home addresses up to ten years prior to their diagnoses.

The annual mean values for these pollutants were just above the WHO guidelines and the peak values were much lower than in countries with heavy air pollution.

Up to 30 per cent higher risk

Long-term exposure to air pollution, even at relatively low levels typical of Sweden, was associated with a 20 to 30 per cent higher risk of developing MND. Moreover, people who had lived in areas with higher levels of air pollution experienced more rapid motor and pulmonary deterioration after diagnosis. They also had an elevated risk of death and were more likely to need treatment in an invasive ventilator.

Our results suggest that air pollution might not only contribute to the onset of the disease, but also affect how quickly it progresses," says Caroline Ingre, adjunct professor at the Department of Clinical Neuroscience, Karolinska Institutet.

When confining their analyses to ALS patients, the researchers found virtually the same pattern as for the entire MND group.

Inflammation and oxidative stress

The researchers stress that the study is unable to show the mechanisms behind the association, but previous research indicates that air pollution can cause inflammation and oxidative stress in the nervous system. Since it was an observational study, no causal relationship can be ascertained.

The study was based on Swedish registry data and was financed by several bodies, including the US Center for Disease Control and Prevention, the Swedish Research Council and Karolinska Institutet. Some of the authors have received research grants and/or fees from pharmaceutical companies; see the article for a full conflict of interest declaration.

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https://technologynetworks.com

Sweetening the deal for sustainability, while removing carbon dioxide

2025-01-21

Here's a novel pathway to a more sustainable planet: carbo-loading for the public good. In a new study published in Nature Synthesis, chemists at Yale and the University of California-Berkeley have developed a two-step process that removes carbon dioxide (CO2) from the air and converts it into carbohydrates, aka sugars.

Previous studies from various research institutes, including Yale, have explored ways to convert CO2 into simple molecules, such as methanol and formate, that can be used as industrial feedstocks for other products and to reduce greenhouse gases.

The new study pushes this idea further. It describes a process for using renewable electricity to transform CO2 into long-chain carbohydrates (molecules with five or six carbon atoms), which are considered the molecular building blocks of life.

"We were motivated by the successes and limitations of our own previous work," said Hailiang Wang, a chemistry professor in Yale's Faculty of Arts and Sciences, member of the Yale Energy Sciences Institute and Yale Center for Natural Carbon Capture, and co-corresponding author of the study. "The products we've made up to now, such as methanol, are very useful, but we wanted to develop conversions for even more complex and valuable products."

Wang also has a secondary appointment in materials science at the Yale School of Engineering & Applied Science.

In the new study, Wang and his colleagues begin with an electrochemical reaction that, if left uninterrupted, will convert carbon dioxide into methanol. However, the researchers halt the process in mid-reaction—when the molecule is formaldehyde.

At this point, the researchers convert the formaldehyde molecule into a molecule called hydroxymethanesulfonate (HMS), an organosulfur compound that is stable against further reduction.

"Formaldehyde is so reactive, it is challenging to work with," Wang said. "But we've been able to stabilize it."

The HMS can then be converted, in a thermochemical reaction, into carbohydrates, such as synthetic sugars for agricultural feedstocks and sweeteners. In addition to these potential uses in agriculture and food production, the new chemical process may have applications in drug design and biotech, Wang said.

Such applications are all in addition to the environmental benefits of disposing of CO2—a main contributor to climate change.

The researchers are planning to refine the results with additional research and are pursuing a patent application for the process.

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https://phys.org

Unexpected Chemical Contaminants Identified in Breast Milk

2026-01-21

An interdisciplinary team including researchers at McGill University has found a range of unexpected chemical contaminants in human milk samples from Canada and South Africa. The chemicals include traces of pesticides, antimicrobials and additives used in plastics and personal-care products. The findings were published across five papers.

"It is important to note that these chemicals were detected at low concentrations, and we do not fully understand the health effects of many of them. So, despite these findings, breast milk remains ideal for infants, as it has the nutrients infants need to develop as well as antibodies that protect them against diseases," said Stéphane Bayen, study co-author and Associate Professor in the Department of Food Science and Agricultural Chemistry.

The researchers said the data could help improve chemical safety regulations and protect infant and parental health by expanding testing targets. The information could also encourage further research to better understand how certain chemicals are metabolized in the human body.

Search for unusual residues

While earlier studies have often focused on individual substances and the health consequences of exposure, the researchers used a non-targeted analysis to conduct a broad search for any unusual chemical residues.

In this way, several new compounds were found, including:

- Antimicrobial preservatives (2-ethylhexyl 4-hydroxybenzoate and phenyl paraben) commonly added to soaps, disinfectants and personal-care products
- Plastic-related antioxidant additives (Irganox 1010 and BHT-COOH) used during manufacturing to stabilize plastics and packaging materials
- Pesticide-related or antimicrobial compounds: an agricultural herbicide (propanil) and an antimicrobial used in disinfectants and household products (chloroxylenol).

These compounds had not been previously reported in human milk.

In samples from South Africa, the researchers also detected 8-hydroxyefavirenz, a breakdown product of a medication called efavirenz used to treat HIV.

"To our knowledge, the compound had never before been identified in human milk. Its presence suggested that the mothers in South Africa used efavirenz during or prior to the sample years. This treatment was replaced by another regimen after 2019," Bayen said.

Analyzed samples in Montreal and South Africa

The researchers analyzed 594 human milk samples collected in Canada (Montreal) and South Africa (Vhembe and Pretoria) between 2018 and 2019.

They used different data-mining strategies in combination with high-resolution mass spectrometry, a technique that precisely identifies molecules in complex samples, to explore and identify unexpected or unknown contaminants in the body.

"Our results highlight – perhaps unsurprisingly – that populations are exposed to a complex cocktail of chemical residues, reflecting each individual's diet, environment and lifestyle," Bayen said.

He added that establishing baseline data is a necessary step toward reducing unwanted exposures.

The team also found that breast milk concentrations of certain chemicals, such as bisphenol A and bisphenol AF, were associated with altered growth among South African infants, highlighting potential adverse effects of exposure to breast milk contaminants. However, Jonathan Chevrier, Associate Professor of Epidemiology, cautions: "This is the first study of this type and so results need to be replicated before any conclusion can be drawn."

"Human milk is considered the gold standard for infant nutrition. It is therefore essential to understand everything infants are exposed to during this critical window of susceptibility in development," Chevrier said.

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https://technologynetworks.com

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

2026-12-25

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.

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https://sciencedaily.com

Low-platinum catalyst could make hydrogen production cheaper

2026-01-21

A new type of catalyst that uses five times less platinum than usual could help make hydrogen production more affordable in the future.

Hydrogen generated by splitting water molecules with electricity (electrolysis) has great potential as a plentiful and green energy source. But the materials needed to accelerate the chemical reaction don't come cheap: platinum alone currently costs about $85 per gram.

"The process is dependent on platinum, which is scarce and expensive," said Victor Mashindi, an electrochemist at the University of the Witwatersrand in Johannesburg, South Africa. "We wanted to find an alternative catalyst that doesn't use as much platinum."

Mashindi was part of an international team—involving researchers from South Africa, Brazil, Canada, and Germany—that developed the new catalyst. Their work was published in ACS Applied Energy Materials.

Previous research has shown that metals like nickel and cobalt provide some catalytic activity in electrolysis, though they are not as effective as platinum. So the team created a catalyst that replaces some of the platinum with nickel and cobalt and mounted it on tiny structures made of carbon (nanospheres), to hold the metals in place and maximize the surface area for the chemical reaction.

While a typical catalyst contains around 20% platinum by weight, the new version uses around five times less platinum—just 4% by weight—which represents big cost savings.

"The catalyst uses the same total amount of material, just with less platinum, to produce the same amount of hydrogen," said Mashindi, and performs just as well as more platinum-rich catalysts.

The team used the Canadian Light Source at the University of Saskatchewan to study how the various components of the new catalyst are arranged and how they interact.

"The data we obtained from the CLS helped us form a clearer understanding of the atomic structure of the catalyst," said Dean Barrett, a materials scientist at the University of the Witwatersrand, who led the work. "This information enabled us to fine-tune the material properties at the nanoscale towards the desired outcome of producing more hydrogen and using less platinum. We can only get that type of data by using a facility like the CLS."

While the new catalyst shows promise, the work is still at an early stage, said Barrett. The team has identified a local start-up company in South Africa they may work with to develop the idea further. "We work at the level of fundamental science," he said. "We need to make sure what works in the lab can be scaled up," he said.

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https://phys.org

This New Device Turns Carbon Emissions Into a Valuable Chemical

2026-01-21

This new technology turns everyday carbon emissions into a useful chemical—right at the source, even from thin air.

Exhaust gases released from home furnaces, fireplaces, and industrial facilities send carbon dioxide (CO_2) into the atmosphere, adding to climate pollution. Scientists reporting today (January 21) in ACS Energy Letters have developed a new type of electrode that can capture CO_2 from the air and immediately transform it into a useful chemical called formic acid. In laboratory tests, the system outperformed existing electrode designs when exposed to simulated flue gas and even when CO_2 levels matched those found in normal outdoor air.

"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 CO_2 utilization under realistic gas conditions," explains Wonyong Choi, a corresponding author on the study.

Why Converting CO2 Is So Challenging

Removing carbon dioxide from the air may sound straightforward — after all, plants do it every day. The real challenge comes afterward. Turning captured CO_2 into something useful is difficult, yet essential if carbon capture technologies are to be widely adopted. In real-world industrial exhaust, CO_2 is mixed with large amounts of other gases, including nitrogen and oxygen. Most existing conversion systems only work efficiently when CO_2 has already been purified and concentrated, which adds cost and complexity.

To overcome this limitation, Donglai Pan, Myoung Hwan Oh, Wonyong Choi, and their colleagues set out to create a system that could both capture and convert CO_2 under realistic conditions. Their goal was to make a device that functions directly with flue gas and remains effective even when carbon dioxide is present in small amounts.

A Three-Layer Electrode Design

The researchers designed an electrode that allows gas to flow through it, trap CO_2, and convert it at the same time. The device is built from three distinct layers: a material that selectively captures carbon dioxide, a sheet of gas-permeable carbon paper, and a catalytic layer made of tin(IV) oxide. Together, these components enable the direct conversion of CO_2 gas into formic acid.

Formic acid is a valuable chemical used in several applications, including fuel cells and other industrial processes. Producing it directly from exhaust gases could make carbon recycling far more practical.

Strong Performance Under Realistic Conditions

When tested with pure CO_2, the new electrode showed about 40% higher efficiency than existing carbon conversion electrodes under similar laboratory conditions. The difference became even more striking when the researchers switched to a simulated flue gas made up of 15% CO_2, 8% oxygen gas, and 77% nitrogen gas. Under those conditions, the new system continued producing significant amounts of formic acid, while other approaches produced almost none.

The electrode also worked at CO2 concentrations similar to those found in the atmosphere, showing that it can operate in ambient air. According to the researchers, this approach could make carbon capture more practical for industrial use. They also suggest that similar designs might one day be adapted to capture and convert other greenhouse gases, such as methane.

Sci Tech Daily, 21 January 2026

https://scitechdaily.com

A new crystal makes magnetism twist in surprising ways

2026-01-12

The findings, published in the Journal of the American Chemical Society, show that blending two materials with nearly identical chemical makeup but very different crystal structures can produce an entirely new structure. This unexpected hybrid crystal exhibits magnetic properties that do not appear in either of the original materials.

How Atomic Spins Create Magnetism

Magnetism begins at the atomic scale. In magnetic materials, each atom behaves like a tiny bar magnet because of a property called atomic spin. Spin can be pictured as a small arrow showing the direction of an atom's magnetic field.

When many atomic spins line up, either pointing the same way or in opposite directions, they generate the familiar magnetic forces used in everyday technologies like computers and smartphones. This type of orderly alignment is typical of conventional magnets.

The FSU team demonstrated that their new material behaves very differently. Instead of lining up neatly, the atomic spins organize into complex, repeating swirl patterns. These arrangements, known as spin textures, strongly influence how a material responds to magnetic fields.

Creating Magnetic Swirls Through Structural Frustration

To produce these unusual effects, the researchers intentionally combined two compounds that are chemically similar but structurally mismatched. Each compound has a different crystal symmetry, meaning the atoms are arranged in incompatible ways.

When these structures meet, neither arrangement can fully dominate. This instability at the boundary creates what scientists call structural "frustration," where the system cannot settle into a simple, stable pattern.

"We thought that maybe this structural frustration would translate into magnetic frustration," said co-author Michael Shatruk, a professor in the FSU Department of Chemistry and Biochemistry. "If the structures are in competition, maybe that will cause the spins to twist. Let's find some structures that are chemically very close but have different symmetries."

The team tested this idea by combining a compound made of manganese, cobalt, and germanium with another made of manganese, cobalt, and arsenic. Germanium and arsenic sit next to each other on the periodic table, making the compounds chemically similar but structurally distinct.

Once the mixture cooled and crystallized, the researchers examined the result and confirmed the presence of the swirling magnetic patterns they were aiming for. These cycloidal spin arrangements are known as skyrmion-like spin textures, which are a major focus of current research in physics and chemistry.

To map the magnetic structure in detail, the team used single-crystal neutron diffraction measurements collected on the TOPAZ instrument at the Spallation Neutron Source. This U.S. Department of Energy Office of Science user facility is located at Oak Ridge National Laboratory.

Why These Magnetic Patterns Matter

Materials that host skyrmion-like spin textures have several promising technological advantages. One potential use is in next-generation hard drives that store far more information in the same physical space.

Skyrmions can also be moved using very little energy, which could significantly reduce power demands in electronic devices. In large-scale computing systems with thousands of processors, even modest efficiency gains can translate into major savings on electricity and cooling.

The research may also help guide the development of fault-tolerant quantum computing systems. These systems are designed to protect delicate quantum information and continue operating reliably despite errors and noise -- the holy grail of quantum information processing.

"With single-crystal neutron diffraction data from TOPAZ and new data-reduction and machine-learning tools from our LDRD project, we can now solve very complex magnetic structures with much greater confidence," said Xiaoping Wang, a distinguished neutron scattering scientist at Oak Ridge National Laboratory. "That capability lets us move from simply finding unusual spin textures to intentionally designing and optimizing them for future information and quantum technologies."

Designing Materials Instead of Searching for Them

Much of the earlier work on skyrmions involved searching through known materials and testing them one by one to see whether the desired magnetic patterns appeared.

This study took a more deliberate approach. Rather than hunting for existing examples, the researchers designed a new material from the ground up, using structural frustration as a guiding principle to create specific magnetic behavior.

“It’s chemical thinking, because we’re thinking about how the balance between these structures affects them and the relation between them, and then how it might translate to the relation between atomic spins,” Shatruk said.

By understanding the underlying rules that govern these patterns, scientists may eventually be able to predict where complex spin textures will form before making the material.

“The idea is to be able to predict where these complex spin textures will appear,” said co-author Ian Campbell, a graduate student in Shatruk’s lab. “Traditionally, physicists will hunt for known materials that already exhibit the symmetry they’re seeking and measure their properties. But that limits the range of possibilities. We’re trying to develop a predictive ability to say, ‘If we add these two things together, we’ll form a completely new material with these desired properties.’”

This strategy could also make future technologies more practical by expanding the range of usable ingredients. That flexibility may allow researchers to grow crystals more easily, lower costs, and strengthen supply chains for advanced magnetic materials.

Research Experience at Oak Ridge National Laboratory

Campbell completed part of the research at Oak Ridge National Laboratory while supported by an FSU fellowship.

“That experience was instrumental for this research,” he said. “Being at Oak Ridge allowed me to build connections with the scientists there and use their expertise to help with some of the problems we had to solve to complete this study.”

Florida State University has been a sponsoring member of Oak Ridge Associated Universities since 1951 and is also a core university partner of the national laboratory. Through this partnership, FSU faculty members, postdoctoral researchers, and graduate students can access ORNL facilities and collaborate with laboratory scientists.

Collaboration and Funding

Additional co-authors on the study include YiXu Wang, Zachary P. Tener, Judith K. Clark, and Jacnel Graterol from the FSU Department of Chemistry and Biochemistry; Andrei Rogalev and Fabrice Wilhelm from the European Synchrotron Radiation Facility; Hu Zhang and Yi Long from the University of Science and Technology Beijing; Richard Dronskowski from RWTH Aachen University; and Xiaoping Wang from Oak Ridge National Laboratory.

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Science Daily, 12 January 2026

https://sciencedaily.com

Life on Earth May Have Started With a Frozen Poison

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Researchers are uncovering how a poisonous chemical could have helped life emerge.

A chemical that is deadly to humans may have contributed to the earliest steps toward life on Earth. Hydrogen cyanide can freeze into solid crystals at low temperatures. Computer modeling work reported in ACS Central Science shows that certain crystal surfaces are highly reactive, allowing chemical reactions to occur that normally would not happen in such cold conditions. Researchers suggest these reactions may have triggered a chain process that produced several of the fundamental building blocks of life.

“We may never know precisely how life began, but understanding how some of its ingredients take shape is within reach. Hydrogen cyanide is likely one source of this chemical complexity, and we show that it can react surprisingly quickly in cold places,” says Martin Rahm, the corresponding author of the study.

Hydrogen Cyanide in Space and Prebiotic Chemistry

Hydrogen cyanide is common in environments beyond Earth. It has been found on comets and in the atmospheres of planets and moons (e.g., Saturn's moon Titan). When hydrogen cyanide comes into contact with water, it can give rise to polymers, amino acids, and nucleobases (components of proteins and DNA strands, respectively). To better understand how this molecule behaves under frozen conditions, Marco Capelletti, Hilda Sandström and Martin Rahm used computer simulations to study solid hydrogen cyanide.

Simulating Crystal Shapes Seen in Nature

In the simulations, the team modeled a stable hydrogen cyanide crystal as a cylinder about 450 nanometers long. The structure included a rounded base and a top with multiple flat faces, similar in appearance to a cut gemstone. According to the researchers, this geometry matches earlier observations of crystal formations described as "cobwebs" that spread outward from a central point where the multifaceted ends meet.

Unexpected Chemical Activity in Extreme Cold

The calculations showed that these frozen crystals could promote chemical reactions that rarely occur in extremely cold environments. By analyzing the chemistry of the crystal surfaces, the researchers identified two reaction routes that could convert hydrogen cyanide into hydrogen isocyanide, a more reactive compound.

Depending on the temperature, this transformation could take place within minutes or over several days. The presence of hydrogen isocyanide on the crystal surface suggests that even more complex prebiotic precursors could form in these regions.

Next Steps Toward Experimental Tests

The researchers hope their predictions will be tested in laboratory experiments. One possible approach would involve crushing hydrogen cyanide crystals in the presence of substances like water. Exposing fresh crystal surfaces could reveal whether these surfaces truly encourage the formation of complex molecules at extremely low temperatures.

Sci Tech Daily, 21 January 2026

https://Scitechdaily.com

New material demonstrates ionic conductivity across three states

2026-01-20

For the first time, researchers have reported a new family of materials that maintains its conductivity in liquid, liquid crystal and solid states. Surprisingly, ions still swim swiftly across its crystalline structure with no decrease in speed. Such 'state-independent' ionic conductivity opens possibilities for safer solid-state batteries, as well as more efficient electronics.

The discovery was serendipitous, according to lead author Paul McGonigal from the University of Oxford, UK. 'We wanted to study how liquid crystals stack and create columns using structures with diffuse and symmetrical charge distributions,' he explains. To create the new material, a rigid aromatic cyclopropenium cation at the core is combined with flexible hydrocarbon sidechains, 'like a wheel with soft bristles'. This structure spreads the charge across the molecule, which allows ions to flow freely, even in the solid state. 'The disorder in the dendritic structure ensures the ions easily hop around,' says McGonigal.

While the conductivity of the liquid crystal structure is comparable to compounds in the literature, it still stays strong in the solid state. 'It's a breakthrough to observe [this] across three states of matter – liquid, liquid crystal and crystal,' says Amar Flood, an expert in self-assembly and supramolecular chemistry from the University of Indiana, US. Maybe most importantly, the mechanism is maintained too. 'It's remarkable, it appears to always occur in the same way,' he adds. Indeed, the team 'studied conductivity parallel and perpendicular to the liquid crystal assembly', to help decipher the behaviour of ions in the solid state, which is isotropic – the movement is similar in all directions.

'This study challenges the conventional expectation that conductivity comes from conformational freedom,' explains Alberto Concellón, an expert in liquid crystals at the Institute of Nanoscience and Materials of Aragón in Spain. It is an unusual behaviour, he says, because 'ionic conductivity in liquid crystals is generally … higher than in rigid solid electrolytes.' However, researchers realise 'the power of chemical design to control macroscopic properties … preserving liquid-like ion transport even in the solid state,' adds Concellón. 'It's a delicate balance between weak ion pairing, self-assembly and residual flexibility in the solid state.'

McGonigal says it's a start as, so far, the team only studied a small selection of sidechains, cationic cores and anions – chloride and bromide. Tweaking the structures could 'start collapsing the columns', he jokes, 'but also potentially improve the properties after a first spectacular result.'

Concellón agrees it's a great starting point: 'the study establishes clear molecular design principles to inspire the development of related systems beyond a single class of molecules'.

The importance of improving ionic conductivity in solids is key for applications in energy generation, storage and transportation, 'where the electrolyte plays a central role in ionic mobility and device lifetime', explains Concellón. In contrast to liquid electrolytes, solids don't leak', says Flood, which increases the simplicity and safety of systems. Liquids in lithium-ion batteries, for example, are a common cause of accidents. But besides better batteries, the versatility of organic solids opens opportunities in flexible and efficient electronics. 'We're working with a group in Japan at the moment to implement our materials to modify the performance of memory devices,' explains McGonigal. 'Because it's state independent, it's easy to apply the electrolyte as a liquid to ensure a homogeneous coating, which keeps the conductivity once solidified,' he adds. Now, the priority is improving conductivity and versatility, as well as expanding the new family of materials with similar structures.

Chemistry World, 20 January 2026

https://chemistryworld.com

A novel dual-chemical looping method for efficient ammonia synthesis

2026-01-21

Ammonia is an essential chemical used across many industries worldwide. Beyond its traditional role as a fertilizer, it is also a promising liquid hydrogen carrier and low-carbon fuel that could help reduce reliance on fossil fuels.

However, conventional ammonia production based on the Haber–Bosch (HB) process requires considerable energy and contributes significantly to greenhouse gas emissions, accounting for roughly 1–1.3% of global emissions annually. Given its growing importance, there is an urgent need to reduce the environmental burden of ammonia production.

Recently, chemical looping ammonia synthesis (CLAS) has emerged as a viable alternative method for ammonia production. Specifically, aluminum-oxide (Al2O3)-based chemical looping has shown promise for enabling ammonia synthesis under more energy-efficient conditions.

Building on this concept, a research team led by Assistant Professor Sunghyun Cho from the School of Chemical Engineering, School of Semiconductor and Chemical Engineering at Jeonbuk National University in South Korea, has developed a new dual-chemical looping process combining Al2O3 and iron oxide (Fe2O3).

"Our approach combines methane thermal decomposition with Al2O3- and Fe2O3-based chemical looping cycles," explains Dr. Cho. "This method enables ammonia synthesis without the energy-intensive steps, significantly improving both sustainability and efficiency."

Their study was published in Energy Conversion and Management.

The Al2O3-based chemical loop (A-CL) has two stages: nitrogen fixation and hydrolysis. During nitrogen fixation, Al2O3 comb ines with nitrogen and solid carbon to generate aluminum nitride (AlN). This is followed by hydrolysis, where AlN interacts with steam to produce ammonia.

In the proposed dual-looping process, A-CL is complemented by thermal decomposition of methane (TDM) and an Fe2O3-based chemical loop (F-CL).

TDM supplies solid carbon for A-CL, while F-CL provides nitrogen, eliminating the need for additional air separation units. Additionally, carbon monoxide generation within A-CL provides reusable feedstock for F-CL systems. Together, these interactions create a cross-linked circulation of key feedstock materials.

To test practical feasibility, the researchers then conducted a comprehensive energy, exergy, economic, and environmental (4E) analysis of 10 different process configurations, including the proposed dual-looping system and its modified variations, the conventional HB process, and both Al2O3-based and Fe2O3-based single-chemical looping systems.

Simulation results showed that the proposed configuration outperformed conventional production methods in both energy and exergy efficiencies by 8.4% and 19.0%, respectively. It reduced global warming potential by up to 15.85 kg of CO2-equivalent per kilogram of ammonia produced.

It also demonstrated the lowest production costs among all evaluated cases. Sensitivity analysis further confirmed its robustness under varying technoeconomic conditions. Notably, integrating heat exchangers significantly improved energy and exergy efficiencies of all configurations.

“Our dual-looping technology can be applied across industries that require large-scale ammonia production while reducing carbon emissions and maintaining economic feasibility,” concludes Dr. Cho.

“As the world moves toward cleaner energy systems, this process could support future clean-fuel applications and broader carbon-neutral energy-transition strategies.”

Phys Org, 21 January 2026

https://phys.org

Two unusual alkenes stretch the limits of molecular geometry

2026-01-21

Some people just really enjoy pushing molecules out of their comfort zones. Neil Garg and his team at the University of California, Los Angeles, proudly count themselves among those people. Their latest work, published in in Nature Chemistry, explores the chemistry of cubene and 1,7-quadricyclene, two molecules with extremely distorted double bonds (2026, DOI: 10.1038/s41557-025-02055-9).

It’s “pushing the limits of what geometric distortion looks like,” Garg says.

Cubene and quadricyclene are descended from cubane and quadricylane, both cage-shaped structures with bonds that are fairly distorted from typical alkane geometries, even without a double bond in the mix.

Both alkenes have been made before—quadricyclene debuted in 1979 and cubene in 1988—but nobody really did anything with them, Garg says. “They may have been a little bit ahead of their time.” Nowadays, rigid 3D structures such as cubane are highly desirable in drug discovery, making reactions to install them also desirable. And highly strained molecules are eager to undergo reactions to relieve their stress.

The bonds in cubene and quadricyclene aren’t twisted like the ones in the anti-Bredt olefins that Garg’s team described in an earlier study, but they’re even more bent. Where the bonds to a normal alkene carbon all lie in a flat plane, computational modeling predicts that the bond angles in these molecules are forced out of plane by over 30°.

This distortion severely weakens the bond and makes it much more reactive. The double bond in cubene has a bond order of 1.59 and the one in quadricyclene has a bond order of 1.55, well below the normal alkene bond order of 2. The estimated activation energy barrier for a cycloaddition reaction with anthracene is about half as high for cubene as it is for ethylene; the barrier for quadricyclane is even lower.

The molecules are too unstable to isolate, so the team used the same approach they used with the anti-Bredt olefin: generating the alkene from a silyl precursor and then trapping it through a cycloaddition reaction. Based on the products they got, the researchers inferred the fleeting presence of the strained intermediates.

By varying the cycloaddition partners, the researchers constructed a range of funky 3D structures. One of the molecules they made was a dimer they nicknamed “the Beast,” which they formed by linking a cubene trapping product to a quadricylene product.

Paul Wender, an organic and medicinal chemist at Stanford University who was not involved in the work, says that this paper “builds insightfully and innovatively on a foundation of previous and emerging studies” of how unconventional carbon-carbon bonds behave and how to use them in practical chemistry. “There’s lots to unpack, lots to exploit, lots to use.”

Physical organic chemist Alistair Sterling of the University of Texas at Dallas says the work is a great balance between fundamental science and real-world applications. It “really shows that fundamental physical organic chemistry is still alive and kicking, and we still need this type of research to make progress,” he says.

C&EN, 21 January 2026

https://cen.acs.org

CHEMWATCH

Bulletin Board

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JAN. 23, 2026

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