CHEMWATCH

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ASIA PACIFIC

~ Committee on Technical Barriers to Trade - Notification - Thailand - Young child food - Addendum

2025-04-03

Description: According to the Notification of the Ministry of Public Health on Young Child Food Specifically Subject to Ministerial Marketing Promotion Control B.E. 2567, issued under the authority of the definition of "young child food" as stipulated in the Act on the Marketing of Infant and Young Child Food Control B.E. 2560, this notification shall come into force three hundred sixty-five days after its publication in the Royal Gazette. To ensure clarity in complying with the said Ministerial Notification, the Explanation on the Implementation of the Notification of the Ministry of Public Health on Food for Young Children Specifically Designated by the Minister for Marketing Regulation B.E. 2567 (A.D. 2024) have been issued.

Under this Notification, food for young children must meet both of the following criteria:

1. Contains statements (where "statements" includes an act of causing an appearance through a letter, a figure, an artificial mark, an image, a cinematographic movie, a light, a sound, or a mark, or any act enabling persons in general to comprehend the meaning) indicating that the product is intended for feeding young children. This includes statements in any of the following forms:
2. Marketing communications that create an association with young children;
3. Displaying statements, names, or nutritional components that are suitable and sufficient for young children on labels or in marketing communications. For example, stating: "A specially formulated milk for young children, developed by Company A, contains ingredients ABC, suitable for children over twelve months old to support good nutrition for young children";

1.3 Presenting the nutritional value of food products for young children on labels or in marketing communications. For example, stating: "Packed with even more benefits while maintaining great taste, containing ingredients

ABC along with a variety of nutrients to support bright, healthy growth and age-appropriate development for young children"

Read More

WTO Center, 03-04-25

https://web.wtocenter.org.tw/Page/13317/410743

Australia List of evaluations in progress – updated 2 April 2025

2025-04-02

We've updated our Rolling Action Plan. We've published 18 draft evaluation statements which are now open for public comment. There are a total of 24 evaluations currently in progress. For each evaluation, we list the subject, reason and time period for completion (an estimated evaluation completion date).

View our Rolling Action Plan

Published date

2 April 2025

Read More

AICIS, 02-04-25

https://www.industrialchemicals.gov.au/news-and-notices/list-evaluations-progress-updated-2-april-2025

AMERICA

Some States Are Banning Forever Chemicals. Now Industry Is Fighting Back.

2025-04-10

In 2021, James Kenney and his husband were at a big box store buying a piece of furniture when the sales associate asked if they'd like to add fabric protectant. Kenney, the cabinet secretary of New Mexico's Environment Department, asked to see the product data sheet. Both he and his husband were shocked to see forever chemicals listed as ingredients in the protectant.

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"I think about your normal, everyday New Mexican who is trying to get by, make their furniture last a little longer, and they think, 'Oh, it's safe, great!' It's not safe," he says. "It just so happens that they tried to sell it to the environment secretary."

Last week, the New Mexico legislature passed a pair of bills that Kenney hopes will help protect consumers in his state. If signed by the governor, the legislation would eventually ban consumer products that have added PFAS—per- and polyfluorinated alkyl substances, known colloquially as "forever chemicals" because of their persistence in the environment—from being sold in New Mexico.

Read More

Mother Jones, 10-04-25

https://www.motherjones.com/politics/2025/04/state-regulations-bans-pfas-forever-chemicals-industry-lobbying-epa-trump/

How a ban on food dye in West Virginia has forged an unlikely alliance

2025-03-24

A West Virginia law signed this week bans synthetic dyes and preservatives in food – a first-in-the-nation consumer protection led by Republicans in the face of vociferous industry opposition.

West Virginia's law is one of dozens of bills introduced across the country, as Republican state lawmakers get on board with one of the most powerful forces to emerge from the 2024 presidential campaign – the movement to "make America healthy again" or Maha.

The result has been an explosive growth in proposed legislation to ban synthetic dyes, preservatives and chemicals in food packaging – chemicals that consumer advocates have railed against, in some cases, for decades.

"There's a growing bipartisan interest to ban this, and also a bipartisan frustration with how the [Food and Drug Administration] is working," said Jensen Jose, regulatory counsel for the non-profit group Center for Science in the Public Interest (CSPI).

"You're seeing more and more states looking into banning these chemicals," Jose said, adding the tidal wave of new legislation was "unprecedented". West Virginia's new law owes a debt to California, advocates said, which banned some of the same dyes from school meals

in 2024. The Biden administration followed in the waning days of the administration by banning Red Dye No 3.

Read More

The Guardian, 24-03-25

https://www.theguardian.com/us-news/2025/mar/30/west-virginia-food-dye-ban

EUROPE

Commission proposes flexibility to help manufacturers comply with 2025 CO2 emission targets for new cars and vans

2025-04-01

The European Commission proposed a targeted amendment to the Regulation setting CO2 emission performance standards for new cars and vans. The amendment introduces a flexibility measure with their CO2 targets between 2025 and 2027.

This proposal was announced as part of the Commission's Industrial Action Plan for the European automotive sector, adopted on 5 March 2025. This followed the Strategic Dialogue on the Future of the Automotive Industry launched by President von der Leyen on 30 January 2025 and involving an open public consultation and multiple discussions and engagement with industry leaders, social partners and stakeholders to address the most pressing challenges facing the sector.

President of the European Commission, Ursula von der Leyen, said: "Our highly innovative automotive industry is decarbonising to contribute to the fight against climate change, but also to maintain its competitive edge on the world markets. With today's initiative, we grant more flexibility to this key sector, and at the same time we stay the course of our climate goals. Together, we want to prove that decarbonisation and competitiveness can go hand in hand."

The proposed flexibility measure allows manufacturers' compliance with the CO2 targets for 2025, 2026 and 2027 to be assessed over the entire three-year period averaging their performance, rather than annually. This approach allows manufacturers to balance any excessive annual emissions by outperforming the target in the remaining year(s).

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This additional flexibility will help safeguard the industry's capacity to invest in the clean transition, while maintaining the 2025 target and keeping the industry on track for the next round of emissions reductions. The EU wide targets intend to make the EU's transport system more sustainable and put road transport on a firm path to zero-emission mobility in 2050.

The Commission calls on the co-legislators to reach an agreement on this amendment without delay to ensure predictability and certainty for the automotive industry and investors.

Read More

European Commission, 01-04-25

https://ec.europa.eu/commission/presscorner/detail/en/ip_25_854

UK Cosmetics Regulation Amendment Published (Contains Methyl Salicylate)

2025-04-01

On 1 April 2025, the Office for Product Safety and Standards (OPSS) published an amendment to the UK Cosmetics Regulations, updating Annex III to include the new restriction to methyl salicylate.

The Annex III entry for methyl salicylate is proposed as below:

- rinse-off skin and hair products (except hand wash products) at 0.02% (products intended for children 0.5-1 years), and at 0.06% (products intended for children above 1 year and adults);
- hand wash products at 0.02% (products intended for children 0.5-1 years), and at 0.6% (products intended for children above 1 year and adults);
- leave on skin products (except face make-up, spray/aerosol body lotion, spray/aerosol deodorant and hydroalcoholic-based fragrances) and hair products (non-aerosol) at 0.02% (products intended for children 0.5-1 years), and at 0.06% (products intended for children above 1 year and adults);
- lip products at 0.02% (products intended for children 0.5-1 years), and at 0.03% (products intended for children above 1 year and adults);
- face make-up products at 0.05%;
- eye make-up products and make-up remover at 0.002%;
- toothpaste at 2.5%;

- mouthwash at 0.1% (products intended for children 6 to 10 years), and at 0.4% (products intended for children above 10 years and adults);
- mouth spray at 0.65%;
- hydroalcoholic-based fragrances at 0.6%;
- deodorant spray/aerosol products 0.003%;
- hair products (spray/aerosol) at 0.009%
- body lotion spray at 0.04%.

The 'placing on the market' deadline is 30 September 2025; the 'making available' on the market (off-shelf) deadline is 31 March 2026.

Read More

ctpa, 01-04-25

https://www.ctpa.org.uk/news/uk-cosmetics-regulation-amendment-published-contains-methyl-salicylate-8292

SCCS Opinion on Benzophenone - 1 (CAS No. 131-56-6, EC No. 205-029-4)

2025-04-01

Conclusion of the opinion:

(1) In light of the data provided and taking under consideration the concerns related to potential endocrine disrupting properties of Benzophenone-1, does the SCCS consider Benzophenone-1 safe when used as a light stabilizer in cosmetic products up to a maximum concentration of 2%?

Having considered the data provided (including two new mutagenicity/genotoxicity studies submitted to ECHA as part of the REACH registration dossier), and the concerns relating to genotoxicity and potential endocrine disrupting properties, the SCCS considers Benzophenone-1 not safe when used as a light stabiliser in cosmetic products for the following reasons:

• The available data indicate genotoxicity potential of Benzophenone-1.

• The evidence assessed by the SCCS also shows that Benzophenone-1 is an endocrine-active substance due to clear demonstration of estrogenic activity and weak anti-androgenic activity both in vitro and in vivo, and potential activity against thyroid modality in vitro.

A new (2023) OECD TG 422 study relating to ED effects submitted to ECHA as part of the REACH registration dossier has not been assessed by the

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SCCS at this stage because of the remaining concerns over genotoxicity of Benzophenone-1. The SCCS will be ready to assess the evidence in support of the safe use of Benzophenone-1 in cosmetic products when received in a new mandate.

(2) Alternatively, what is according to the SCCS the maximum concentration considered safe for use of Benzophenone-1 in cosmetic products?

Read More

https://health.ec.europa.eu/publications/sccs-opinion-benzophenone-1-cas-no-131-56-6-ec-no-205-029-4_en

Danish EPA Studies on Chemicals in Consumer Products is Open for Comments

2025-02-19

Each year, the Danish Environmental Protection Agency (EPA) conducts studies on chemicals in selected consumer products to assess potential health or environmental risks. Consultants are invited to submit bids for three specific projects by 14 March 2025:

1. Mapping and Risk Assessment of Glue for Beauty Products

The project investigates the ingredients in adhesives used in beauty products like artificial lashes, nails, and wigs, particularly focusing on their regulation.

2. Preservatives in Detergents

This project will assess the prevalence and safety of preservatives in detergents, investigating potential allergenic or other harmful effects like skin and respiratory irritation.

3. Chemicals in Children's Fashion from Online Stores

The study will explore the occurrence of illegal or harmful chemicals in children's fashion items (textiles and jewelry) from various online sources, including large marketplaces and EU dropshipping stores. The findings will contribute to the European enforcement project, REF-13.

Read More

Freyr, 19-02-25

https://www.freyrsolutions.com/chemicals-industry-news/danish-epa-studies-on-chemicals-in-consumer-products-is-open-for-comments

Animals still suffer and die in the name of beauty. Why?

2025-04-10

Cruelty Free Europe responds to the European Commission ahead of an-assessment of the Cosmetics Product Regulation. 12 years after it supposedly banned animal testing for cosmetics, it's now clear that it is not fit for purpose.

The sale of cosmetics tested on animals has been banned in the EU for 12 years. But the Cosmetics Product Regulation (CPR), through which the bans were introduced, is currently not fit for purpose.

Cosmetics ingredients are still being tested on animals, partly because of the way that the EU's main chemicals law REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) has been implemented alongside the CPR.

Animals continue to suffer and die in the name of beauty, to gauge the safety of ingredients which can be used in cosmetics and personal care products, such as make-up, shampoo, moisturiser, soap, perfume and toothpaste. Bringing just one new cosmetics ingredient onto the market could potentially involve the death of at least 1,200 animals.

Read More

Euractiv, 10-04-25

https://www.euractiv.com/section/agriculture-food/opinion/animals-still-suffer-and-die-in-the-name-of-beauty-why/

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INTERNATIONAL

Standard will provide broad knowledge of activated carbon usage

2025-03-28

ASTM International's activated carbon committee (D28) is developing a proposed standard that will address flue gas applications after the release of mercury and air toxics standards (MATS) regulations.

ASTM member Christine Valcarce says that the proposed standard (WK67359) will be used to educate power utilities on aspects of an activated carbon bid and their significance to the energy industry.

"Many activated carbon specifications are aimed at the water treatment industry, and it is important that power plants understand their meaning and contribution to quality control or performance before adopting them for their industry," says Valcarce.

Valcarce adds that the proposed guide will provide some broad knowledge about activated carbon to an industry in which integration of the technology is relatively new.

Read More

ASTM, 28-03-25

https://www.astm.org/news/activated-carbon-addressed-in-proposed-standard

Unsustainable fashion and textiles in focus for International Day of Zero Waste 2025

2025-03-27

Ahead of the International Day of Zero Waste 2025, events in Nairobi, New York and across the world have shone a spotlight on waste in the fashion and textiles industry, highlighting the environmental and social challenges of overproduction and overconsumption caused by the sector's linear business model.

The International Day of Zero Waste—officially observed on 30 March each year—was the focus of a high-level event on 27 March at the UN General Assembly Hall in New York, as well as an event at the UN Environment Programme (UNEP) and the UN Human Settlements Programme (UN-Habitat) headquarters in Nairobi, Kenya, on the same day.

Every year, 92 million tonnes of textile waste is produced globally. Production doubled from 2000 to 2015, while the duration of garment use decreased by 36 per cent. Eleven per cent of plastic waste comes from clothing and textiles, with only 8 per cent of textiles fibres in 2023 made from recycled sources.

Discarded clothing often ends up in low-income countries, where lack of waste management infrastructure leads to dumping, burning, and severe environmental and social consequences. Additionally, textile and fashion waste in cities often end up in landfills, where it takes decades to decompose and releases harmful greenhouse gases. A zero-waste approach is key to the required transition to more circular approaches.

"Unsustainable fashion is aggravating the triple planetary crisis of climate change, nature, land and biodiversity loss, and pollution and waste," said Inger Andersen, Executive Director of UNEP. "We need to focus on a circular economy approach that values sustainable production, reuse and repair. By working together, consumers, industry and governments can support genuinely durable fashion and help reduce our fashion footprint."

Read More

UNEP, 27-03-25

https://www.unep.org/news-and-stories/press-release/unsustainable-fashion-and-textiles-focus-international-day-zero

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Fragrance industry calls for a balanced REACH revision to support innovation and competitiveness, while safeguarding high safety standards

2025-04-01

As the EU prepares to revise its REACH regulation, the fragrance industry is calling for a smarter and balanced approach that maintains high safety standards while supporting innovation and industrial resilience.

In a new position paper, the International Fragrance Association (IFRA) outlines practical recommendations to improve the workability and scientific basis of REACH, while avoiding disproportionate compliance burdens – for all companies including SMEs.

"Our sector depends on a clear, proportionate regulatory framework to continue delivering safe ingredients that make a wide range of consumer products possible - supporting everyday habits and addressing essential needs, particularly in terms of hygiene, well-being, and quality of life" said Alexander Mohr PhD, President of IFRA. "REACH must remain practical, enforceable and science-based, preserving a risk-based approach. The stakes are high—not only for our industry, but for Europe's role as a hub for innovation, manufacturing and global competitiveness."

The fragrance industry supplies ingredients for over 500,000 everyday products and includes more than 750 SMEs, responsible for a large portion of economic activity. Fragrance ingredients are used in low concentrations, leading to minimal consumer exposure while delivering essential olfactory and functional benefits.

Key IFRA recommendations include:

Make rules clearer and more coordinated, improving the dialogue with EU authorities.

Ensure proportionate rules, to support competitiveness.

Preserve a balanced risk management system, ensuring that regulatory measures are proportionate to the actual exposure to humans and the environment.

Ensure scientific rigor in assessing the combined exposure to multiple chemical substances, avoiding a blanket Mixture Assessment Factor (MAF)

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Accelerate the regulatory acceptance and use of New Approach Methodologies (NAMs) and Next Generation Risk Assessments (NGRAs) to reduce animal testing.

Streamline REACH implementation to reduce compliance costs, improve digital systems and ensure effective enforcement.

Read More

IFRA, 01-04-25

https://ifrafragrance.org/docs/default-source/position-papers/ifra-position-paper-reach-revision-1-april-2025.pdf

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Janet's Corner

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I expect a "reaction" from you all

2025-04-18

SCIENTIST: I just boiled water

ME: solid

SCIENTIST: no

ME: I just mean that's cool

SCIENTIST: WRONG AGAIN

https://x.com/memescentrai/status/1231685655907971073

Chloroprene

2025-04-18

USES [2,3]

The only commercial use identified for chloroprene is as a monomer in the production of the elastomer polychloroprene (neoprene), a synthetic rubber used in the production of automotive and mechanical rubber goods, adhesives, caulks, flame-resistant cushioning, construction materials, fabric coatings, fibre binding, and footwear. Other uses of this polymer include applications requiring chemical, oil, or weather resistance or high gum strength. The United States Food and Drug Administration permits the use of chloroprene as a component of adhesives used in food packaging and also permits the use of polychloroprene in products intended for use with food.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

Workers may be occupationally exposed to chloroprene by inhalation or dermal exposure.

The release of chloroprene to the environment may occur during its manufacture, transport, and storage and during the manufacture of polychloroprene elastomers and polychloroprene-containing products.

Routes of Exposure

The routes of human exposure to chloroprene are:

- Inhalation;
- Ingestion; and
- Dermal contact.

HEALTH EFFECTS [4]

Acute Health Effects

- Symptoms reported from acute human exposure to high concentrations of chloroprene include giddiness, headache, irritability, dizziness, insomnia, fatigue, respiratory irritation, cardiac palpitations, chest pains, nausea, gastrointestinal disorders, dermatitis, temporary hair loss, conjunctivitis, and corneal necrosis.

Chloroprene is the common name for the organic compound 2-chlorobuta-1,3-diene, which has the chemical formula C4H5Cl. [1] It is a halogenated alkene that exists at room temperature as a clear colourless liquid with a pungent ether-like odour. Chloroprene is practically insoluble in water, soluble in alcohol, and miscible with acetone, benzene, and ethyl ether. It is highly flammable and polymerises on standing, making it unstable in the environment. [1,2]

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- Acute exposure may damage the liver, kidneys, and lungs; affect the circulatory system and immune system; depress the central nervous system (CNS); irritate the skin and mucous membranes; and cause dermatitis and respiratory difficulties in humans.
- High level exposures have affected the liver, lungs, kidneys and CNS in animals exposed by inhalation, gavage, or injection.
- Acute oral exposure of rats caused inflammation of the mucous membranes; damage to the lungs, liver, spleen, and kidneys; and irritation of the gastrointestinal tract.
- Acute animal tests in rats and mice, have demonstrated chloroprene to have moderate acute toxicity by inhalation and high acute toxicity from ingestion.

Carcinogenicity

- Epidemiological studies of rubber workers in the Soviet Union have indicated a possible association between exposure to chloroprene and skin and lung cancer. However, levels of exposure causing symptoms have not been well defined and these studies have major methodological deficiencies. An increased incidence of lung cancer was not reported in another study of American workers occupationally exposed to chloroprene during the manufacture of neoprene.
- An inhalation bioassay by the NTP showed clear evidence of carcinogenic activity in both rats and mice, based on increased incidences of neoplasms of the oral cavity, thyroid gland, lung, kidney, liver, skin, mammary glands, and other organs.
- EPA has classified chloroprene as a Group D, not classifiable as to human carcinogenicity, because of the absence of adequate data.
- The International Agency for Research on Cancer (IARC) has classified chloroprene as a Group 2B, possibly carcinogenic to humans.

Other Effects

- Symptoms of chronic exposure in workers were fatigue, chest pains, giddiness, irritability, dermatitis, and hair loss.
- One study has suggested that chronic exposure of humans to chloroprene vapour associated with neoprene production may contribute to liver function abnormalities. Disorders of the cardiovascular system and depression of the immune system have also been observed in workers chronically exposed to chloroprene.
- Eye irritation, nasal discharge, olfactory epithelial degeneration, restlessness, lethargy, hair loss, growth retardation, and effects to the

liver, kidney, thyroid, blood, and lungs have been observed in rodents following chronic inhalation exposure.
- EPA has calculated a provisional Reference Concentration (RfC) of 0.007 milligrams per cubic metre (mg/m3) for chloroprene based on respiratory effects in rats.
- EPA has calculated a provisional Reference Dose (RfD) of 0.02 milligrams per kilogram body weight per day (mg/kg/d) for chloroprene.

SAFETY

First Aid Measures [5]

- Local exhaust ventilation may be necessary to control air contaminants from hot processing. The use of local ventilation is recommended to control emissions near the source.
- Provide mechanical ventilation for confined spaces.
- Facilities storing or utilising this material should be equipped with an eyewash facility and a safety shower.

Personal Protective Equipment [5]

The following personal protective equipment is recommended when handling chloroprene:

- **Eye/Face Protection:** In the heating process, wear safety glasses when possibility exists for eye and face contact due to splashing or spraying of molten material. Have eye-wash stations available where eye contact can occur.
- **Skin Protection:** Wear gloves impervious to the heating conditions of use. Additional protection may be necessary to prevent skin contact including use of face shield, boots or full body protection. A safety shower should be located in the work area.
- **Respirators:** In the heating process, air purifying respirator with an organic vapour cartridge with a dust/mist filter may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits.
- **Protective Clothing:** If there is potential contact with hot/molten material, wear heat resistant clothing and footwear.

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REGULATION

United States

OSHA: The Occupational Safety & Health Administration has set the following Permissible Exposure Limits (PEL)for chloroprene:

- General Industry:29 CFR 1910.1000 Z-1 Table-- 25 ppm, 90 mg/m3 TWA; Skin
- Construction Industry:29 CFR 1926.55 Appendix A -- 25 ppm, 90 mg/m3 TWA; Skin
- Maritime: 29 CFR 1915.1000 Table Z-Shipyards -- 25 ppm, 90 mg/m3 TWA; Skin

ACGIH: The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (TLV) for chloroprene of 10 ppm, 36 mg/m3 TWA; Skin

NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for chloroprene of 1 ppm, 3.6 mg/m3 Ceiling (15 minutes); Appendix A - NIOSH Potential Occupational Carcinogens

REFERENCES

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3. http://www.epa.gov/ttn/atw/hlthef/chloropr.html
4. http://dhard.ucp-is.com/docs/Regulatory/MSDS/MSDS.SN.grades.en.pdf
5. https://www.osha.gov/dts/chemicalsampling/data/CH_228000.html
6. http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/772/Workplace-exposure-standards-airborne-contaminants.pdf

Laughing Gas Could Help Combat Treatment-Resistant Depression

2025-10-04

Nitrous oxide—better known as "laughing gas"—can potentially transform treatment for tough-to-beat depression. This centuries-old anesthetic gas targeted specific brain cells in mice and quickly reduced symptoms, according to new research from the Perelman School of Medicine at the University of Pennsylvania, reported today in Nature Communications.

"Nitrous oxide is the oldest anesthetic we've got—it's been used worldwide for over 180 years, costs about $20 a tank, and yet we're still learning what it can do," said Joseph Cichon, MD, PhD, an assistant professor of Anesthesiology and Critical Care. "I felt like Indiana Jones, going back in time to crack the mystery of this ancient drug."

Discovering the hidden mechanism

First discovered for its gidy, mood-lifting effects (hence the nickname "laughing gas"), nitrous oxide was a go-to anesthetic in the 19th century. For years, it was widely understood to work by blocking certain receptors (called NMDA receptors) which are in nearly all brain cells and are known to play a big role in how brain cells communicate, especially in managing pain.

Cichon's team, however, found something different; After hundreds of experiments and a process of elimination, they zeroed in on a group of brain cells called layer 5 neurons, which lie deep in the grey matter of the brain, in an area called the cingulate cortex helping regulate emotions and behavior. "We were trying to unlock the secrets of these layer 5 neurons," Cichon said. "This wasn't part of the old assumptions about nitrous oxide—and it's turning what we thought we knew upside down."

How it works: A brain wake-up call

The Penn team, working with researchers from the University of Chicago and Washington University in St. Louis, tested nitrous oxide on mice who were exposed to stressful conditions. After breathing the gas for an hour through masks, the mice's L5 neurons, sprang to life within minutes. "Most anesthetics calm the brain, then the effects of the anesthetic fade away," Cichon explained. "But this one flips a switch-- those cells start firing like crazy, and they keep going even after the gas is gone. That was a total surprise."

The mice quickly showed signs of feeling better, moving more and sipping sweet water, a mouse version of enjoying life. These effects lasted hours,

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and sometimes a full day. There are pores in brain cells (L5 neurons), called potassium channels or SK2 channels, that allow potassium ions to flow out of the cells and "calm" them. The nitrous gas blocks those channels, revving the cells up and waking nearby cells too. Blocking these SK2 channels keeps the brain cells buzzing, which quickly lifts mood—a new way for laughing gas to fight depression. Unlike the old NMDA theory, this is a fresh mechanism that could explain why nitrous oxide helps people with depression that resists other treatments.

Fast and full of potential

About one in three people with depression don't respond to typical antidepression medications, which can take weeks to kick in—if they work at all. Nitrous oxide acts fast and lingers longer than its five-minute stay in the body would suggest. Human trials led by Peter Nagele, MD, a Professor at the University of Chicago, and Charles Zorumski, MD, a Professor at University of Washington in St. Louis, both authors on the study, have already shown it can ease symptoms rapidly in people with treatment-resistant depression.

The catch? It's not a pill that can be taken at home. A person must make an appointment and travel to see a medical professional who is trained to administer the gas with anti-depressant dosage. Possible side effects include feeling claustrophobic from the mask and nausea from the gas. But looking ahead, Cichon sees bigger possibilities: "If we can figure out how to tweak those potassium channels directly in the brain, scientists might be able to develop new depression drugs inspired by this gas."

Digging deeper into the past for the future

This discovery isn't just about nitrous oxide—it's about learning from a drug that was thought to be fully understood. "We use it every day around the world, yet it still has secrets to share," Cichon said.

Next steps include determining how long the mood boost could last in mice and whether nitrous oxide could help rewire the brain for lasting relief. If confirmed, a drug in use for over 180 years could bring renewed hope to those struggling with depression.

Technology Networks, 4 April 2025

https://technologynetworks.com

Electricity from rainwater: New method shows promise

2025-04-16

Tiny drops of water might not seem like powerhouse energy producers, but a new method shows how simple tubes might be able to turn falling rain into an energy source. In tests, the method was able to power up 12 LED lights.

When it comes to generating clean energy from water, hydroelectric would certainly be the first thing to come to mind. But the issue with utility-level turbines is that they need large flows of water to operate, so their installation locations are limited. Wave energy is steadily coming on board as well, but again, that type of power generation is very site specific.

But there's another type of water that blankets nearly all of our planet at one time or another: raindrops. And now researchers from the National University of Singapore have shown that there might be a way to generate power just by channeling the drops a certain way.

"Water that falls through a vertical tube generates a substantial amount of electricity by using a specific pattern of water flow: plug flow," says Siowling Soh, the corresponding author of the new study. "This plug flow pattern could allow rain energy to be harvested for generating clean and renewable electricity."

The pattern Soh references was established through a rainwater simulating device in the team's lab. The researchers created a tower topped with a metallic needle that allowed rain-sized drops of water to drip out. Beneath this, they placed a 32-cm-tall tube (12-in) with a diameter of 2 mm (0.07 in). The tube was made out of an electrically conductive polymer. When the drops slammed into the top of this tube, they were broken into pieces that had air in between each – a pattern known as plug flow.

As the air and water traveled down the tubes, electrical charges in the water separated, and wires attached to the top of the tube and a collection cup beneath it harvested the resulting electricity. The plug-flow system was five times more effective than one tested with a steady flow of water. It was ultimately able to convert about 10% of the energy from the falling water into electricity.

Further testing showed that using two tubes doubled electrical production, enough to power 12 LEDs continuously for 20 seconds. While that's no Hoover Dam, the researchers believe that their system could

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eventually be installed in bulk in areas like urban rooftops where they could contribute to a building's overall clean energy supply. They also say that the droplets flowing through their system worked at a much slower rate than actual rainfall, so the system should work just as well – or better – in actual outdoor conditions.

The research has been published in the journal ACS Central Science.

New Atlas, 16 April 2025

https://newatlas.com

Glowing gunshot residue: New method illuminates crime scene clues

2025-04-16

Crime scene investigation may soon become significantly more accurate and efficient thanks to a new method for detecting gunshot residues. Researchers from the groups of Wim Noorduin (AMOLF/University of Amsterdam) and Arian van Asten (University of Amsterdam) developed the technique that converts lead particles found in gunshot residue into light-emitting semiconductors. This method is faster, more sensitive, and easier to use than current alternatives.

Forensic experts at the Amsterdam police force are already testing it in actual crime scene investigations. The researchers published their findings in Forensic Science International on March 9.

Gunshot residue clues

The innovative light-emitting lead analysis method offers exciting opportunities for crime scene investigations. When a weapon is fired, it leaves gunshot residue containing lead traces on the surrounding environment, including clothing and skin.

Bente van Kralingen, a forensic expert at the Amsterdam Police, explains, "Obtaining an indication of gunshot residue at the crime scene is a major advantage, helping us answer key questions about shooting incidents. For instance, determining whether the damage found could have been caused by a bullet and determining the relative position of a person who might have been involved in a shooting incident. We test for lead traces on possible bullet holes and a suspect's or a victim's clothing or hands."

Currently, police send all samples to the lab for analysis. However, the methods used there are often time-consuming, labor-intensive, and

require expensive equipment. "We're excited about the tests we're conducting, and hopefully this will allow us to use the light-emitting method soon in actual court cases as evidence," says van Kralingen.

Semiconductor technology

The new analysis method builds on recent advances in perovskite research. Perovskites are a promising material used in applications ranging from solar cells to LEDs. A few years ago, the research group of Wim Noorduin developed an easy-to-use lead detection method based on perovskite technology.

In this method, a reagent converts lead-containing surfaces into a perovskite semiconductor. Shining with a UV lamp will make the newly formed semiconductor emit a bright green glow visible to the naked eye—making even small traces of lead easily detectable.

In 2021, Noorduin and Lukas Helmbrecht (formerly Ph.D. student in the group) established a start-up company to develop this lead testing method into a practical lead detection kit: Lumetallix. Over the past years, many people worldwide have been investigating their surroundings using the Lumetallix test kit. They report positive tests in all sorts of objects, for example: dinner plates, beer glasses, but also in paint dust at construction sites.

Helmbrecht developed an altered version of the Lumetallix reagent for the forensic application: one that reacts especially well with lead atoms in gunshot residue and produces a long-lasting green glow.

At the shooting range

To validate the effectiveness of this method, the researchers conducted a series of controlled experiments. Ph.D. students Kendra Adelberg and Arno van der Weijden (AMOLF/UvA) visited a shooting range in Amsterdam. Adelberg states, "We used standard 9 mm full metal jacket bullets and fired them from two different pistols at cotton cloth targets placed at various distances.

"After applying the reagent, we visualized the gunshot residue patterns. The results revealed well-defined luminescent patterns that were clearly visible to the naked eye, even at extended distances."

During their experiments, Adelberg and her colleagues made two other remarkable discoveries. First, unlike other methods, the new light-emitting technique remains effective even after extensive washing of the shooter's

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hands. This is important for forensic investigations, as suspects often try to tamper with or remove evidence of their involvement.

Second, bystanders standing approximately 2 meters away from the shooter also tested positive for lead traces on their hands. "These findings provide valuable pieces of the puzzle when reconstructing a shooting incident. But, a positive test also needs to be carefully interpreted. It does not automatically mean that you fired a gun," says Adelberg.

Who will benefit?

The researchers believe this new method will be especially beneficial to first responders, such as police officers, who can use it to rapidly screen potential suspects and witnesses to secure crucial evidence.

Beyond forensic applications, the team is also exploring the potential of this light-emitting method to detect lead contamination in environmental samples such as water and soil. Since lead is toxic and harmful to the environment, this research could have broader implications for environmental monitoring and public health.

Phys Org, 16 April 2025

https://phys.org

Scientists Turn Discarded Wood Waste Into Valuable Chemicals

2025-04-14

A new enzyme can turn lignin waste into valuable chemicals using green, hydrogen peroxide-based processing, offering a cleaner, sustainable alternative to petroleum-based methods.

Approximately 98% of lignin, a by-product of forestry derived from plants, is currently discarded. However, a newly discovered enzyme may enable the efficient extraction of valuable molecules from this waste using environmentally friendly, green chemistry methods.

These extracted molecules serve as the building blocks for products such as fragrances, flavorings, fuels, and pharmaceuticals, transforming a largely unused waste stream into a valuable resource.

"Traditional chemical processes for the synthesis of these types of chemicals rely on petroleum-based starting compounds and heavy metal catalysts, making them non-renewable and inherently toxic processes,"

says Dr Fiona Whelan, a Cryo-electron Microscopist from Adelaide Microscopy at the University of Adelaide, whose study was published in Nature Communications.

"This new catalytic processing method will support the development of other new green chemistry 'enzyme factories' or biorefineries to turn the lignin and other biological waste streams into a valuable repository of fine chemicals."

Understanding Lignin and Its Potential

Lignin is the name given to the hard polymers that act as mechanical support in hard- and softwoods and is one of the most abundant polymers on Earth.

Agriculture and forestry amass around 100 million tonnes of waste lignin per year, but this could be diverted to become a promising renewable and sustainable feedstock for chemicals currently obtained from fossil fuels.

"Strategies for using lignin involve a combination of chemical and biological processes," says Associate Professor Stephen Bell, from the University's School of Physics, Chemistry and Earth Sciences.

"High temperatures, high pressure, strong acids, and poisonous solvents are used to break up the polymers in the waste stream.

"The valuable compounds trapped in the waste are then extracted and undergo further chemical processing at temperatures higher than 400°C to 'valorize' the lignin. These processes are expensive and bad for the environment."

A Biological Breakthrough

Hardwood lignin has two key chemical components that require processing to make useful compounds.

Researchers had previously discovered an enzyme that could be used to break down one of these compounds, which is also found in softwood, but no biological breakdown process had been identified that could use the second more complex hardwood compound, comprising about 50 percent of the waste.

"Biological breakdown of lignin occurs in a complex microbial quorum, with fungal enzymes likely breaking up hard polymers, and bacteria taking the unreactive smaller compounds and processing them to get metabolic energy," said Dr Whelan.

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"Looking to the microbial kingdom, we identified that a soil bacterium, Amycolatopsis thermoflava, contains enzymes that could process molecules from lignin cheaply, using hydrogen peroxide to drive the reaction – making valorization much less harmful to the environment."

The research team has used this new enzyme as a model for retrofitting the hydrogen peroxide driven activity into other enzymes to generate green chemistry approaches of the future for the generation of high-value chemicals of use in the flavor, fragrance, and medicinal chemistry industries.

Sci Tech Daily, 14 April 2025

https://scitechdaily.com

Engineers develop eco-friendly plastic from mineral found in seashells

2025-04-16

According to UNESCO, plastic waste makes up 80% of all marine pollution, with 8–10 million metric tons of plastic making its way into our oceans each year. USC Viterbi School of Engineering researchers have discovered a mineral commonly found in seashells could be the key to a safer plastic alternative.

The research is led by Eun Ji Chung, the Dr. Karl Jacob Jr. and Karl Jacob III Early-Career Chair at USC Viterbi School of Engineering and a leading expert in engineered nanoparticles for clinical applications. Chung has a background in biomaterials, and her lab recently developed a new biocompatible plastic alternative by adding calcium carbonate from seashells into poly (1,8-octanediol-co-citrate) (POC), an FDA-approved biodegradable material used in orthopedic fixation devices. The research is published in MRS Communications.

Chung began to revisit work she had done as a graduate research student, where she worked on a biodegradable polymer made of citric acid, which is found in oranges. The research from this work was geared towards creating polymers for biomedical applications for sutures and tendon fixation devices.

"In graduate school, we added hydroxyapatite, which are these calcium particles that are in your bone, and I fabricated them together, and they are now biodegradable materials that are already FDA-approved," said Chung.

"I started thinking that seashells have calcium, too. That's why they're stiff like bone. But they have a different kind of calcium particle. So, I basically adapted what I did and replicated it to be more suitable for an alternative plastic material."

Chung said the citric acid polymer's texture is sticky, like a gum. When the calcium particles are added and it is heated and cured in an oven, it forms a plastic-like material. The resulting material, POC-CC, was developed into a prototype and cut into the formation of soda can beverage holder rings that were robust enough to hold cans.

The team hypothesized that the POC-CC material would be a biocompatible plastic substitute that could degrade in marine environments while maintaining sufficient strength for industrial applications.

To test this, POC-CC was synthesized with varying concentrations of calcium carbonate. Over six months, they observed various factors including the weight degradation rate in ocean water and the effect the material had on the pH of the water after long-term incubation.

"Our results show the degradation rate increases with increased POC content, and the addition of CC maintains the pH of ocean water," Chung said.

Another benefit of the material is its biocompatibility—it doesn't cause harm to marine life in the way that introduced microplastics do. The research team incubated a type of green algae (Scenedesmus sp.) alongside the POC-CC material, housing them in simulated ocean water for six months. The team noted high cell viability, confirming the fact that the POC-CC plastic substitute was biocompatible with marine microorganisms.

Chung and her team are now planning an improved second-generation version of the material to help it degrade faster.

Chung added that the material had many potential applications, such as in the production of biodegradable straws that were stronger than bamboo or paper straws and safer than reusable metal ones.

Phys Org, 16 April 2025

https://phys.org

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Making desalination more eco-friendly: New membranes could help eliminate brine waste

2025-04-15

Desalination plants, a major and growing source of freshwater in dry regions, could produce less harmful waste using electricity and new membranes made at the University of Michigan.

The membranes could help desalination plants minimize or eliminate brine waste produced as a byproduct of turning seawater into drinking water. Today, liquid brine waste is stored in ponds until the water evaporates, leaving behind solid salt or a concentrated brine that can be further processed. But brine needs time to evaporate, providing ample opportunities to contaminate groundwater.

Space is also an issue. For every liter of drinking water produced at the typical desalination plant, 1.5 liters of brine are produced. Over 37 billion gallons of brine waste is produced globally every day, according to a UN study. When space for evaporation ponds is lacking, desalination plants inject the brine underground or dump it into the ocean. Rising salt levels near desalination plants can harm marine ecosystems.

"There's a big push in the desalination industry for a better solution," said Jovan Kamcev, U-M assistant professor of chemical engineering and the corresponding author of the study published today in Nature Chemical Engineering. "Our technology could help desalination plants be more sustainable by reducing waste while using less energy."

To eliminate brine waste, desalination engineers would like to concentrate the salt such that it can be easily crystallized in industrial vats rather than ponds that can occupy over a hundred acres. The separated water could be used for drinking or agriculture, while the solid salt could then be harvested for useful products. Seawater not only contains sodium chloride -- or table salt -- but valuable metals such as lithium for batteries, magnesium for lightweight alloys and potassium for fertilizer.

Desalination plants can concentrate brines by heating and evaporating the water, which is very energy intensive, or with reverse osmosis, which only works at relatively low salinity. Electrodialysis is a promising alternative because it works at high salt concentrations and requires relatively little energy. The process uses electricity to concentrate salt, which exists in water as charged atoms and molecules called ions.

Here's how the process works. Water flows into many channels separated by membranes, and each membrane has the opposite electrical charge of its neighbors. The entire stream is flanked by a pair of electrodes. The positive salt ions move toward the negatively charged electrode, and are stopped by a positively charged membrane. Negative ions move toward the positive electrode, stopped by a negative membrane. This creates two types of channels -- one that both positive and negative ions leave and another that the ions enter, resulting in streams of purified water and concentrated brine.

But, electrodialysis has its own salinity limits. As the salt concentrations rise, ions start to leak through electrodialysis membranes. While leak-resistant membranes exist on the market, they tend to transport ions too slowly, making the power requirements impractical for brines more than six times saltier than average seawater.

The researchers overcome this limit by packing a record number of charged molecules into the membrane, increasing their ion-repelling power and their conductivity -- meaning they can move more salt with less power. With their chemistry, the researchers can produce membranes that are ten times more conductive than relatively leak-proof membranes on the market today.

The dense charge ordinarily attracts a lot of water molecules, which limits how much charge can fit in conventional electrodialysis membranes. The membranes swell as they absorb water, and the charge is diluted. In the new membranes, connectors made of carbon prevent swelling by locking the charged molecules together.

The level of restriction can be changed to control the leakiness and the conductivity of the membranes. Allowing some level of leakiness can push the conductivity beyond today's commercially available membranes. The researchers hope the membrane's customizability will help it take off.

"Each membrane isn't fit for every purpose, but our study demonstrates a broad range of choices," said David Kitto, a postdoctoral fellow in chemical engineering and the study's first author. "Water is such an important resource, so it would be amazing to help to make desalination a sustainable solution to our global water crisis."

The research was funded by the U.S. Department of Energy and relied on NSF-funded X-ray facilities at the University of Pennsylvania Materials Research Science and Engineering Center.

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The team filed for patent protection with the assistance of U-M Innovation Partnerships.

Science Daily, 15 April 2025

https://sciencedaily.com

How deadly pesticides ended up in the food of South Africa's poorest citizens

2025-04-11

Terbufos and aldicarb, highly toxic pesticides used in South African agriculture, have found their way into the country's poor townships as rat poisons. This in turn has led to the accidental contamination of stored food and poisoning deaths.

'I almost fainted when they rushed her to the ICU,' recalls Edith Lokwane, a mother in Soweto, the biggest township lying west of Johannesburg. Her 7-year-old daughter, on the way home from school last October, had eaten seemingly harmless samosas and buns. Within three hours, her vomiting was relentless, her breathing shallow, her body lethargic, Lokwane says.

In townships where public ambulances are largely absent due to bankrupt municipalities, a neighbour took her daughter to hospital where doctors pumped her stomach and stabilised her. She was discharged after a two-week stay but one of her school friends died.

In November, at least 23 children died in Soweto as a result of eating contaminated food. 900 others were sickened. The cause of the deaths and illnesses was 'consumption of food contaminated with highly neurotoxic pesticides', the health minister, Aaron Motsoaledi, told parliament. Many of the pesticides, such as terbufos, are 'severely' restricted in richer countries, with the EU banning them.

'Terbufos is intended for agricultural use and should specifically not be stored or used in or around homes. It is fatal to humans if it is swallowed,' says chemist Patricia Forbes, head of the Environmental Monitoring and Sensing Research Group at the University of Pretoria.

The neighbouring country of Zimbabwe banned Terbufos in 2002 and Botswana followed suit last year. In South Africa, campaigners pushing to ban terbufos say it is hard to know the number of highly hazardous pesticides (HHPs) legalised for use because the government has no open database of registered chemicals. A vocal, united push by health academics, agriculture trade unions and lawyers has demanded the

country's agriculture minister move swiftly to ban HHPs or face court action.

Misdirected anger

When the poisonings and deaths began in July last year, mobs of anti-migrant vigilantes in South Africa's townships blamed refugees from Pakistan, Somalia or Nigeria – who often run cheap grocery shops – with deliberately poisoning children. Threats, violence and looting were directed at these shops. 'We continue to be hunted,' says Hamid*, a Somali refugee who ran a bread and milk shop in Naledi township and saw xenophobic mobs ransack his business before he took refuge in Pretoria. Fearing for his safety he will not share his surname.

Investigations by the National Institute for Communicable Diseases found that controlled pesticides have been diverted by unscrupulous dealers for use as a rat poison in poor slums, resulting in accidental contamination of food.

At the heart of these tragedies is a wave of urban municipal decay across South Africa. This has created a 'full-blown crisis' of uncollected waste and overflowing sewers, Marais de Vaal, the environment manager at Afriforum, the country's leading civic pressure group, warned. Just 14% of the South African landfill sites audited by Afriforum in 2024 met 80%+ of the country's biosafety requirements.

In the slums where 15 million people live, mostly Black South Africans, rat infestations are disrupting lives and businesses. With municipal rat control services bankrupt, black market pesticide traders are illegally diverting terbufos and aldicarb to desperate township households. Street food traders, informal food warehouses and families clamour for any solution to the pest problem, however untested, says Forbes.

'Pesticides that are informally sold have been decanted into unlabelled packages, therefore customers are not provided with essential handling and safety information related to these products, although this is legally required when selling pesticides,' she warns. 'This greatly increases human health risks.' By law, some pesticides can be sold in supermarkets, while others, including terbufos, are more highly regulated, she adds.

Deadly inequality

South Africa, one of the most unequal countries in the world, has a two-tier food system. While the country has a thriving agricultural sector, this does not translate into household food security, particularly in Black

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working-class and low-income communities, explains Paula Knipe, a lawyer and researcher at the Dullah Omar Institute in Cape Town. This is because of deeply rooted historical and structural inequality, which has divided South Africa's food system along economic and racial lines.

'The affluent middle to upper class, mostly concentrated in suburbs and city centres, have access to regulated, clearly labelled and high-quality food from supermarkets,' Knipe explains. 'The poor rely on meals that are cheaper, but are often not inspected for food safety, exposing people to expired, repackaged and counterfeit foodstuffs.'

South Africa is currently experiencing a 'complex' crisis of food adulteration and penalties for food safety violations and fraud are lenient and inadequate, researchers have recently warned. Eight years ago, South Africa faced a deadly listeriosis food-borne outbreak that killed 260, infected 1060 and is rated as the largest outbreak of its kind in the world. The origin was sausages and other processed meat stuff.

South Africa's agriculture ministry should be closely monitoring the informal food industry for contaminants by now, but 'lessons have not been learnt', laments environmental technician and academic, Shamiso Mupara.

Bowing to public anger, in December, South Africa's authorities raided every cheap food shop run by migrants in the townships, giving owners a 21-day ultimatum to register on a government database or risk prosecution. Over a thousand shops were shut down. Lokwane is unimpressed: 'It's a populist stunt, to save face,' she says.

Chemistry World, 11 April 2025

https://chemistryworld.com

Uncovering the hidden cost of water splitting: Study paves the way for more efficient clean energy production

2025-04-15

As the global pursuit for sustainable energy solutions intensifies, water splitting remains a promising avenue for producing clean hydrogen fuels. But the process of splitting water into hydrogen and oxygen is inherently inefficient—requiring significantly more energy than theoretically predicted.

Now, Northwestern University chemists have found a molecular-level explanation for this discrepancy. In the crucial moment before giving up oxygen atoms, the water molecules perform an unexpected trick: They flip.

After observing the water molecules flip, the team quantified the precise energy cost associated with that critical step. They discovered the acrobatic act is a major contributor to water splitting's efficiency bottleneck. But, in yet another discovery, they found increasing the pH of water lowers that energy cost and thereby contributes to making the process more efficient.

This new knowledge could help researchers find new ways to reduce the energy barrier for generating clean hydrogen fuel and for producing breathable oxygen during future missions to Mars.

The study is published in the journal Nature Communications.

"When you split water, two half-reactions occur," said Northwestern's Franz Geiger, who led the study. "One half-reaction produces hydrogen and the other produces oxygen. The half-reaction that produces oxygen is really difficult to perform because everything has to be aligned just right. It ends up taking more energy than theoretically calculated. If you do the math, it should require 1.23 volts. But, in reality, it requires more like 1.5 or 1.6 volts. Providing that extra voltage costs money, and that's why water splitting hasn't been implemented at a large scale.

"We argue that the energy required to flip the water is a significant contributor to needing this extra energy. By designing new catalysts that make water flipping easier, we could make water splitting more practical and cost-effective."

Geiger is the Charles E. and Emma H. Morrison Professor of Chemistry at Northwestern's Weinberg College of Arts and Sciences and member of the International Institute for Nanotechnology and the Paula M. Trienens Institute for Energy and Sustainability. The study's lead author is Raiden Speelman and the second author is Ezra J. Marker, who are both members of Geiger's lab. Other co-authors include Alex Martinson from Argonne National Laboratory and Mavis Boamah, Jacob Kupferberg, Mark Engelhard, Yatong Zhao and Kevin Rosso—all from the Pacific Northwest National Laboratory.

Water splitting's promise and challenges

As the climate continues to warm, scientists have become increasingly interested in water splitting as a way to produce clean hydrogen energy

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as an alternative to fossil fuels. To perform the process, scientists add water to an electrode and then apply a voltage. This electricity splits water molecules into two components—hydrogen and oxygen—without any unwanted byproducts. From there, researchers can collect hydrogen for fuel or repurpose the hydrogen and oxygen into energy-efficient fuel cells.

While water splitting could play a significant role in a future clean-energy economy, it faces several challenges. The main issue is that the oxygen part of the reaction, called the oxygen evolution reaction (OER), can be difficult and inefficient. Although it's most efficient when iridium is used as the electrode, Geiger said scientists need more affordable alternatives.

"Iridium only comes to Earth from meteoric impact, like the famous iridium anomaly at the Cretaceous-Paleogene boundary, so there's a limited amount," he said. "It's very expensive and certainly not going to help solve the energy crisis any time soon. Researchers are looking at alternatives, like nickel and iron, and we're hoping to find ways to make these materials just as efficient—if not more efficient—than iridium."

'Optical equivalent to noise-canceling headphones'

In the new study, Geiger and his team focused on hematite, an inexpensive and earth-abundant iron oxide mineral. Although hematite is a promising material for performing the OER, it suffers from inefficiency—much like other inexpensive metals. To explore the reason why, the researchers applied a sophisticated new light-based technique called phase-resolved second harmonic generation (PR-SHG).

Previously developed in Geiger's laboratory, PR-SHG enables researchers to observe how water molecules interact with the metallic electrode in real time. To conduct the experiment, the team first placed a hematite electrode into a special container with water. Then, they shined a laser onto the electrode's surface and measured the light intensity at half the wavelength. Using multiple optical components—including lenses, mirrors and crystals—the researchers manipulated the laser beam to gain detailed information.

"Our technique is the optical equivalent to noise-canceling headphones," Geiger said. "We can essentially control constructive and deconstructive interference—the photon's phase—and from that, we can precisely quantify how many water molecules are pointing to the surface and how many rearrange to point away from it."

By analyzing the amplitude and phase of the signal photons, Geiger's team inferred the water molecules' arrangement. Before applying the voltage, the researchers noticed the water molecules were randomly positioned. As they applied a precise voltage to the electrode, however, they watched the water molecules reorient themselves.

Quantifying the energy hurdle

Directly observing the water molecules flip enabled the researchers to measure how many water molecules flipped as well as the energy associated with that flipping. They found the flipping happens immediately before OER starts, indicating this is a necessary, non-negotiable step in the process.

"These electrodes are negatively charged, so the water molecule wants to put its positively charged hydrogen atoms toward the electrode's surface," Geiger said. "In that position, electron transfer—from water's oxygen atoms to the electrode's active site—is blocked. We find that when the electric field becomes strong enough, it causes the molecules to flip, so the oxygen atoms point toward the electrode's surface. Then, the hydrogen atoms are out of the way, and the electrons can move from water's oxygen to the electrode."

When quantifying the amount of energy used, Geiger and his team discovered that the energy required to align the water molecules closely matches the energy that holds liquid water together. They also found that water's pH level influences the orientation of water molecules. While low pH levels required more energy to flip the water molecules into the correct alignment, higher pH levels, by contrast, made the process more efficient.

"When you go below a pH level of nine, there's little-to-no electrical current produced at all," Geiger said. "So, while the water molecules still flip, the work associated with doing so is so high that there's no electrochemistry happening."

Confirmed conclusions

These findings confirm a previous study from Geiger's laboratory, published in March in the journal Science Advances. In that study, Geiger's team watched OER on a nickel electrode. The researchers witnessed the same behavior: water molecules flipped immediately before the reaction started.

"We now know that water flipping happens on both metal and semiconductor electrodes," Geiger said. "So, this is probably a more general

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behavior than we initially thought. Now, we can optimize the conditions where water flipping is easiest."

Although nickel and hematite are both inexpensive and abundant materials, hematite, which is a semiconductor, has potential applications as a photoanode and therefore solar water oxidation.

"A key goal is to move away from fossil fuels and toward a hydrogen economy," Geiger said. "One long-pursued idea is to use a material with the right electrocatalytic and optical properties. Through solar radiation, it generates catalytically active sites that do the electrochemistry. You still need to apply a current to perform the electrochemistry, but the sun's photons allow you to apply less voltage. And the less voltage you apply, the cheaper the fuel becomes.

"Our study shows that the catalyst surfaces need to be tailored to facilitate water flipping so the electron transfer can initiate."

Phys Org, 15 April 2025

https://phys.org

The Crystal That Wasn't Supposed to Exist – Now It's Reinventing 3D-Printed Metal

2025-04-12

Quasicrystals, once considered impossible, were found in a 3D-printed aluminum alloy – and they make it stronger. This could change how we design aircraft and car components.

- Researchers at NIST discovered quasicrystals, rare, non-repeating atomic structures, in 3D-printed aluminum alloys.
- These quasicrystals were found to strengthen the metal, making it more suitable for lightweight, high-performance parts like those used in airplanes.
- Quasicrystals were first discovered at NIST in the 1980s, a breakthrough that challenged long-held scientific beliefs, and earned a Nobel Prize in Chemistry in 2011.

Strange Patterns at the Atomic Scale

While examining a sliver of a new aluminum alloy under an electron microscope, materials research engineer Andrew Iams noticed something unusual. At the atomic scale, the atoms were arranged in a highly irregular pattern—one that didn't follow the typical repeating structure of most

crystals. “That’s when I started to get excited,” said Iams, a materials research engineer, “because I thought I might be looking at a quasicrystal.”

His instincts were right. Iams and his colleagues at the National Institute of Standards and Technology (NIST) confirmed that the alloy contained quasicrystals, rare atomic structures that don’t repeat like conventional crystals. Even more surprising, they found that these quasicrystals actually increased the alloy’s strength. The team published their findings in the Journal of Alloys and Compounds.

The alloy had formed during metal 3D printing, a manufacturing process that uses high-powered lasers to fuse metal powder into complex shapes. Studying this material at the atomic level could lead to a new class of 3D-printed components, from aircraft parts to heat exchangers and car frames. It also opens the door to designing new aluminum alloys that intentionally incorporate quasicrystals for added strength.

What Are Quasicrystals?

Quasicrystals are like ordinary crystals but with a few key differences.

A traditional crystal is any solid made of atoms or molecules in repeating patterns. Table salt is a common crystal, for example. Salt’s atoms connect to make cubes, and those microscopic cubes connect to form bigger cubes that are large enough to see with the naked eye.

There are only 230 possible ways for atoms to form repeating crystal patterns. Quasicrystals don’t fit into any of them. Their unique shape lets them form a pattern that fills the space, but never repeats.

Dan Shechtman, a materials scientist at Technion-Israel Institute of Technology, discovered quasicrystals while on sabbatical at NIST in the 1980s. Many scientists at the time thought his research was flawed because the new crystal shapes he found weren’t possible under the normal rules for crystals. But through careful research, Shechtman proved beyond a doubt that this new type of crystal existed, revolutionizing the science of crystallography and winning the chemistry Nobel Prize in 2011.

Working in the same building as Shechtman decades later, Andrew Iams found his own quasicrystals in 3D-printed aluminum.

How Does Metal 3D Printing Work?

There are a few different ways to 3D-print metals, but the most common is called “powder bed fusion.” It works like this: Metal powder is spread evenly in a thin layer. Then a powerful laser moves over the powder,

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melting it together. After the first layer is finished, a new layer of powder is spread on top and the process repeats. One layer at a time, the laser melts the powder into a solid shape.

More than 40 metal 3D printers at a GE Aviation plant in Auburn, Alabama, have produced more than 30,000 fuel nozzles for the high performance LEAP engine. In this ASME video, the engineer who was given the task to design the fuel nozzle describes how he took on the challenge.

3D printing creates shapes that would be impossible with any other method. For example, in 2015 GE designed fuel nozzles (see video above) for airplane engines that could only be made with metal 3D printing. The new nozzle was a huge improvement. Its complex shape came out of the printer as a single lightweight part. In contrast, the previous version had to be assembled from 20 separate pieces and was 25% heavier. To date, GE has printed tens of thousands of these fuel nozzles, showing that metal 3D printing can be commercially successful.

One of the limitations of metal 3D printing is that it only works with a handful of metals. “High-strength aluminum alloys are almost impossible to print,” says NIST physicist Fan Zhang, a co-author on the paper. “They tend to develop cracks, which make them unusable.”

Extreme Temperatures Create New Properties

Normal aluminum melts at temperatures of around 700 degrees C. The lasers in a 3D printer must raise the temperature much, much higher: past the metal’s boiling point, 2,470 degrees C. This changes a lot of the properties of the metal, particularly since aluminum heats up and cools down faster than other metals.

In 2017, a team at HRL Laboratories, based in California, and UC Santa Barbara discovered a high-strength aluminum alloy that could be 3D printed. They found that adding zirconium to the aluminum powder prevented the 3D-printed parts from cracking, resulting in a strong alloy.

The NIST researchers set out to understand this new, commercially available 3D-printed aluminum-zirconium alloy on the atomic scale. “In order to trust this new metal enough to use in critical components such as military aircraft parts, we need a deep understanding of how the atoms fit together,” said Zhang.

The NIST team wanted to know what made this metal so strong. Part of the answer, it turned out, was quasicrystals.

Quasicrystals Disrupt Weak Points

In metals, perfect crystals are weak. The regular patterns of perfect crystals make it easier for the atoms to slip past each other. When that happens, the metal bends, stretches or breaks. Quasicrystals break up the regular pattern of the aluminum crystals, causing defects that make the metal stronger.

When Iams looked at the crystals from just the right angle, he saw that they had fivefold rotational symmetry. That means there are five ways to rotate the crystal around an axis so that it looks the same.

"Fivefold symmetry is very rare. That was the telltale sign that we might have a quasicrystal," said Iams. "But we couldn't completely convince ourselves until we got the measurements right." To confirm they had a quasicrystal, Iams had to carefully rotate the crystal under the microscope and show that it also had threefold symmetry and twofold symmetry from two different angles.

The Future of Alloy Design

"Now that we have this finding, I think it will open up a new approach to alloy design," says Zhang. "We've shown that quasicrystals can make aluminum stronger. Now people might try to create them intentionally in future alloys."

Sci Tech Daily, 12 April 2025

https://scitechdaily.com

Study finds dramatic boost in air quality from electrifying railways

2025-04-16

Switching from diesel to electric trains dramatically improved the air quality aboard the San Francisco Bay Area's Caltrain commuter rail line, reducing riders' exposure to the carcinogen black carbon by an average of 89%, finds a new study published today in the journal Environmental Science and Technology Letters.

The electrification of the system also significantly reduced the ambient black carbon concentrations within and around the San Francisco station, the study found.

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"The transition from diesel to electric trains occurred over just a few weeks, and yet we saw the same drop in black carbon concentrations in the station as California cities achieved from 30 years of clean air regulations," said study senior author Joshua Apte, a professor of environmental engineering and environmental health at the University of California, Berkeley. "It really adds to the case for electrifying the many other rail systems in the U.S. that still use old, poorly regulated diesel locomotives."

Caltrain operates the busiest commuter rail system in the western U.S., carrying millions of passengers a year along its 47-mile route between San Francisco and San Jose. Over the course of six weeks in August and September 2024, the system retired all 29 of its diesel locomotives and replaced them with 23 new electric trains. The debut of the new trains was the culmination of a $2.44 billion modernization and decarbonization project that first launched in 2017.

Apte, an expert in air quality monitoring, was inspired to pursue the study after visiting a Caltrain station in August 2024, when the very first electric trains were being introduced.

"I was stunned at how much the station smelled like diesel smoke and how noisy it was from the racket of diesel locomotives idling away at the platforms, dumping smoke out into the community," Apte said. "A light bulb went off my head -- I realized this would all be going away in a few weeks."

After securing the support of Caltrain, Apte and study lead author Samuel Cliff quickly mobilized, installing black carbon detectors at Caltrain stations and carrying portable air quality detectors aboard the trains. For four weeks, they tracked the rapid improvements in air quality as old diesel locomotives were replaced by new electric trains.

"A lot of these transitions happen pretty slowly. This one happened in a blink of an eye," Apte said. "We had the unique opportunity to capture the ancillary public health benefits."

According to Apte and Cliff's calculations, the reduction in black carbon exposure achieved from Caltrain's electrification cut excess cancer deaths by 51 per 1 million people for riders and 330 per 1 million people for train conductors. For reference, the U.S. Environmental Protection Agency has a policy that any exposure that increases the average individual's cancer risk by more than one per million is considered unacceptable.

"If you think about this in the context of the whole of the U.S., where we have millions of people commuting by rail every day, that's hundreds of cases of cancer that could be prevented each year," said Cliff, a postdoctoral scholar at UC Berkeley.

The majority of U.S. commuter trains are still powered by diesel fuel, despite the fact that electric trains are quieter, more reliable and produce fewer greenhouse gases than diesel locomotives. Apte hopes the study motivates more U.S. municipalities to follow the lead of Asian and European countries in electrifying their railways.

"This is something that we ought to find a way to do as quickly as possible, everywhere," Apte said. "California has long-term plans to electrify most of its rail systems, but this shows that we shouldn't be waiting another 25 years to get it done. We should be speeding it up."

Co-authors of the study include Haley McNamara Byrne and Allen Goldstein of UC Berkeley.

Science Daily, 16 April 2025

https://sciencedaily.com

Scientists Redesign LSD To Create a Non-Hallucinogenic Antidepressant

2025-04-14

Could a subtle tweak to lysergic acid diethylamide (LSD) unlock its therapeutic potential, without the trip?

In a study published in Proceedings of the National Academy of Sciences, researchers at the University of California, Davis (UC Davis) report the creation of JRT – a chemically modified version of LSD that retains its brain-rewiring effects while eliminating hallucinogenic side effects.

The promise of non-hallucinogenic neuroplasticity drugs

Psychedelics like LSD and psilocybin are now the subject of serious scientific investigation for their therapeutic applications. Recent research has shown that these compounds can do far more than alter perception; they can physically reshape the brain. By promoting dendritic growth, increasing synaptic density and enhancing cortical connectivity, psychedelics exhibit powerful neuroplastic effects that may help reverse the structural brain changes seen in conditions such as depression, post-traumatic stress disorder (PTSD), addiction and schizophrenia.

However, these same compounds that regenerate damaged neural pathways also induce profound alterations in consciousness – hallucinations, perceptual distortions and dissociation – that make them unsuitable or even dangerous for many patients. Individuals with schizophrenia or a family history of psychosis are often excluded from psychedelic clinical trials due to concerns that these drugs could exacerbate their symptoms. As a result, a large and vulnerable segment of the population is effectively cut off from a class of therapies that might otherwise be transformative.

The team at UC Davis set out to answer a difficult question: Can you keep the benefits of LSD while removing the hallucinogenic effects that make it unsafe for many patients?

The researchers focused on the chemical structure of LSD itself. Prior studies have suggested that certain parts of the LSD molecule are responsible for triggering hallucinations – specifically, a small chemical group that forms a key interaction with brain receptors. By slightly rearranging the molecule – moving just two atoms – the team was able to disrupt this interaction without affecting the parts of LSD that promote brain cell growth. The result was a new compound, called JRT, which

closely resembles LSD in shape and weight but behaves very differently in the body.

"Basically, what we did here is a tire rotation," said corresponding author Dr. David E. Olson, professor in the Department of Biochemistry and Molecular Medicine, at UC Davis. "By just transposing two atoms in LSD, we significantly improved JRT's selectivity profile and reduced its hallucinogenic potential."

This minor-looking change was chemically complex to carry out. JRT, named after Dr. Jeremy R. Tuck, a former graduate student who was the first to synthesize the compound, couldn't be made by modifying LSD directly; instead, the researchers had to develop a completely new 12-step synthesis process to build the compound from scratch – a task that took nearly 5 years to complete.

Once synthesized, JRT was tested for how it interacts with different receptors in the brain. It showed strong, selective binding to serotonin receptors, particularly 5-HT2A, which plays a key role in mood and brain plasticity.

Importantly, unlike LSD, JRT showed little to no activity at other receptors such as those for dopamine or adrenaline, which are often linked to side effects like psychosis or cardiovascular stress.

While LSD triggered changes in genes linked to schizophrenia, JRT showed no such effect.

In cultured brain cells, JRT increased the number and complexity of neuron branches, as well as the tiny spines where neurons form connections.

In live mice, a single dose of JRT led to a 46% increase in dendritic spine density and an 18% increase in synapse density in a part of the brain involved in decision-making and emotion. In a model where mice had been stressed to the point of losing brain connections, JRT reversed this damage, bringing their brain structure back to normal.

JRT also did not produce the "head-twitch" response – a widely used indicator of hallucinogenic activity – in mice. When mice were co-treated with LSD, JRT blocked this behavior, suggesting it may actively suppress hallucinogenic activity.

In tests related to mood and cognition, JRT showed strong promise. In a standard test for antidepressant effects, it was ~100 times more potent than ketamine, a fast-acting antidepressant already used in clinical

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settings. It also helped animals perform better in a learning task that measures cognitive flexibility – the ability to adapt to changing situations, which is often impaired in conditions like schizophrenia.

In a model of amphetamine-induced hyperactivity, JRT reduced abnormal movement in female mice, but not in males – highlighting a potential sex-specific therapeutic response.

JRT's therapeutic promise and clinical potential

JRT opens up new possibilities for treating difficult-to-manage brain disorders, particularly schizophrenia, where current medications fall short. While existing antipsychotics are generally effective at controlling hallucinations and delusions, they often fail to address other symptoms – such as reduced motivation, lack of pleasure and problems with memory and attention. These so-called negative and cognitive symptoms can have a major impact on a patient's daily life, and they remain one of the biggest challenges in psychiatric treatment.

JRT's ability to promote the growth of brain cell connections – combined with its antidepressant and cognition-enhancing effects in animal studies – suggests it could help with these harder-to-treat aspects of schizophrenia. Its effects may also extend to other conditions that involve loss of brain connectivity, including depression, bipolar disorder and neurodegenerative diseases like Alzheimer's, where parts of the brain gradually shrink or lose function.

JRT may also offer several advantages over current treatments. For example, clozapine – the most effective drug for treatment-resistant schizophrenia – can cause serious side effects like sedation, weight gain and metabolic problems, partly because it acts on a broad range of brain systems. JRT, in contrast, has been designed to act more selectively on serotonin receptors, which are involved in mood and cognition, while avoiding other systems that are often linked to unwanted side effects.

Crucially, JRT appears to avoid the hallucinogenic effects seen with traditional psychedelics like LSD, which are a major barrier to their use in people with psychotic disorders.

"No one really wants to give a hallucinogenic molecule like LSD to a patient with schizophrenia. The development of JRT emphasizes that we can use psychedelics like LSD as starting points to make better medicines. We may be able to create medications that can be used in patient populations where psychedelic use is precluded," said Olson.

Eventually, the goal is to move toward clinical trials in humans.

"JRT has extremely high therapeutic potential. Right now, we are testing it in other disease models, improving its synthesis, and creating new analogues of JRT that might be even better," said Olson.

Technology Networks, 14 April 2025

https://technologynetworks.com

With a dash of water and sunlight, researchers turn propane into propylene using copper single-atom catalyst

2025-04-15

Propane dehydrogenation (PDH) reaction is a highly endothermic reaction, typically requiring temperatures above 600°C in conventional thermo-catalysis. However, elevated temperatures lead to significant energy consumption, catalyst sintering, and coke deposition. Overcoming these thermodynamic and kinetic challenges to achieve propane dehydrogenation under ambient conditions remains a major goal in catalysis.

In a study published in Nature Chemistry, a team led by Prof. Zhang Tao and Prof. Wang Aiqin from the Dalian Institute of Chemical Physics of the Chinese Academy of Sciences (CAS), collaborating with Prof. Gao Yi's team from the Shanghai Advanced Research Institute of CAS, developed a water-catalyzed PDH reaction route using a copper single-atom catalyst (SAC) through photo-thermo catalysis, enabling highly efficient propane-to-propylene conversion under mild conditions.

By using a Cu1/TiO2 SAC, researchers achieved PDH under near-ambient conditions in a water vapor atmosphere. In a continuous-flow fixed-bed reactor, the reaction temperature was reduced to just 50–80 °C, achieving a maximum reaction rate of 1201 μmol gcat-1 h-1.

Researchers revealed that Cu single atoms, water vapor, and light illumination all played essential roles in the propane-to-propylene conversion.

Through photocatalytic water splitting on the Cu1/TiO2 SAC, hydrogen and hydroxyl species were generated. Hydroxyl radicals subsequently adsorbed on the catalyst surface, abstracting hydrogen atoms from propane to form propylene and water. Water acted catalytically without

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being consumed. This mechanism fundamentally differs from traditional PDH and oxidative dehydrogenation of propane.

Furthermore, researchers demonstrated that the developed route could be extended to the dehydrogenation of other light alkanes, including ethane and butane. The reaction could even be directly driven by sunlight using the Cu1/TiO2 SAC.

"Our study not only provides a new way for PDH but also establishes a paradigm for conducting high-temperature reactions driven by solar energy," said Prof. Liu Xiaoyan, one corresponding author of the study.

Phys Org, 15 April 2025

https://phys.org

Living fungus-based building material repairs itself for over a month

2025-04-16

Engineers have developed a building material that uses the root-like mycelium of a fungus and bacteria cells. Their results, publishing April 16 in the Cell Press journal Cell Reports Physical Science, show that this material -- which is manufactured with living cells at low temperatures -- is capable of self-repairing and could eventually offer a sustainable alternative for high-emission building materials like concrete.

"Biomineralized materials do not have high enough strength to replace concrete in all applications, but we and others are working to improve their properties so they can see greater usage," said corresponding author Chelsea Heveran, an assistant professor at Montana State University.

Compared to other similar biomaterials, which typically are only usable for a few days or weeks, Heveran's team's materials -- which are made using fungal mycelium and bacteria -- are useful for at least a month.

"This is exciting, because we would like for the cells to be able to perform other functions," says Heveran.

When the bacteria live within the material longer, their cells could have more time to perform useful functions such as self-repair or cleaning up contamination.

Self-healing and remediation were not tested in this work, but the extended viability of these materials lays the groundwork for these functionalities.

Materials made from once-living organisms are beginning to enter the commercial market, but those made with organisms that are still alive have proven challenging to perfect -- both because of their short viability periods and because they tend to lack the complex internal structures needed for many construction projects.

To address these challenges, the team, led by first author Ethan Viles of Montana State University, explored using fungal mycelium as a scaffold for biomineralized materials, inspired by the fact that mycelium had previously been used as a scaffold for packaging and insulation materials.

The researchers worked with the fungus species Neurospora crassa and found that it could be used to craft materials with a variety of complex architectures.

"We learned that fungal scaffolds are quite useful for controlling the internal architecture of the material," said Heveran.

"We created internal geometries that looked like cortical bone, but moving forward, we could potentially construct other geometries too."

The researchers hope their new biomaterials can help replace building materials with high carbon footprints like cement, which contributes up to 8% of all carbon dioxide emissions produced from human activities. As a next step, they plan to further optimize the materials by coaxing the cells to live even longer and figuring out how to manufacture them efficiently on a larger scale.

Science Daily, 16 April 2025

https://sciencedaily.com

Nanoparticles of Toxic Metal in MRI Scans Can Infiltrate Human Tissue

2024-04-07

University of New Mexico researchers studying the health risks posed by gadolinium, a toxic rare earth metal used in MRI scans, have found that oxalic acid, a molecule found in many foods, can generate nanoparticles of the metal in human tissues.

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In a new paper published in the journal Magnetic Resonance Imaging, a team led by Brent Wagner, MD, professor in the Department of Internal Medicine in the UNM School of Medicine, sought to explain the formation of the nanoparticles, which have been associated with serious health problems in the kidneys and other organs.

"The worst disease caused by MRI contrast agents is nephrogenic systemic fibrosis," he said. "People have succumbed after just a single dose." The condition can cause a thickening and hardening of the skin, heart and lungs and cause painful contracture of the joints.

Gadolinium-based contrast agents are injected prior to MRI scans to help create sharper images, Wagner said. The metal is usually tightly bound to other molecules and is excreted from the body, and most people experience no adverse effects. However, previous research has shown that even in those with no symptoms, gadolinium particles have been found in the kidney and the brain and can be detected in the blood and urine years after exposure.

Scientists are left with intertwined puzzles: Why do some people get sick, when most don't, and how do gadolinium particles become pried loose from the other molecules in the contrast agent?

"Almost half of the patients had been exposed only a single time, which means that there's something that is amplifying the disease signal," Wagner said. "This nanoparticle formation might explain a few things. It might explain why there's such an amplification of the disease. When a cell is trying to deal with this alien metallic nanoparticle within it, it's going to send out signals that tell the body to respond to it."

In their study, Wagner's team focused on oxalic acid, which is found in many plant-based foods, including spinach, rhubarb, most nuts and berries and chocolate, because it binds with metal ions. The process helps lead to the formation of kidney stones, which result when oxalate binds with calcium. Meanwhile, oxalic acid also forms in the body when people eat foods or supplements containing vitamin C.

In test tube experiments the researchers found that oxalic acid caused minute amounts of gadolinium to precipitate out of the contrast agent and form nanoparticles, which then infiltrated the cells of various organs.

"Some people might form these things, while other do not, and it may be their metabolic milieu," Wagner said. "It might be if they were in a high oxalic state or a state where molecules are more prone to linking to the

gadolinium, leading to the formation of the nanoparticles. That might be why some individuals have such awful symptoms and this massive disease response, whereas other people are fine."

The finding points to a possible way to mitigate some of the risks associated with MRI scan, he said.

"I wouldn't take vitamin C if I needed to have an MRI with contrast because of the reactivity of the metal," Wagner said. "I'm hoping that we're getting closer to some recommendations for helping these individuals."

The team is now researching ways to identify those who might be at greatest risk from gadolinium contrast agents. In a new study they're building an international patient registry that will include a collection of blood, urine, fingernail and hair samples, which could provide evidence of gadolinium accumulation in the body.

"We want to get a lot more information to come up with the risk factors that relate to those with symptoms," he said. "We're going to ask about what medical conditions you had at the time of exposure, what medications are you on, and we want to include dietary supplements, because that might piece it all together – why some people have symptoms, whereas others seem to be impervious."

Technology Networks, 7 April 2025

https://technologynetworks.com

Artful single-atom catalysts can enable sustainable chemical and pharmaceutical synthesis

2025-04-14

National University of Singapore (NUS) chemists have developed an "anchoring-borrowing" strategy, combined with facet engineering, to develop a new class of artful single-atom catalysts (ASACs). These catalysts are formed by anchoring foreign single atoms onto specific facets of reducible support materials, allowing them to bypass the traditional oxidative addition step in cross-coupling reactions, which are widely used in the fine chemical and pharmaceutical industries.

The work is published in the journal Nature Communications.

Single-atom catalysts (SACs), a new type of solid catalyst, have attracted a lot of attention for their ability to maximize the use of every atom and create well-defined, highly active reaction sites. They offer a unique

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combination of the benefits found in both traditional and modern methods used in making chemicals.

In general, the material that holds the metal atom must be designed to keep it stable while allowing it enough flexibility to perform efficiently. However, the strong bonding between the metal atoms and the support, which is needed to prevent the metal atoms from clumping together, can sometimes restrict their reactivity. This limitation can make it challenging for the single metal site to perform well in certain chemical reactions that involve multiple steps, such as cross-coupling reactions.

A research team led by Associate Professor Lu Jiong, from the NUS Department of Chemistry, developed the "anchoring-borrowing" strategy. The key idea behind this innovation involves anchoring single metal atoms onto specific sites of metal oxide surfaces. These surfaces can "borrow" oxygen atoms from their surroundings to act as anchor points, while using the metal oxide as an electron reservoir. This unique design allows the structure to adapt and change in a way that avoids the high demand for complex electronic changes in the metal itself, which is a common challenge in traditional cross-coupling reactions.

This work is a collaborative effort with Associate Professor Wu Jie from the NUS Department of Chemistry, Associate Professor Wang Yang-Gang from Southern University of Science and Technology, China, Assistant Professor Wu Dongshuang from Nanyang Technological University, Singapore, and Assistant Professor Hai Xiao from Peking University, China.

The researchers used cerium oxide (CeO2,110) as the support material and discovered that the resulting Pd1-CeO2(110) ASAC works exceptionally well, even with difficult-to-react chemicals such as aryl chlorides and complex compounds. This catalyst outperformed traditional ones, providing high yields, excellent stability, and setting a new benchmark for turnover numbers.

This discovery, combined with the ability to produce the catalyst quickly in large amounts, shows the promising potential of ASACs for large-scale production of pharmaceutical ingredients and products.

This research demonstrates that ASACs are highly effective and versatile catalysts for cross-coupling reactions, a key class of transformations in chemical and pharmaceutical manufacturing. Traditional SACs usually struggle with aryl chlorides because the carbon-chlorine bond is very strong and this makes the reaction slow and inefficient. However, ASACs overcome this problem by having a flexible and adaptive active site

that enhances the reactivity with aryl chlorides and other demanding substrates, such as heterocyclic compounds, achieving consistently high yields.

ASACs also exhibit broad applicability across other types of reactions, including the Heck reaction (between aryl halides and alkenes), and the Sonogashira reaction (between aryl halides and alkynes), demonstrating its broad potential for a variety of coupling reactions.

Through a combination of experimental and theoretical studies, the researchers found that ASACs work by dynamically changing the structure of the palladium (Pd) atom. The CeO2 material helps by acting as an electron reservoir, providing electrons to stabilize the Pd atoms and prevent them from becoming over-oxidized. This electron buffering significantly lowers the energy required for the reaction. Advanced X-ray absorption near-edge structure (XANES) measurements confirmed that the Pd atoms maintain their oxidation state nearly unchanged during the reaction, ensuring that the catalyst remains active and stable over time.

Assoc. Prof Lu said, "The new concept of heterogeneous ASACs provides a much greener way to tackle the long-standing challenge of oxidative addition in cross-coupling reactions. This strategy goes beyond the limitations of traditional homogeneous and heterogeneous catalysts, and holds great potential for large-scale, sustainable production of fine chemicals and pharmaceuticals.

"Looking ahead, we plan to extend this approach to a wider range of metals that can be used in cross-coupling reactions. By adjusting the types and combinations of single atoms and support materials, we could enhance the performance of more abundant, non-precious metals in these reactions."

Phys Org, 14 April 2025

https://phys.org

Scalable graphene membranes: A leap for carbon capture

2025-04-11

Capturing carbon dioxide (CO_2) from industrial emissions is crucial in the fight against climate change. But current methods, like chemical absorption, are expensive and energy-intensive. Scientists have long eyed graphene -- an atom-thin, ultra-strong material -- as a promising

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alternative for gas separation, but making large-area, efficient graphene membranes has been a challenge.

Now, a team at EPFL, led by Professor Kumar Agrawal, has developed a scalable technique to create porous graphene membranes that selectively filter CO_2 from gas mixtures. Their approach slashes production costs while improving membrane quality and performance, paving the way for real-world applications in carbon capture and beyond.

Graphene membranes are excellent at separating gases because they can be engineered with pores just the right size to let CO_2 through while blocking larger molecules like nitrogen. This makes them ideal for capturing CO_2 emissions from power plants and industrial processes. But there's a catch: manufacturing these membranes at a meaningful scale has been difficult and costly.

Most existing methods rely on expensive copper foils to grow high-quality graphene needed for membranes and require delicate handling techniques that often introduce cracks, reducing membrane efficiency. The challenge has been to find a way to create large, high-quality graphene membranes in a cost-effective, reproducible manner.

The EPFL team tackled these challenges head-on. First, they developed a method to grow high-quality graphene on low-cost copper foils, dramatically cutting down material expenses. Then, they refined a chemical process using ozone (O_3) to etch tiny pores into the graphene, allowing for highly selective CO_2 filtration. Crucially, they improved how the gas interacts with the graphene, ensuring uniform pore formation over large areas -- a key step toward industrial scalability.

To solve the issue of membrane fragility, the researchers also introduced a novel transfer technique. Instead of floating the delicate graphene film onto a support, which often leads to cracks, they designed a direct transfer process inside membrane module that eliminates handling issues and reduces failure rates to near zero.

Using their new approach, the researchers successfully created 50 cm^2 graphene membranes -- far larger than what was previously feasible -- with near-perfect integrity. The membranes demonstrated exceptional CO_2 selectivity and high gas permeance, meaning they efficiently let CO_2 through while blocking unwanted gases.

Moreover, by optimizing the oxidation process, they were able to increase the density of CO_2-selective pores, further enhancing performance.

Computational simulations confirmed that improving gas flow across the membrane played a crucial role in achieving these results.

This breakthrough could change the game for carbon capture. Traditional CO_2 capture technologies rely on energy-intensive chemical processes, making them complex and expensive for widespread use. Graphene membranes, on the other hand, require no heat input, and operate using simple pressure-driven filtration, significantly reducing energy consumption.

Beyond carbon capture, this method could be applied to other gas separation needs, including hydrogen purification and oxygen production. With its scalable production process and cost-effective materials, EPFL's innovation brings graphene membranes one step closer to commercial viability.

Science Daily, 11 April 2025

https://sciencedaily.com

Eco-Friendly Method Recycles Wind Turbine Blades Into Stronger Plastics

2025-04-03

A new method to recycle wind turbine blades without using harsh chemicals resulted in the recovery of high-strength glass fibers and resins that allowed Washington State University researchers to re-purpose the materials to create stronger plastics.

The innovation provides a simple and environmentally friendly way to recycle wind turbine blades to create useful products.

Reporting in the journal, Resource, Conservation, and Recycling, the team of researchers cut the lightweight material that is commonly used in wind turbine blades, called glass fiber-reinforced polymer (GFRP), into approximately two inch-sized blocks. They then soaked the flakes in a bath of low-toxicity organic salt in pressurized, superheated water for about two hours to break down the material. They then re-purposed its components to make stronger plastics.

"It works very well, especially considering the mild conditions that we applied," said Cheng Hao, a former graduate student in the School of Mechanical and Materials Engineering and co-first author on the paper. "The solvent is a green solvent, and also the temperature is acceptable for this purpose."

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The GFRP material has traditionally been very difficult to recycle. While thermoplastics, the type of plastic used in milk bottles, can be melted and easily re-used, the glass-fiber composites are typically made with thermosets. These types of composites are cured and can't easily be undone and returned to their original materials. The first generation of modern wind turbines made of composites from the 1990s are now reaching the end of their lifetimes, creating a significant challenge for disposal. The glass fiber-reinforced material makes up about two-thirds of a wind turbine blade's total weight. Furthermore, when the blades are made, about 15% of the material is also wasted in manufacturing.

"As wind energy grows, recycling and reusing wind turbine waste is becoming increasingly urgent," said Jinwen Zhang, corresponding author and a professor in the School of Mechanical and Materials Engineering. "This recycling method is scalable, cost-effective, and environmentally friendly, providing a sustainable solution for reusing large quantities of glass fiber reinforced waste."

In their work, the researchers soaked the blade material in a mild solution of zinc acetate, which is used in medicines, such as in throat lozenges and food additives. The mild solution allowed the researchers to recover glass fibers and resins in good condition which they then added directly to thermoplastics to produce strong composite materials with up to 70% of the recycled glass fiber materials. Moreover, the researchers were able to recover and reuse most of the catalyzing zinc acetate solution through simple filtration.

"The ease of the catalyst recovery enhances the overall sustainability and cost-effectiveness of the method," said Zhang, who conducts research in the Composite Materials and Engineering Center.

When the researchers added the recycled material to nylon plastic and tested it, they found that the additional fibers made the nylon more than three times stronger and more than eight times stiffer. They also found that the recycled GFRP material can reinforce other plastics, such as polypropylene and the type of plastics used in milk jugs and shampoo bottles.

"For this work, we didn't need to fully break down all the bonds and push the reaction to completion," said Baoming Zhao, co-first author and research assistant professor in the Composite Materials and Engineering Center, "As long as we can break the cross-linked network into smaller pieces, and they are melt processable, we can compound that with nylon

and get a new composite. We are not separating the resin from the fiber – we just blend everything with nylon and get a new composite."

The researchers are continuing studies to make the chemical conditions even easier for recycling by reducing the requirements for pressurization. Working with WSU's Office of Commercialization they also hope to develop blade materials that are fully recyclable in the first place.

Technology Networks, 3 April 2025

https://technologynetworks.com

First atomic-level video of catalytic reaction reveals hidden pathways

2025-04-11

A Northwestern University-led international team of scientists has, for the first time, directly observed catalysis in-action at the atomic level.

In mesmerizing new videos, single atoms move and shake during a chemical reaction that removes hydrogen atoms from an alcohol molecule. By viewing the process in real time, the researchers discovered several short-lived intermediate molecules involved in the reaction as well as a previously hidden reaction pathway.

The observations were made possible by single-molecule atomic-resolution time-resolved electron microscopy (SMART-EM), a powerful instrument that enables researchers to watch individual molecules react in real time.

Observing reactions in this manner helps scientists understand how catalysts work. These new insights could potentially lead to designs for more efficient and sustainable chemical processes.

The study, "Atomic-resolution imaging as a mechanistic tool for studying single-site heterogeneous catalysis," is published in the journal Chem.

"By visualizing this process and following the reaction mechanisms, we can understand exactly what's happening in the finest detail," said Northwestern's Yosi Kratish, the study's first and co-corresponding author.

"In the past, we haven't been able to see how atoms move. Now we can. When I realized what we accomplished, I had to close my laptop and take a break for a few hours. Nobody has done this before in catalysis, so I was stunned."

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"Catalysts make modern life possible," said Northwestern's Tobin J. Marks, the study's senior author. "They are used to make everything from fuel and fertilizers to plastics and medicines. To make chemical processes more efficient and environmentally friendly, we need to understand exactly how catalysts work at the atomic level. Our study is a big step toward achieving that."

An expert in catalysis, Marks is the Charles E. and Emma H. Morrison Professor of Chemistry and Vladimir N. Ipatieff Professor of Catalytic Chemistry at Northwestern's Weinberg College of Arts and Sciences and a professor of chemical and biological engineering at Northwestern's McCormick School of Engineering.

Kratish is a research assistant professor of chemistry in Marks' group. Marks and Kratish co-led the study with Michael Bedzyk, professor of materials science and engineering at McCormick, and George C. Schatz, the Charles E. and Emma H. Morrison Professor of Chemistry at Weinberg, as well as the University of Tokyo's Professor Eiichi Nakamura, who invented SMART-EM, and Assistant Professor Takayki Nakamuro.

Catching fleeting molecules with 'cinematic chemistry'

Researchers have long sought to observe live catalytic events at the atomic level. Chemical reactions are like a journey between starting materials and the final product. Along the journey, transient—and sometimes unexpected—molecules form and then abruptly transform into other molecules. Because these so-called "intermediate" molecules are unpredictable and fleeting, they are difficult to detect.

By directly watching the reaction unfold, however, scientists can determine the exact sequence of events to reveal the complete reaction pathway—and view those elusive intermediates. But, until recently, it was impossible to observe these covert dynamics.

While traditional electron microscopes can image atoms, their beams are too strong to image the soft, organic matter used in catalysis. The high-energy electrons easily break down carbon-based structures, destroying them before scientists can gather the data.

"Most conventional transmission electron microscopy techniques operate at conditions that easily damage organic molecules," Kratish said. "This makes it extremely challenging to directly observe sensitive catalysts or organic matter during a reaction using traditional TEM methods."

To overcome this challenge, the team turned to SMART-EM, a novel technique that can capture images of delicate organic molecules. Unveiled by Nakamura and his team in 2018, SMART-EM uses a much lower electron dose, minimizing the amount of energy—and damage—transferred to the sample. By capturing rapid sequences of images, SMART-EM generates videos of dynamic processes, which Nakamura calls "cinematic chemistry."

"Since 2007, physicists have been able to realize a dream over 200 years old—the ability to see an individual atom," Nakamura said in a 2019 statement. "But it didn't end there. Our research group has reached beyond this dream to create videos of molecules to see chemical reactions in unprecedented detail."

From messy to measurable

When applying SMART-EM to catalysis for the first time, the Northwestern team chose a simple chemical reaction: removing hydrogen atoms from an alcohol molecule. But first they needed to select the right catalyst. About 85% of industrial catalysts are heterogeneous, meaning they are solid materials that react with liquids and gases.

Although heterogeneous catalysts are stable and efficient, they are also messy, with many different surface sites where reactions might occur.

"Heterogeneous catalysts have many advantages," Kratish said. "But there's a major disadvantage: in many cases, they are a black box. They have an unknown number of sites where reactions can occur. So, we don't fully understand where and how reactions take place. That means we cannot exactly figure out what part of the catalyst is most effective."

To make the catalyst easier to study, the Northwestern team designed a single-site heterogeneous catalyst with a well-defined active site. The single-site catalyst comprised molybdenum oxide particles anchored to a cone-shaped carbon nanotube. Then, the team used SMART-EM to investigate how their catalyst facilitated the conversion of ethanol into hydrogen gas, a clean alternative to fossil fuels.

"Having a single site is a lot more convenient," Kratish said. "We can pick a good site to monitor and really zoom into it."

Unveiling a hidden pathway

Before the study, scientists posited that alcohol went straight to the catalyst, where it became hydrogen gas and aldehyde (a molecule that forms when an alcohol molecule oxidizes). From there, the aldehyde,

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which is a gas at room temperature, escaped into the air. But watching the process unfold revealed a different story.

Using SMART-EM, the researchers discovered the aldehyde doesn't float away but instead sticks to the catalyst. They also found the aldehydes linked together to form short-chain polymers—a previously unknown step that appeared to drive the overall reaction. In another surprise, the researchers discovered the aldehyde also reacts with alcohol to form hemiacetal, an intermediate molecule that is then converted into other products.

To confirm these findings, the team used various microscopy techniques, X-ray analysis, theoretical models and computer simulations. All matched the SMART-EM data.

"This is a big breakthrough," Kratish said. "SMART-EM is changing the way we look at chemistry. Eventually, we want to isolate those intermediates, control the amount of energy we put into the system and study the kinetics of a live organic catalytic transformation. That will be phenomenal. This is just the beginning."

Phys Org, 11 April 2025

https://phys.org

Botanic Gardens May Be Accidentally Killing the Corpse Flower

2025-04-13

Commonly known as the "corpse flower," Amorphophallus titanum is endangered for several reasons, including habitat loss, climate change, and invasive species. Now, researchers from Northwestern University and the Chicago Botanic Garden have identified another critical threat: incomplete historical records.

In a recent study, scientists traced the ancestry of corpse flowers held in botanical gardens and institutional collections worldwide. They discovered a major gap in standardized, consistent data. Without full breeding histories, conservationists have struggled to make informed decisions. As a result, 24% of the corpse flowers examined were clones, and 27% were the result of inbreeding between closely related individuals.

The findings were recently published in the journal Annals of Botany.

"There are many risks associated with low genetic diversity," said Olivia Murrell, the study's lead author. "Decreasing genetic diversity over time leads to a decrease in fitness. Generally speaking, inbred plants might not produce as much pollen or might die right after they flower. One institution reported that, possibly as a result of inbreeding, all their corpse flower offspring were albino, so they didn't survive because they didn't have chlorophyll to photosynthesize. The population as a whole also doesn't have the variation it needs to survive. So, if a disease or pest affects plants that are all genetically similar, all plants in that population are more likely to suffer. We don't think people are consciously making the choice to inbreed their plants. They just don't know what they have because the data are incomplete."

At the time of the study, Murrell was a master's student in plant biology in the Program in Plant Biology and Conservation, a partnership between Northwestern's Weinberg College of Arts and Sciences and the Chicago Botanic Garden. Now she is a Ph.D. student at Manchester Metropolitan University in the U.K. and a conservation scholar at the Chester Zoo. Senior authors from the Program in Plant Biology and Conservation are Jeremie Fant, Nyree Zerega, and Kayri Havens. Fant, Zerega, and Havens also are conservation scientists with the Negaunee Institute for Plant Conservation Science and Action at the Chicago Botanic Garden.

A finicky flower

Nicknamed for its smell, the corpse flower emits an odor that mimics rotting flesh when it blooms. A clever evolutionary trick, the pungent odor attracts flies and carrion beetles, the plant's primary pollinators. Because the bloom is rare and short-lived — lasting just 24 to 48 hours — gardens often hold events for visitors to experience the infamous stench firsthand.

"Usually, you have to get close to a flower to be able to smell it," Murrell said. "That is not true for the corpse flower. The second you walk into its greenhouse, its smell smacks you across the face. It's very strong. The plant also heats up when it blooms, which spreads its smell farther."

Gardens go to great lengths to care for these charismatic companions. The corpse flower is one of several "exceptional plants," a designation given to species whose seeds cannot be effectively conserved in seed banks. In the corpse flower's case, its seeds are no longer viable after drying, which is a necessary step for long-term seed storage. Instead, corpse flowers and other exceptional plants are conserved in "living collections" within research facilities, botanic gardens, and arboreta.

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Because male and female corpse flowers bloom at different times, the flowers in these living collections rely on humans to keep their lineages alive. Their caretakers, however, face several challenges.

"The female flowers open first, and then the male flowers open later," Murrell said. "So, the female flowers are no longer viable by the time pollen is produced. The plant also blooms rarely and unpredictably. It could go seven to 10 years without blooming. Then, when the blooms do open, the female flowers are only viable for a couple hours. With that limited time to pollinate, conservationists scramble to use whatever they have on hand. That might be pollen from a previous flower on the same individual, which results in inbreeding."

Wilted records

To better understand what happens in these situations, Murrell located all the living collections around the world which contained corpse flowers. Ultimately, she received data from nearly 1,200 individual plants from 111 institutions across North America, Asia, Australia, and Europe. The data arrived in the forms of handwritten notes, prose, lists, and spreadsheets.

Ideally, a plant's records should contain detailed information about its origin, parents, characteristics, health, and propagation. Crucial for conservation efforts, these data help conservationists maintain genetic diversity and plant health while preventing loss. Without this information, people cannot make informed decisions about which plants to cross for breeding.

After organizing all the information received from institutions, Murrell found it was severely lacking. Institutions often did not record the sources and origins of individual plants. Even when they did record seed sources, they did not record information about which plant's pollen was used for breeding.

"The highest rate of missing data occurred when plants were transferred to new locations," Murrell said. "The plants moved, but their data didn't move with them. So, records easily got lost over time as plants moved around."

Clones and crosses

To determine prevalence of inbreeding, Murrell and her team examined the records for clones and breeding between related plants. Of the 1,188 individual plants in the dataset, 287 (24%) were clones and 27% were

offspring from closely related individuals. Fewer than one-third of crosses occurred between unrelated individuals.

Looking to substantiate these conclusions, Murrell performed a small molecular genetics study on 65 plants. By sequencing the plants' DNA, the team confirmed low genetic diversity and high inbreeding across all collections.

Native only to Sumatra, the corpse flowers' numbers continue to decline. According to a recent estimate published in the journal Biodiversity and Conservation, just 162 individual corpse flowers remain in the wild. The dwindling population underscores the need to ensure these plants can thrive in living collections, so they eventually can be reintroduced into the wild.

"The population needs variation to survive," Murrell said. "If nothing changes, it could inbreed itself into extinction. That's why it's really important to keep consistent, standardized, and centralized data. Not keeping data has clear conservation implications. In the meantime, our study provides valuable information about relationships among existing collections, which can be used to determine which crosses might be most successful."

To help improve collections of corpse flowers and other species, Murrell and her coauthors made five recommendations. They urged institutions to (1) document parents and destinations of plants sampled in the wild, (2) standardize data across collections, (3) track parent plants across institutions, (4) transfer data with plants when they are moved to new institutions and (5) determine common language for recordkeeping so all definitions are consistent.

Sci Tech Daily, 13 April 2025

https://scitechdaily.com

Plant-Based Leather: The Future of Sustainable Fashion?

2025-04-14

The fashion industry doesn't just have a monetary price tag – it also comes with a hefty toll on the environment. Figures from the European Parliament suggest that the textile sector is the third-largest source of water degradation and land use, with textile purchases in the EU generating around 270 kg of CO_2 emissions per person. On top of that,

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estimates suggest that less than 1% of used clothes are recycled into new articles of clothing.

The leather industry has received especially strong backlash in recent decades, largely from animal rights groups but also on account of the sector's poor environmental credentials. The leather industry's reliance on animal agriculture contributes to deforestation and greenhouse gas emissions. The strong chemicals required during the tanning of animal leather have also been a point of concern, as these chemicals may be introduced into the environment through waste or accidental releases, resulting in damage to local ecosystems.

In response to these criticisms, the fashion world has begun to turn its back on the traditional leather industry. In 2018, Helsinki Fashion Week announced, via a press release issued by the animal rights non-profit PETA, that they would be prohibiting leather from their shows to take "an active stand against cruelty to animals and the damaging environmental impacts that the use of animal leather brings with it."

This shift in attitudes, combined with recent advancements in materials science, has given rise to a new industry – that of leather alternatives.

The problem with current vegan leathers

Most non-animal-based leather currently available on the market – often labeled as "vegan" leather – is made from petroleum-derived synthetic polymers, such as polyurethane (PU) or polyvinyl chloride (PVC).

While this synthetic faux leather does largely side-step the ethical and environmental concerns associated with animal products, these vegan leathers are non-biodegradable and are limited to the same constrained end-of-life recycling possibilities as most common plastics. Some studies also suggest that these synthetic leathers may become a source of microplastics as they age.

Bio-based eco-leather

In the continued hunt for a more ecologically sound alternative to animal leather and petroleum-based leathers, scientists have turned to the natural world for inspiration.

Bio-leather alternatives are derived from natural materials, such as fruit peel and pulp, fungal mycelium or bacterial cellulose. By incorporating natural feedstocks, academics and industry R&D partners hope to create

even more sustainable, eco-friendly, vegan alternatives with improved biodegradability and longevity.

Mycelium leather

Fungal leather may not sound like a particularly appealing concept, but leathers made from fungal mycelium are gaining traction due to their biodegradability, biocompatibility and low carbon footprint.

The concept of using fungal mycelium as a form of textile is not new; indigenous peoples in the United States and Canada have used forest fungi for a wide variety of applications, including as a textile in fabric mats. In Transylvania and surrounding areas in Europe, amadou – a spongey material derived from Fomes fomentarius and similar fungi – is processed by hand and used to make leather-like hats and bags.

On the global commercial stage, mushroom leather is one of the more popular leather alternative options. According to current estimates, fungal-based leather substitutes had a leading 26.6% market share of the bio-based leather market in 2021, with the total bio-based leather market being projected to reach a market value of $97 million by 2027. Major fashion brands, including Adidas, Kering, Lululemon and Stella McCartney have also looked to get in on the mushroom leather action, announcing partnerships and products made with fungi-based leather manufacturers.

Despite the relative popularity of mycelium leather, there are still a number of important challenges facing the sector. Firstly, there is no real consensus over which fungal strain makes for the most optimal final properties and the number of strains tested only reflects a small fraction of the millions of fungal species that exist. Strain selection can also have a significant impact on downstream processing techniques. Additionally, the physical properties of these leathers are not yet on par with traditional animal leather or plastic-based vegan leathers.

Plant-based leather

Plants and fruits are another popular option for generating leather-like materials from non-animal sources. The methods of producing these leather alternatives vary greatly depending on the starting material, but generally, these eco-leathers are made from cellulose that has been extracted from fruit or plant biomass.

Piñatex®, developed by the plant-based textiles company Ananas Anam, is one of the most well-known plant-based leathers. Piñatex is made from fibers extracted from waste pineapple plant leaves that are generated

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during the harvest. These pineapple fibers are then washed and purified before being mixed with corn-derived polylactic acid (PLA) to form a non-woven mesh base material. Additional coatings and finishings then turn the material into something similar to leather.

Another popular leather alternative is Desserto® – which has already launched collaborations with fashion and automotive industry giants, including Karl Lagerfeld, Mercedes-Benz and BMW. Desserto is 90% plant-based and is made using fibers and proteins extracted from cactus, which has the benefit of being a hardy plant that can thrive in harsh temperatures and requires much less water to grow than traditional crops.

However, while these products are a popular option for vegans and other consumers seeking non-animal-based leathers, they are not 100% biodegradable as they do contain some amount of petroleum- or plant-based plastics. While some plant-based options are still fully recyclable (as Desserto claims to be), the inclusion of plastics and partial biodegradability may still be a turn-off for some consumers or applications.

Microbial leather

If a plant- or fungi-based leather alternative doesn't sound like your style, there are other options out there.

Motivated by a desire to produce "post-petroleum" alternative textiles – ones that use no plastics or other petroleum-based compounds in their synthesis – researchers have also begun to experiment with engineered bacteria that can produce the cellulose needed for sustainable leather products.

Nanocellulose is naturally produced by bacteria of the Komagataeibacter genus. Through recent advances in synthetic biology and genetic engineering, scientists have been able to genetically engineer specific Komagataeibacter strains that will produce thicker cellulose films and/or have a higher production efficiency.

In a recent paper published in Nature Biotechnology, researchers from Imperial College London showcased a leather wallet made from bacterial cellulose that not only avoids the use of plastics, but also does not require any harsh chemical treatments to dye the leather a darker color.

This was done by introducing additional genetic modifications to the bacteria that would prompt it to also produce the dark pigment eumelanin, in addition to cellulose films.

"Bacterial cellulose is inherently vegan, and its growth requires a tiny fraction of the carbon emissions, water, land use and time of farming cows for leather," said lead study author Professor Tom Ellis, of Imperial's Department of Bioengineering.

"Unlike plastic-based leather alternatives, bacterial cellulose can also be made without petrochemicals, and will biodegrade safely and non-toxically in the environment."

Microbial leather bags and clothing have been flaunted by fashion brands in recent years, with the material's flexibility and high tensile strength making it a promising alternative to traditional leather. However, there are several challenges still facing the field, most notably concerning the scalability of production and issues with homogeneity and contamination.

Cultivated leather

One extremely novel approach to sustainable leather-making takes the alternative leather industry almost full circle — back to where it all began, with animals.

Similar to the production of cultivated or "lab-grown" meat from animal cells, these leather-like materials are made by cultivating animal skin cells in a controlled laboratory environment until they begin to form animal hide-like tissues. These tissues can then go through the leather tanning process, effectively producing animal leather but without the need for animal slaughter.

While this kind of cultivation approach is generally positioned as being a cruelty-free way of making leather, rather than an explicitly sustainable one, some lab-grown leather start-ups do suggest that this production method could reduce greenhouse gas emissions and land use due to the lessened need for animal agriculture. However, it is worth noting that the powering of a laboratory environment is also energy-intensive and potentially could limit the scalability of such approaches.

The outlook for alternative leathers

The invention and adoption of such eco-leathers marks an exciting direction for the fashion industry, with high-end and mass-market fashion brands seemingly keen to experiment with sustainable materials to reduce their environmental footprint and offer non-animal-based alternatives for certain consumer markets.

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While challenges do remain in terms of scaling up production and improving durability, continued advancement in materials science and synthetic biology could help to propel these materials even further into the mainstream.

Technology Networks, 14 April 2025

https://technologynetworks.com

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Technical Notes

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(NOTE: OPEN YOUR WEB BROWSER AND CLICK ON HEADING TO LINK TO SECTION)

CHEMICAL EFFECTS

Effects of organic and inorganic contaminants and their mixtures on metabolic health and gene expression in developmentally exposed zebrafish

Combining multi-surface and biotoxicity models to predict cadmium bioavailability and accumulation in a soil collembolan

Reproductive and developmental toxicity screen (OECD TG 421) and extended one generation reproductive toxicity study (OECD TG 443) of decahydronaphthalene in Sprague Dawley rats

ENVIRONMENTAL RESEARCH

Analysis of heavy metal pollution sources caused by sulfide minerals in tunnel waste under photocatalytic oxidation conditions

Manganese Uptake and Lethality in the Sea Star Asterias rubens: Effect of Hypoxia

PHARMACEUTICAL/TOXICOLOGY

Diesel exhaust promoted diethylnitrosamine-induced hepatocarcinogenesis in mice

Co-occurrence and risk emission potential of antibiotics, antibiotic resistance genes, and heavy metals in concentrated leachate in China

OCCUPATIONAL

Wound Healing in Human Skin Equivalents Reconstructed with Biopolymers Under Fine-Dust Exposure

Polyfloral nutritional resources promote bumble bee colony development after exposure to a pesticide mixture

Prevalence of respiratory symptoms and lung function impairments among woodworkers in Gondar City