CHEMWATCH

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(click on page numbers for links)

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ASIA PACIFIC

Industrial Chemicals Categorisation Guidelines

2025-09-02

The Industrial Chemicals Categorisation Guidelines are issued by the Executive Director of AICIS and set out technical details and requirements for categorising chemical introductions in Australia. These Guidelines are amended from time to time.

You must read the Guidelines in conjunction with the General Rules.

Current guidelines

Industrial Chemicals Categorisation Guidelines - 1 September 2025

List of chemicals with high hazards for categorisation

This is part of Appendix 8.1 of the Industrial Chemicals Categorisation Guidelines. It is a list of chemicals that trusted national and international sources consider to be high hazardous to human health or the environment, with hazard characteristics that are in our highest hazard bands.

View the high hazards list and how to use as part of categorising a chemical introduction.

Guide to categorising your chemical importation and manufacture (Categorisation Guide)

Drawing on information in the The Act, General Rules and the Industrial Chemicals Categorisation Guidelines, we've put together this practical, step-by-step plain language guide and self-guided decision tools to help you complete the categorisation process. The guide walks you through what you need to check and in what order you need to do it.

Read our Categorisation Guide

Read More

AICIS, 02-09-25

https://www.industrialchemicals.gov.au/about-us/industrial-chemicals-law-australia

AMERICA

Mexico Bans 35 Pesticides to Protect Health, Agriculture

2025-09-09

The Mexican government has banned 35 hazardous pesticides, aiming to protect public health and reduce the risks posed by agrochemicals. The decree, coordinated by the Ministry of Health, COFEPRIS, the Ministry of Agriculture and Rural Development (SADER), the Ministry of Economy, and the Ministry of Environment and Natural Resources, argues that these substances are harmful to farmworkers, consumers, and ecosystems.

Exposure to some pesticides has been linked to severe health consequences, including developmental effects on fetuses and infants, neurological damage, and contamination of food and water.

Certain chemicals are also highly toxic to pollinators like bees, threatening biodiversity and food security. Mexico ranks as the 11th largest consumer of pesticides globally, with decades of largely unregulated use contributing to significant health and environmental risks.

To support the transition to safer agricultural practices, the United Nations Development Program (UNDP) in Mexico will contribute to the preparatory phase of the "Financing for the Reduction and Management of Agrochemical Products Plus in Mexico (FARM+ Mexico)" project.

Running from 2026 to 2031, FARM+ Mexico aims to implement a national strategy to phase out high-risk pesticides, strengthen monitoring and control systems, and promote agroecological alternatives. The project has secured US$7.5 million in funding from the Global Environment Facility (GEF).

Read More

Mexico Business News, 09/09/25

https://mexicobusiness.news/health/news/mexico-bans-35-pesticides-protect-health-agriculture

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Share your thoughts: Proposed changes to the Common Names for Ingredients and Components document for milk ingredients and modified milk ingredients

2025-08-22

Current status: Open

Open on August 22, 2025 and will close to input on October 21, 2025

At the request of the dairy processing sector, the Canadian Food Inspection Agency (CFIA) is seeking feedback on proposed changes to the ingredients or components that are allowed to use the common name "milk ingredients" or "modified milk ingredients" in the list of ingredients on a food label. This will include changes to the Common Names for Ingredients and Components document that is incorporated by reference in the Food and Drug Regulations.

In Canada, prepackaged foods with more than one ingredient generally have a list of ingredients on the food label. This list shows all the ingredients in the food, starting with the ingredient that weighs the most and ending with the ingredient that weighs the least.

Ingredients and components must be shown in the list of ingredients by their English and French common names. For certain ingredients and components, there is an option to use a common name for the class of foods they belong to instead of their individual common names. "Milk ingredients" and "modified milk ingredients" are two examples of these class common names.

Read More

Government of Canada, 22-08-25

https://inspection.canada.ca/en/about-cfia/transparency/consultations-and-engagement/milk-ingredients

White House publishes strategy to address childhood chronic disease in the US

2025-09-11

On September 9, 2025, the White House released the Make Our Children Healthy Again (MAHA) Strategy, an inter-agency plan the U.S. Department of Health and Human Services (HHS) describes as "sweeping," with more than 120 initiatives spanning food, health, education, and research. Actions related to food contact chemicals and materials include

investigating new approach methodologies (NAMs, FPF reported), a focus on microplastics (FPF reported), GRAS reform (FPF reported), and removing harmful chemicals from the food supply (FPF reported). The plan also highlights expanded federal research on environmental exposures and cumulative risks (FPF reported, also here).

The Strategy is divided into four sections, (i) advance research, (ii) realign incentives, (iii) foster private sector collaboration, and (iv) increase public awareness. Sections (i) and (ii) contain actions related to food contact chemicals and materials.

Advance research

New Approach Methodologies (NAMs). According to the strategy, the Environmental Protection Agency (EPA), Food and Drug Administration (FDA), and National Institutes of Health (NIH) "have all committed to using NAMs moving forward, when appropriate." Techniques such as organoid models, computational simulations, and the integration of real-world data could generate faster, more predictive insights into chronic disease mechanisms. The goal is to improve prevention, diagnosis, and personalized care while reducing reliance on animal studies "that often fail to replicate complex human conditions."

Read More

Food Packaging Forum, 11-09-25

https://foodpackagingforum.org/news/white-house-publishes-strategy-to-address-childhood-chronic-disease-in-the-us

EUROPE

The Fluoropolymers Products Group Releases Comprehensive Guide on Safe Handling of Fluoropolymer Resins as part of its Manufacturing Programme

2025-09-03

The members of the Fluoropolymer Product Group (FPG) are pleased to announce the release of their updated guide for the safe handling, processing and waste management of fluoropolymer resins, aiming at equipping the industry and its downstream users with robust safety information and best practices in emission control.

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The Guide for the Safe Handling of Fluoropolymer Resins is an essential pillar of FPG's Manufacturing Programme; a voluntary, industry-led initiative, launched in September 2023. The Programme sets a new benchmark for emissions control in fluoropolymer production across European manufacturing sites to ensure the safe and continued use of these critical, advanced materials.

Overview of the Manufacturing Programme

At the end of 2024, FPG's members completed the first milestone in their Manufacturing Programme by successfully meeting their emissions reduction targets for non-polymeric PFAS. The Programme comprises three pillars, more specifically:

- An industry-led commitment to achieve average emissions factors for non-polymeric PFAS residues from polymerisation aid technology that is used in the fluoropolymer manufacturing process:
  - **By end 2024:** 0.009% to air; 0.001% to water.
  - **By end 2030:** 0.003% to air; 0.0006% to water.
- A commitment to inform downstream users of fluoropolymers on their safe handling and use in the Guide for the Safe Handling of Fluoropolymer Resins.
- A platform to exchange information on commercially available state-of-the-art technologies to minimise non-polymeric PFAS emissions in manufacturing.

Read More

Fluoropolymers Products Group, 03-09-25

https://fluoropolymers.eu/2025/09/03/fpgs-releases-comprehensive-guide-on-safe-handling-of-fluoropolymer-resins/

Datasets per country: Biota PFOS monitoring data from seven Member States

2025-09-02

This document contains the datasets that form the basis for the assessment of the extent of PFOS contamination of freshwater and coastal fish in the EEB briefing "Forever chemicals poisoning Europe's waters and fish: The tip of the PFAS iceberg".

The datasets contain monitoring data of PFOS in biota from Austria, France, Germany, Italy, Poland, Spain, and Sweden reported between 2009 and 2023.

Read More

EEB, 02-09-25

https://eeb.org/library/118601/

Emergency authorisation to use, sell, supply or store a pesticide product

2025-09-12

This guidance is for anyone who is applying for an emergency authorisation to use, sell, supply or store a plant protection product (PPP). Emergency authorisations allow a plant protection product (PPP) to be placed on the market for limited and controlled use. They may be granted in special circumstances where the PPP is necessary because of a danger that cannot be contained by any other reasonable means.

Read More

UK HSE, 12-09-25

https://www.hse.gov.uk/pesticides/applicant-guide/emergency-authorisations.htm

INTERNATIONAL

Commission proposes Mercosur and Mexico agreements for adoption

2025-09-03

The European Commission has put forward its proposals to the Council for the signature and conclusion of the EU-Mercosur Partnership Agreement (EMPA) and the EU-Mexico Modernised Global Agreement (MGA). These landmark deals form a critical part of the EU's strategy to diversify its trade relations and strengthen economic and political ties with like-minded partners around the world.

These partnerships will create billions of euro's worth of export opportunities for EU companies of all sizes, contribute to economic growth and competitiveness, support hundreds of thousands of European

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jobs, and promote EU interests and values. They will strengthen value chains, and help the EU to widen its range of reliable sources for critical inputs and raw materials. In a time of growing geopolitical instability, these agreements bind us closer to strategically important partners, providing a shared platform to strengthen mutual trust and tackle shared global challenges, including the modernisation of the rules-based global trading system.

Both agreements reaffirm our joint commitment to human rights, multilateralism and international peace and security. They will also reinforce our engagement on key issues such as sustainable development, transnational organised crime, and migration.

Read More

European Commission, 03-09-25

https://ec.europa.eu/commission/presscorner/detail/en/ip_25_1644

UNECE tools to help turn waste into resources

2025-09-03

The world's reliance on raw materials is rising just as the pressure to cut emissions and safeguard ecosystems grows. New research shows the stakes: a Science study found that by-product recovery from U.S. metal mines alone could sharply reduce dependence on imported critical minerals. Globally, the potential is even greater.

These innovative approaches were highlighted at the World Resources Forum 2025 – "New Strategies for a Sustainable Future", Geneva, 2-3 September.

"But unlocking this opportunity requires more than technology. It demands standards, transparency, and systems that keep resources circulating through the economy instead of being lost as waste," said Tatiana Molcean, Executive Secretary, UNECE, opening the Forum. This is where UNECE is stepping up.

Tackling Resource Pressure across the Life Cycle

Mitigating pressure on resources starts at the very beginning of their life cycle.

- During extraction, processing and refining: UNECE's United Nations Framework Classification for Resources (UNFC) and the United Nations Resource Management System (UNRMS) provide tools to classify

and manage resources with full social, environmental and economic accountability. They are life cycle frameworks that ensure resource development is transparent, sustainable, and aligned with the Sustainable Development Goals.

- At the stage of primary demand: Digital and artificial intelligence technologies are helping to reduce the need for physical hardware and the resources they consume. From energy efficiency solutions to resource servitization models, digital innovation is becoming a powerful lever to cut material intensity.
- In the demand for secondary resources: UNECE's UNFC and UNRMS provide the key drivers for integrating secondary resources into national policies and corporate strategies. They are already embedded in the EU Critical Raw Materials Act, in the African AMREC/PARC system, and are being scaled through International Centres of Excellence on Sustainable Resource Management. Building on this foundation, UNECE is also advancing transparency and trust through the UN Transparency Protocol, which enable supply chain data to be exchanged across borders in interoperable, verifiable formats. In cooperation with ISO, work on Digital Product Passports further ensures that information on the origin, composition, and sustainability of products is accessible throughout their life cycle. Together, these innovations create the conditions needed to enable circularity at scale.

Read More

UNECE, 03-09-25

https://unece.org/climate-change/news/unece-tools-help-turn-waste-resources

SME registrants: check your company size and documents

2025-09-11

If you declared that your company is micro, small or medium-sized (SME), check that you have claimed the SME fee reductions correctly when registering your substance in REACH-IT. If the size was declared incorrectly, inform ECHA to avoid an administrative charge.

Helsinki, 9 September 2025 – We are continually initiating new verifications on the size of companies who have declared they are an SME at the time of their REACH registration.

If you notice that your declared company size in REACH-IT is smaller than it actually was at the time of your dossier submission, inform ECHA's Helpdesk.

By declaring and correcting your company size before we begin checking it, you will not have to pay the administrative charge, but only the difference to the correct registration fee.

If we learn during the verification process that you have claimed your size incorrectly, you will have to pay the difference to the correct fee and an administrative charge of up to EUR 19 900.

Help on how to determine your company size is available on ECHA's website.

Remember to upload documents supporting your claimed SME size in REACH-IT, and regularly check your REACH-IT account for new messages and tasks. Make sure to also keep your registrations and contact details up to date.

Read More

ECHA, 11-09-25

https://echa.europa.eu/-/sme-registrants-check-your-company-size-and-documents

Updated classification information for titanium dioxide

2025-09-11

Following the European Court of Justice's ruling of the classification of titanium dioxide, we have updated the relevant information on our websites.

The harmonised classification has been removed from the C&L Inventory and the registry of intentions has been updated. We have also deleted ECHA's guide on classification and labelling of titanium dioxide from our website.

The ruling of the European Court of Justice to annul titanium dioxide's classification is effective from 1 August 2025.

Read More

ECHA, 11-09-25

https://echa.europa.eu/news-and-events/news-alerts

New proposals and withdrawal to harmonise classification and labelling

2025-09-11

Eight proposals have been submitted for:

- ametoctradin (ISO); 5-ethyl-6-octyl[1,2,4]triazolo[1,5-a]pyrimidin-7-amine (EC -, CAS 865318-97-4)
- Hydrolysed chitosan, hydrochloride ((DP)= 25-55; average acetylation degree 0-20%); [OptiCHOS] (EC -, CAS -)
- fluopicolide (ISO); 2,6-dichloro-N-[3-chloro-5-(trifluoromethyl)-2-pyridylmethyl]benzamide (EC -, CAS 239110-15-7)*
- 4-chloroformylphthalic anhydride (EC 214-874-8, CAS 1204-28-0)*
- ethylene bis[1,3-dihydro-1,3-dioxo-iso-benzofuran-5-carboxylate] (EC 217-062-1, CAS 1732-96-3)*
- tetrabromophthalic anhydride (EC 211-185-4, CAS 632-79-1)*
- 1,2,3,6-tetrahydromethyl-3,6-methanophthalic anhydride; [1] and any of the individual isomers and/or combinations thereof [and others] (EC 246-644-8 [1]; 212-585-1; 258-647-1 [and others], CAS 25134-21-8 [1]; 828-66-0; 53584-57-9 [and others])*
- Agrobody, anti-fungal VHH (ASFBIOF01-02)* (EC -, CAS -)

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*chemical name, EC and/or CAS to be confirmed.

A withdrawal has been received for:

- 2,3-epoxypropyl neodecanoate (EC 247-979-2, CAS 26761-45-5)

Read More

ECHA, 11-09-25

https://echa.europa.eu/news-and-events/news-alerts

Janet's Corner

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Who am I?

2025-08-15

I am the eighth element on the periodic table. I'm a nonmetal and a crucial component of the air you breathe, making up about 21% of Earth's atmosphere. I'm highly reactive and support combustion, meaning things burn much more readily in my presence. You need me to live, and I'm often found in compounds with silicon in the Earth's crust.

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

I am the eighth element on the periodic table.

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Hazard Alert

SEP. 19, 2025

Nitrogen Dioxide

2025-09-19

USES [2,3]

Nitrogen dioxide has been used as a catalyst in certain oxidation reactions; as an inhibitor to prevent polymerisation of acrylates during distillation; as a nitrating agent for organic compounds; as an oxidising agent; as a rocket fuel; as a flour-bleaching agent and in increasing the wet strength of paper.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

The major source of nitrogen dioxide in Australia is the burning of fossil fuels: coal, oil and gas. Most of the nitrogen dioxide in cities comes from motor vehicle exhaust (about 80%). Other sources of nitrogen dioxide are petrol and metal refining, electricity generation from coal-fired power stations, other manufacturing industries and food processing. Unflued gas heaters and cookers are the major sources of nitrogen dioxide in Australian homes.

Routes of Exposure

- The general population is primarily exposed to nitrogen dioxide by breathing in air. People who live near combustion sources such as coal burning power plants or areas with heavy motor vehicle use may be exposed to higher levels of nitrogen dioxide.
- Households that burn a lot of wood or use kerosene heaters and gas stoves tend to have higher levels of nitrogen dioxides in them when compared to houses without these appliances.
- Nitrogen dioxide is found in tobacco smoke, so people who smoke or breathe in second-hand smoke may be exposed to it.
- Workers employed in facilities that produce nitric acid or certain explosives like dynamite and trinitrotoluene (TNT), as well as workers involved in the welding of metals may breathe in nitrogen dioxide during their work.

Nitrogen dioxide is the chemical compound with the formula NO_2. It is one of several nitrogen oxides. [1]

HEALTH EFFECTS [4]

Acute Health Effects

- Contact can irritate and burn skin and eyes with possible eye damage.
- Breathing nitrogen dioxide can irritate the throat and nose.
- Breathing nitrogen dioxide can irritate the lungs causing coughing and/or a shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary oedema), a medical emergency, with severe shortness of breath.
- High levels can interfere with the ability of the blood to carry oxygen causing headache, fatigue, dizziness, and a blue colour to the skin and lips (methemoglobinemia).
- Higher levels can cause trouble breathing, collapse and even death.

Carcinogenicity

- Nitrogen dioxide may cause mutations (genetic changes).
- There is no evidence that nitrogen dioxide causes cancer in animals.

Other Effects

- There is limited evidence that nitrogen dioxide may damage the developing foetus; and
- Decrease fertility in females.

SAFETY

First Aid Measures [5]

- If inhaled: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
- In case of skin contact: Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.
- In case of eye contact: Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.
- If swallowed: Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

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Personal Protective Equipment [5]

The following personal protective equipment is recommended when handling nitrogen dioxide:

Eye/face protection

- Tightly fitting safety goggles.
- Faceshield (8-inch minimum).
- Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection

- Handle with gloves.
- Gloves must be inspected prior to use.
- Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product.
- Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices.
- Wash and dry hands.
- The selected protective gloves have to satisfy the specifications of EU Directive 89/686/EEC and the standard EN 374 derived from it.

Body Protection

- Complete suit protecting against chemicals.
- The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory Protection

- Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls.
- If the respirator is the sole means of protection, use a full-face supplied air respirator.
- Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

REGULATION

United States

Exposure Limit	Limit Values	HE Codes	Health Factors and Target Organs
OSHA Permissible Exposure Limit (PEL)-General Industry See29 CFR 1910.1000 Table Z-1	5 ppm (9 mg/m^3) Ceiling	HE10	Chronic bronchitis, emphysema
		HE15	Eye, nose, and upper respiratory irritation
OSHA PEL-Construction Industry See 29 CFR 1926.55 Appendix A	5 ppm (9 mg/m^3) Ceiling	HE10	Chronic bronchitis, emphysema
		HE15	Eye, nose, and upper respiratory irritation
OSHA PEL-Shipyard Employment See 29 CFR 1915.1000 Table Z-Shipyards	5 ppm (9 mg/m^3) Ceiling	HE10	Chronic bronchitis, emphysema
		HE15	Eye, nose, and upper respiratory irritation
National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL)	1 ppm (1.8 mg/m^3) STEL	HE7	Mild headache
		HE10	Bronchiolitis obliterans
		HE11	Acute pulmonary oedema; lower respiratory irritation (cough, dyspnea)
		HE15	Eyes, nose, and throat irritation
American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)(2012)	0.2 ppm (0.38 mg/m^3) TWA A4	HE11	Lower respiratory irritation

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Exposure Limit	Limit Values	HE Codes	Health Factors and Target Organs
CAL/OSHA PEL	1 ppm (1.8 mg/m^3) STEL		

References

1. https://en.wikipedia.org/wiki/Nitrogen_dioxide
2. http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=396&tid=69
3. http://www.environment.gov.au/protection/publications/factsheet-nitrogen-dioxide-no2
4. http://www.c-f-c.com/specgas_products/nitrogen-dioxide.htm
5. http://nj.gov/health/eoh/rtkweb/documents/fs/1376.pdf
6. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=AU&language=en&productNumber=295582&brand=ALDRICH&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Faldrich%2F295582%3Flang%3Den
7. https://www.osha.gov/dts/chemicalsampling/data/CH_257400.html
8. http://www.safeworkaustralia.gov.au/sites/swa/about/Publications/Documents/772/Workplace-exposure-standards-for-airborne-contaminants.docx

Harvard's salt trick could turn billions of tons of hair into eco-friendly materials

2025-09-17

The textile and meat-processing industries produce billions of tons of waste annually in the form of feathers, wool and hair, all of which are rich in keratin - the strong, fibrous protein found in hair, skin and nails.

Turning all that animal waste into useful products - from wound dressings to eco-friendly textiles to health extracts - would be a boon for the environment and for new, sustainable industries. But upcycling proteins is challenging: Breaking down, or de-naturing, proteins into their component parts typically requires corrosive chemicals in large, polluting facilities, keeping any cost-effective protocol out of reach.

Researchers in the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) have uncovered key fundamental chemistry of how proteins like keratin de-nature in the presence of certain salt compounds - an insight that could take protein recycling to the next level.

A team led by Kit Parker, the Tarr Family Professor of Bioengineering and Applied Physics at SEAS, combined experiments and molecular simulations to better illuminate the chemical mechanisms by which salts cause proteins to unfold. They've shown that a solution of concentrated lithium bromide, a salt compound known to break apart keratin, interacts with the protein molecules in a completely unexpected way - not by binding to the proteins directly, as was conventional wisdom, but by changing the structure of the surrounding water molecules to create a setting more favorable for spontaneous protein unfolding.

This insight allowed the researchers to design a gentler, more sustainable keratin extraction process, separating the protein out of solution easily and without the need for harsh chemicals. The process can also be reversed with the same salt mixture, enabling recovery and reuse of lithium bromide denaturants.

The research is published in Nature Communications and is also featured in a Behind the Paper blog post.

Inspired by keratin biomaterials

First author Yichong Wang, a graduate student in chemistry who works in Parker's group, said the research builds on the lab's longstanding interest in developing keratin biomaterials with shape memory for biomedical applications. They had previously observed that keratin extracted from

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lithium bromide solvents can form thick, shapeable gels that readily separate from the surrounding solution and solidify almost immediately when placed back in water. While useful, they found the behavior odd, and they wanted to understand it better.

"We thought there might be a gap between current mechanistic understanding of how de-naturation works, and what we were seeing," Wang said. "That's when we got very interested in the mechanism itself to see if we could optimize our extraction procedures by explaining this phenomenon better."

Molecular dynamics reveals shifts in surrounding water

To dig deeper, the team turned to the lab of Professor Eugene Shakhnovich in the Department of Chemistry and Chemical Biology, whose expertise is in protein biophysics. Molecular dynamics simulations led by co-author Junlang Liu allowed them to see that the lithium bromides were not working on the proteins at all, but rather, on the water around them.

It turns out lithium bromide ions cause water molecules to shift into two different populations - normal water, and water molecules that become trapped by the salt ions. As the normal water volume decreases, the proteins start to unfold due to the thermodynamic shift in the environment, rather than being directly ripped apart like in other de-naturation methods. "Making the water less like water, allows the protein to unfold itself," Wang said. They had similar results by testing simpler proteins like fibronectin, pointing to a universal mechanism.

Better understanding and designing protein extraction methods that are less energy-intensive and less polluting than conventional ones opens potential avenues for protein-upcycling industries. In the Parker lab, using keratin as a substrate for tissue engineering is a major research thrust; having a reliable, sustainable method to extract and re-use such products would bolster their efforts.

What's more, the process could lay a path for a whole new biomaterials industry, turning a massive waste stream like hair or chicken feathers into low-cost recycled materials, possibly as an alternative for traditional plastics, for example.

Sciene Daily, 17 September 2025

https://sciencedaily.com

"Lightning"-fast process turns toxic red mud into tough ceramics

2025-09-17

Aluminum production creates a toxic byproduct known as red mud. In an effort to cut down on this waste, researchers have figured out a way to send electric pulses through the mud to purify it and allow it to be reused instead of discarded.

The aluminum-creation process begins with bauxite ore, a raw material that contains desirable aluminum-rich minerals but also a host of impurities including silica and iron and titanium oxides. To get to the aluminum, crushed bauxite is mixed with a hot and concentrated sodium hydroxide solution. This allows the aluminum minerals to dissolve while other impurities remain solid.

After the solution settles or is filtered, the aluminum minerals are harvested, forming a material known as alumina, and the rest of the materials form a solid waste known as red mud. This waste product is highly toxic because of its high alkalinity and heavy metal concentration. It is estimated that for every ton of alumina produced, one to two tons of red mud is created.

Seeking a way to reuse this waste stream, researchers from Rice University turned to a process known as flash Joule heating, in which they zapped red mud with a short high-powered electrical pulse, akin to a flash of lightning. This vaporized the harmful metals in the red mud, and left behind a purified compound rich in aluminum. They found that adding a small amount of chlorine gas to the chamber containing the red mud improved the process.

"The speed and simplicity of this method set it apart," said Qiming Liu, co-first author of the study. "In just 60 seconds, we extracted 96% of the iron and nearly all the toxic species, while retaining almost all the aluminum."

The researchers then turned the purified red mud into super-strong ceramics, which, they say, can be used as building materials. They also say that the cleaned mud could also be used over again to create more aluminum.

"Our research presents a potential game-changing solution for the red mud crisis," said James Tour, the study's corresponding author. "This advance is massive from an industrial perspective, turning what was once a toxic liability into a valuable asset in under one minute."

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Purifying the red mud offers multiple environmental benefits, says the research team, including a reduced need for bauxite mining, lower greenhouse gas emissions, and a cleaning up of toxic waste piles that cause environmental disasters.

The new method is now being scaled up by Flash Metals USA, a spinoff from Rice. The team says it can potentially be used in other industries such as steel manufacturing. It joins another method reported last year in which red mud was processed via plasma into green steel as an additional way to deal with the toxic substance, which is produced at a rate of nearly 200 million tons per year.

"This is not just about red mud; it's about changing our perspective on waste," concluded Tour. "If we can apply this method to other industrial residues, it could represent the beginning of a new era in sustainable materials recovery."

The research has been reported in the journal Applied Materials and Interfaces.

New Atlas, 17 September 2025

https://newatlas.com

Artificial Sweeteners May Speed Up Cognitive Decline

2025-09-03

Artificial sweeteners are everywhere, yet their effects on the brain are largely unknown.

New research in Neurology, the medical journal of the American Academy of Neurology, found that frequent consumption of several artificial sweeteners may accelerate cognitive decline, especially in middle-aged adults and those with diabetes.

Artificial sweeteners may influence brain aging

Global dementia cases are set to nearly triple from ~57 million in 2019 to ~153 million by 2050. Although aging populations and rising chronic diseases are major drivers behind this increase, it isn't the whole story. Many forms of dementia are not inevitable and lifestyle choices, from diet and exercise to managing blood sugar, play a big part in how the brain ages.

Ultra-processed foods – such as sodas, desserts, flavoured yogurts, etc., – have been linked to faster cognitive decline and higher dementia risk.

These products often contain artificial sweeteners, which have been marketed as safe alternatives to sugar, and are widely used by people trying to cut calories or manage diabetes.

However, the science on sweeteners and brain health is unclear, and "little is known about the association between consumption of low- and no-calorie sweeteners and cognition," explained the authors of the latest paper.

A few studies have tied saccharin or sucralose to higher dementia risk or poorer memory, while others reported no effect at all. Until now, no long-term, large-scale study has tested the impact of several different sweeteners on cognitive decline.

She added: "While we found links to cognitive decline for middle-aged people both with and without diabetes, people with diabetes are more likely to use artificial sweeteners as sugar substitutes."

Although the results don't prove that sweeteners cause decline, they may raise concerns to warrant caution. The data suggest that not all substitutes are equal, and natural options such as tagatose, or sweeteners from fruit or honey, may be safer choices for long-term brain health.

"More research is needed to confirm our findings and to investigate if other refined sugar alternatives, such as applesauce, honey, maple syrup or coconut sugar, may be effective alternatives," said Suemoto.

However, diet was self-reported, which leaves room for error. Additionally, only the baseline diet was recorded, meaning changes over time were missed. There was also no brain imaging to test mechanisms, and some widely used sweeteners, such as sucralose and stevia, weren't studied.

Future work will need to replicate these results in other groups, test biological pathways and run controlled trials.

The latest research followed more than 12,000 adults in Brazil for nearly a decade, tracking their use of 7 common sugar substitutes, from aspartame to tagatose, measuring changes in thinking and memory.

Artificial sweeteners linked to faster memory loss

The study used data from the Brazilian Longitudinal Study of Adult Health, which included 12,772 civil servants with an average age of 52 years. People with dementia, Parkinson's or incomplete records were excluded.

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At the start of the study, participants filled out detailed food frequency questionnaires covering the previous year. From this, the team estimated intake of seven sweeteners: aspartame, saccharin, acesulfame-K, erythritol, xylitol, sorbitol and tagatose. Based on consumption, participants were sorted into three groups, from lowest to highest intake.

Cognitive testing was conducted at baseline and repeated at follow-ups, which covered memory, verbal fluency, processing speed and a combined measure of global cognition.

The participants in the middle consumption group had a 35% faster decline in global cognition compared to the lowest group, equivalent to ~1.3 extra years of aging. Those in the highest group had a 62% faster decline, or ~1.6 years of added aging.

However, the link was seen only in people under 60 years old, with no association found in those older than 60 years. Diabetes also amplified the effect; among participants with diabetes, higher intake was linked to stronger declines, particularly in memory.

Looking at individual sweeteners, aspartame, saccharin, acesulfame-K, erythritol, xylitol and sorbitol were all tied to faster decline. Tagatose stood out as the only one without harmful associations.

Daily users also showed faster decline compared to occasional users, underscoring that even moderate long-term intake may matter for brain health.

Implications for middle-aged adults and diabetes management

The study points to a sobering possibility: some sugar substitutes may speed up cognitive aging, especially in middle-aged adults. Common sweeteners such as aspartame and saccharin showed the strongest links – a concerning finding for those with diabetes.

"Low- and no-calorie sweeteners are often seen as a healthy alternative to sugar; however, our findings suggest certain sweeteners may have negative effects on brain health over time," said corresponding author Dr. Claudia Kimie Suemoto, an associate professor of geriatrics at the University of São Paulo.

She added: "While we found links to cognitive decline for middle-aged people both with and without diabetes, people with diabetes are more likely to use artificial sweeteners as sugar substitutes."

Although the results don't prove that sweeteners cause decline, they may raise concerns to warrant caution. The data suggest that not all substitutes are equal, and natural options such as tagatose, or sweeteners from fruit or honey, may be safer choices for long-term brain health.

"More research is needed to confirm our findings and to investigate if other refined sugar alternatives, such as applesauce, honey, maple syrup or coconut sugar, may be effective alternatives," said Suemoto.

However, diet was self-reported, which leaves room for error. Additionally, only the baseline diet was recorded, meaning changes over time were missed. There was also no brain imaging to test mechanisms, and some widely used sweeteners, such as sucralose and stevia, weren't studied.

Future work will need to replicate these results in other groups, test biological pathways and run controlled trials.

Technology Networks, 3 September 2025

https://technologynetworks.com

Low-cost biosensor can detect airborne viruses in real-time

2025-09-17

A research team from Universitat Politècnica de València (UPV) and Universitat de València (UV) has developed an innovative biosensor capable of detecting airborne viruses in real-time and at low cost, without the need for chemical markers or laboratory procedures.

This device offers multiple potential applications, including detecting bacteria in hospitals, schools, and transport, thereby increasing safety. The results of this work are published in the journal Talanta.

"After the experience with COVID-19, it is easy to understand that determining the presence of pathogens in the air is vital, as it allows us to take preventive measures. Beyond the coronavirus, there are other microorganisms with a high impact on health and the economy, such as hospital superbugs, avian flu and plant pathogens, which makes it essential to monitor indoor environments," says David Giménez, a researcher at the University of Valencia.

Currently, the most common method for assessing the presence of pathogens in the air is to sample the air for a period of time and

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collect possible pathogens in Petri dishes or collector solutions. The microorganisms are then identified or quantified in the laboratory.

"The main drawback is that this sampling and analysis process is very time-consuming, even taking days," explains Patricia Noguera, from the Universitat Politècnica de València.

In recent years, some systems that use specific receptors have been developed to detect the presence of pathogens in the air in real-time; however, the equipment is often large and expensive. In addition, they usually have another problem: the need for additional reagents. "This is precisely the main innovation of the sensor developed by our team: it does not require additional reagents," says Noguera.

Over the last two years, the electronics and chemistry experts from the UPV and UV team have developed the biosensor from scratch, designing and manufacturing the electronics and managing to detect the M13 virus without the need for additional reagents.

"We chose to work with this virus because it is easy to handle and, as a proof of concept, our results can be extrapolated to any other pathogen, in any environment," concludes Giménez.

Phys Org, 17 September 2025

https://phys.org

Porphyrin ring pushes the size limit for fully aromatic molecules

2025-09-17

A nanoring with a diameter of eight nanometres is the largest molecule yet to show global aromaticity. While aromaticity is usually seen in smaller rings, the new structure pushes the size limit for the phenomenon.

Five years ago, a molecular wheel made from 12 porphyrins linked together by butadiyne units became the world's largest aromatic ring. That structure was produced by a team led by the University of Oxford's Harry Anderson. Now, Anderson's lab has gone bigger, constructing an larger ring that the researchers say 'defines the upper size limit to global aromaticity' in this kind of structure.

This new nanoring consists of 18 zinc porphyrins arranged cyclically and connected by butadiyne linkages. The team designed radial 18-legged templates that act like spokes to hold the ring in shape.

The nanoring's circular structure was confirmed by scanning tunnelling microscopy, while19F NMR spectroscopy and computational modelling revealed measurable ring currents that relate to electron delocalisation at certain oxidation states. When the molecule is in the 10+ state, 242 π electrons participate in the aromatic system.

However, the ring currents are at least two times weaker than those seen in the 12-porphyrin ring, with only a fraction of molecules adopting the right conformation to sustain delocalisation around the entire circumference.

According to Anderson's team, the weakness of the ring current suggests that the nanorings have reached the upper size limit for global aromaticity. However, they note that more rigid macrocycles like fused porphyrin nanobelts may enable ring currents to persist in even larger structures.

Chemistry World, 17 September 2025

https://chemistryworld.com

'Green Lantern' bacteria light up invisible microplastic particles

2025-09-12

One of the problems with microplastics pollution lies in the fact that the plastic particles can be so small, we don't even know they're present in water in the first place. A new type of engineered bacteria could help, by causing those microparticles to glow green.

By definition, microplastics are fragments of plastic smaller than 5 millimeters in diameter.

Found in waterways around the world, they come from a number of sources. These include chunks of floating plastic waste that break down into smaller pieces; products such as toothpaste which contain plastic microbeads; synthetic clothing that sheds fibers while being washed; and car tires that release bits of rubber which make their way into storm sewers.

Researchers are still trying to understand how people's health may be affected by ingesting the particles in and of themselves. That said, harmful bacteria are often drawn to microplastics, living on or around the particles – and we definitely shouldn't be eating or drinking those microbes.

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There are already methods of detecting microscopic plastic particles in water – methods such as Raman or infrared spectroscopy – but they are fairly time-consuming and labor-intensive. In other words, they're not practical to perform on a widespread, ongoing basis. That's where the altered Pseudomonas aeruginosa bacteria come in.

Prof. Song Lin Chua and colleagues from Hong Kong Polytechnic University added two genes to a non-infectious strain of the microbe. One of these genes produces a protein that becomes active when the bacteria come into contact with plastic, while the other gene produces another protein which fluoresces green in response to the first one.

It does so within three hours, and works on a number of different plastics. And what's more, the bacteria remain viable for up to three days if stored at a temperature of 39 ºF (4 ºC).

When tested on filtered seawater samples from a city's sewer system, the engineered bacteria were able to detect the presence of microplastic types such as polyacrylamide, polycaprolactone and methyl cellulose.

"Our biosensor offers a fast, affordable and sensitive way to detect microplastics in environmental samples within hours," says Chua. "By acting as a rapid screening tool, it could transform large-scale monitoring efforts and help pinpoint pollution hotspots for more detailed analysis."

A paper on the research was recently published in the journal ACS Sensors.

New Atlas, 12 September 2025

https://newatals.com

'Inert' scandium unlocked as a powerful blue-light photocatalyst

2025-09-16

Scientists at the University of Chemistry and Technology, Prague (UCT Prague) have revealed a new catalytic role for scandium, an element whose salts were long considered to be redox stable, i.e. not participating in redox reactions. Published in Nature Communications, their research shows a simple scandium salt can act as a potent photocatalyst, using blue light to drive important organic oxidation reactions.

Led by Professor Radek Cibulka, the team demonstrated that scandium triflate ($Sc(OTf)_3$) efficiently powers key chemical transformations, including the aerobic oxidation of compounds like toluene into valuable

acids using oxygen from the air and the direct C-C bond formation needed to attach cyano groups to aromatic rings—a vital step in drug discovery.

The discovery overturns the long-held belief that scandium is "redox-inert" and unsuited for photocatalysis, providing an alternative to traditional catalysts based on expensive, rare metals like iridium and ruthenium. "The discovery was completely unexpected," says Prof. Cibulka. "It points to a completely new application for scandium, a relatively abundant but neglected metal."

The team's research shows that scandium's strong affinity for oxygen is key. The scandium ion forms a complex with molecular oxygen, and it is this scandium-oxygen complex that absorbs the light. In its energized state, it can strip an electron from an organic molecule, initiating the chemical reaction. This crucial scandium-superoxide intermediate was directly observed, confirming the novel mechanism.

The work, part of the Eco&Stor project, was a collaboration between UCT Prague, the J. Heyrovský Institute of Physical Chemistry, and international partners.

Phys Org, 16 September 2025

https://phys.org

First Measurement of Boron in Single Cancer Cells Could Transform Drug Research

2025-09-10

A new technique has measured boron in individual cancer cells for the first time, enabling researchers to better understand how drugs act to kill tumors in some cancers.

In a new article in the Journal of Analytical Atomic Spectrometry, a team from the University of Birmingham funded by the Rosetrees Trust have for the first time used a technology to conduct real-time measurement of boron in live tumor cells. The technique, called single-cell ICP-MS, enabled the team to see how and when treatments for head and neck cancers enter and exit tumor cells.

Boron Neutron Capture Therapy (BNCT) is a new form of therapeutic for head and neck cancer that involves patients taking a drug containing the element boron that accumulates in tumour cells. The tumour is subsequently irradiated with neutrons that interact with boron which selectively kills cancer cells. BNCT relies on the drug getting into cancer

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cells at a sufficient level and then remaining there long enough for the neutron irradiation to be administered.

With this newly tested technique, researchers can begin to understand how to most effectively deliver BNCT for patients with head and neck cancers as a precision treatment.

Dr. James Coverdale from the School of Pharmacy at the University of Birmingham said: "Until now, it's only been possible to measure average boron uptake in hundreds-of-thousands of cells, which masks important differences between individual cells. Our single-cell approach reveals this variability, which is critical in a tumor setting where heterogeneity often determines whether treatment works or fails.

"We believe the results are exciting because we now have the first direct evidence of how much boron is present in individual tumor cells, and how long it stays there. This information could help to optimise when neutron irradiation should be delivered relative to drug administration. By showing which transport pathways bring boron into cells, the work also offers clues for designing better drugs that accumulate more effectively. For the cancer drug discovery community, this study opens a new way of evaluating BNCT drug candidates."

A key breakthrough was creating the right environment for cells to stay alive long enough for measurement, while maintaining compatibility with the highly sensitive equipment. This challenge required the team to carefully optimise both the culture medium and the way cancer cells were introduced into the instrument. Without this step, the cells would rapidly deteriorate, making it impossible to capture meaningful data.

Jack Finch, co-first author of the study and University of Birmingham Biochemistry alumni said: "This will be vital for testing and comparing future BNCT drugs and will help to identify the most effective treatments. Ultimately, our work supports progress toward making the already promising BNCT into a more precise and effective cancer treatment."

According to Cancer Research UK, Head and neck cancer is the 8th most common cancer in the UK, accounting for 3% of all new cancer cases (2017-2019).

Technology Networks, 10 September 2025

https://technologynetworks.com

Scientists Transform Plastic Waste Into Efficient CO2 Capture Materials

2025-09-08

As CO2 concentrations in the atmosphere keep rising regardless of years of political intentions to limit emissions, the world's oceans are drowning in plastics, which threatens marine environments and ecosystems.

The key global problems are often interconnected, and typically, the solution to one problem creates another one while the clock keeps ticking. But what if we could solve several problems at the same time?

It's almost too good to be true, but a new cutting-edge invention promises to do just that. Researchers at the University of Copenhagen have developed a method where one man's trash really does become another man's "treasure", when decomposed PET plastic becomes the main ingredient in efficient and sustainable CO2 capture.

We know the material from plastic bottles, textiles, and many other uses: PET plastic is one of the most widely used types of plastic in the world, but when it has served its purpose, it becomes a pressing global environmental issue. This is because it ends up in landfills in many parts of the world, where it breaks down into polluting microplastics that spread to the air, soil and groundwater. A large portion also end up in the oceans.

"The beauty of this method is that we solve a problem without creating a new one. By turning waste into a raw material that can actively reduce greenhouse gases, we make an environmental issue part of the solution to the climate crisis," says Margarita Poderyte from the Department of Chemistry at the University of Copenhagen, lead author of the research paper disclosing the invention.

The solution is a potential win-win on a global scale, where plastic waste not only does not end up in nature but also becomes an active player in climate mitigation.

With the new chemical technology, researchers can transform PET plastic waste that is overlooked by recyclers into a primary resource in a new form of CO2 sorbent they have developed. The process 'upcycles' it to a new material the researchers have named BAETA, which can absorb CO2 out of the atmosphere so efficiently that it easily compares with existing carbon capture technologies.

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Sustainable, flexible and scalable

The BAETA material has a powdery structure that can be pelletized, and a chemically 'upgraded' surface, which enables it to very effectively bind and chemically capture CO2. Once saturated, CO2 can be released through a heating process allowing the CO2 to be concentrated, collected and stored or converted into a sustainable resource. In practice, the researchers expect the technology to be first installed on industrial plants with exhausts from chimneys passing through BAETA units to cleanse them of CO2.

The research paper is published in Science Advances journal, which describes the chemical process behind the invention. The process is gentle compared to existing technologies and, at the same time, well-suited for industrial scaling.

"The main ingredient is plastic waste that would otherwise have an unsustainable afterlife, and the synthesis we use, where the chemical transformation takes place, is gentler than other materials for CO2 capture because we can make the synthesis in ambient temperatures. It also has the advantage that the technology can be scaled up more easily," Margarita Poderyte says.

She is seconded by co-author and Associate Professor at the Department of Chemistry, Jiwoong Lee, who highlights the material's flexibility also.

"One of the impressive things about this material is that it stays effective for a long time. And flexible. It works efficiently from normal room temperature up to about 150 degrees Celsius, making it very useful. With this kind of tolerance to high temperatures, the material can be used at the end of industrial plants where the exhausts are typically hot," Jiwoong Lee says.

From laboratory to innovation at the end of the chimney

With a potentially revolutionary idea, a proven method and an effective finished product, the researchers are now ready for the next step.

"We see great potential for this material, not just in the lab, but in real-life industrial carbon capture plants. The next big step is scaling up to produce the material in tonnes, and we're already working to attract investments and make our invention a financially sustainable business venture," Margaryte Poderyte says.

The technical challenges do not worry the researchers. Instead, the decisive challenge, they say, is to persuade decision-makers to make the necessary investments. If they succeed in that, the invention could ultimately lead to significant changes.

A sea of cheap plastic

Large amounts of PET plastic accumulate in our oceans, damaging ecosystems and breaking down into microplastics, the consequences of which are yet unknown. That sort of plastic is very well suited for the technology.

"If we can get our hands on the highly decomposed PET plastic floating in the world's oceans, it will be a valuable resource for us as it's so well suited for upcycling with our method," Margarita Poderyte says.

The researchers hope that their invention can help to fundamentally change the way we see climate and environmental issues as separate problems.

"We're not talking about stand-alone issues, nor will the solutions be. Our material can create a very concrete economic incentive to cleanse the oceans of plastic," Jiwoong Lee says.

Technology Networks, 8 September 2025

https://technologynetworks.com

Forever Chemicals Are More Acidic Than We Thought

2025-09-05

One of the ways that per- and polyfluoroalkyl substances (PFAS) earn their "forever chemical" nickname and persist in the environment is their acidity.

Many of these toxic chemicals are highly acidic, meaning they easily give up their protons and become negatively charged. This allows them to dissolve and spread in water more easily.

Now, new research has found that some PFAS are even more acidic than previously thought — an insight critical for predicting their mobility in the environment and potential impacts on human health.

It comes from a University at Buffalo-led team that introduced a new and rigorous experimental method to determine the acidity of 10 types of PFAS and three of their common breakdown products.

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Published last month in Environmental Science & Technology Letters, their measurements of these chemicals' acid dissociation constant, or pKa, were mostly lower, in some cases dramatically, than those reported in experimental studies and predicted by computational chemistry models. In one case, the pKa of GenX, a replacement for perfluorooctanoic acid (PFOA) in the manufacturing of Teflon, was found to be about one thousand times lower than the measurement listed in a previous study.

The lower the pKa, the more likely a chemical is to give up a proton and exist in its charged form.

"These findings suggest that previous measurements have underestimated PFAS' acidity. This means their ability to persist and spread in the environment has been mischaracterized, too," says the study's corresponding author, Alexander Hoepker, PhD, a senior research scientist with the UB RENEW Institute.

More accurate pKa measurements help efforts to understand the behavior of PFAS in the environment. A chemical's pKa could mean the difference as to whether it remains dissolved in water, sticks to soil or a biological membrane or perhaps volatilizes into the air.

"If we're going to understand how these concerning chemicals spread, it's very important we have a reliable method for the accurate determination of their pKa values," says Diana Aga, PhD, director of RENEW and SUNY Distinguished Professor and Henry M. Woodburn Chair in the UB Department of Chemistry.

The work was supported by the National Science Foundation and done in collaboration with Scott Simpson, PhD, professor and chair of the St. Bonaventure University Department of Chemistry, and researchers from Spain's Institute of Environmental Assessment and Water Research.

Combining experiments with computations

PFAS are made of a highly fluorinated, water-repelling tail and a more water-loving headgroup. Many of the most scrutinized PFAS have a highly acidic headgroup, making them more likely to give up a proton and exist in its charged form.

Whether a PFAS exists in its neutral or charged form depends on the pH level of their surrounding environment. That's where pKa comes in. It tells scientists the pH level at which a given PFAS is equal to flip from neutral to charged, or vice versa.

But there has been much disagreement about the pKa measurements of some PFAS, like perfluorooctanoic acid (PFOA), with different teams coming up with widely different values. One of the reasons for this may be the glass used during their experiments.

"PFAS likes to stick to glass. When that happens, it throws off traditional, so-called bulk measurements that quantify how much PFAS is in a solution," Hoepker says. "In other cases, too much organic solvent is used to get PFAS into solution, which similarly biases the pKa measurement."

To address this challenge, the UB team used fluorine and proton (hydrogen) nuclear magnetic resonance (NMR) spectroscopy — think MRI for molecules. NMR places a sample in a strong magnetic field and probes its atomic nuclei with radio waves.

When a PFAS headgroup is negatively charged, nearby fluorine atoms respond at a different (radio) frequency.

Reading these atom-level signatures lets the researchers tell whether a PFAS molecule is charged or neutral — capabilities that other methods that have been used previously cannot provide.

"This unique measurement allows NMR to inherently account for PFAS losses to glass or other adsorption behaviors, so your pKa measurements don't end up way off the mark," Hoepker says.

Some PFAS are so acidic (pKa of less than zero) that generating them in their neutral form would require super-acidic conditions (a pH level of less than zero) that are impractical in standard labs. In those cases, the research team paired NMR experiments with electronic-structure calculations using density functional theory to predict the NMR shifts of the neutral and ionized forms.

"We augmented partial NMR datasets with computational predictions to arrive at more accurate pKa values," Hoepker says. "This NMR-centered hybrid approach — integrating experimental measurements with computational analyses — enhanced our confidence in the results and, to our knowledge, has not previously been applied to PFAS acidity."

Problem PFAS measured more accurately

The PFAS that has been the most difficult to measure is PFOA, once commonly used in nonstick pans and deemed hazardous by the Environmental Protection Agency last year.

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The team found its pKa to be –0.27, meaning it will be negatively charged at practically any realistic pH level. Previous experimental studies had measured its pKa as high as 3.8 and more commonly around 1, while the computational methods COSMO-RS and OPERA had determined its pKa at 0.24 and 0.34, respectively.

Trifluoroacetic acid (TFA) — an emerging PFAS increasingly detected in waters worldwide and likely transported through the atmosphere and deposited by rain — was found to be far more acidic than previously reported, with a pKa of around 0.03. Earlier estimates had anywhere from 0.30 to 1.1.

Notably, the team determined the pKa values for several prominent emerging PFAS that had never been measured, such as 5:3 fluorotelomer carboxylic acid (5:3 FTCA), and PFAS ethers like NFDHA and PFMPA that are newer PFAS but are also likely to pose challenges for regulators due to their health effects.

"This new experimental approach of determining pKa values for PFAS will have wide-ranging applications, from being able to validate computationally derived values, to facilitating the development of machine learning models that can better predict pKa values of newly discovered PFAS contaminants when reference standards are not available," Aga says. "In turn, knowledge of the pKa values of emerging PFAS will allow researchers to develop appropriate analytical methods, remediation technologies, and risk assessment strategies more efficiently."

Technology Networks, 5 September 2025

https://technologyhnetworks.com

Nanoplastics Disrupt Energy Metabolism in Brain Cells

2025-09-16

Scientists from the Trinity Biomedical Sciences Institute (TBSI) have discovered how nanoplastics – even smaller than microplastics – disrupt energy metabolism in brain cells. Their findings may have implications for better understanding neurodegenerative diseases characterised by declining neurological or brain function, and even shed new light on issues with learning and memory.

The study, led by Dr Gavin Davey and undergraduate Devin Seward from Trinity's School of Biochemistry and Immunology, has revealed the specific mechanism by which these tiny nanoplastics can interfere with energy production in the brain in an animal model. The findings, recently published in the Journal of Hazardous Materials: Plastics, provide fresh insights into the potential health risks posed by environmental plastics.

Polystyrene nanoplastics (PS-NPs) are produced when larger plastics break down in the environment. These particles have been detected in multiple organs in the body, including the brain, sparking growing concerns about their possible role in neurological disease.

The Trinity team focused on mitochondria, the "powerhouses" of cells, which are critical for producing the energy needed for brain function. Mitochondrial dysfunction is a well-known feature of neurodegenerative diseases such as Parkinson's and Alzheimer's, as well as normal ageing.

By isolating mitochondria from brain cells, the researchers showed that exposure to PS-NPs specifically disrupted the "electron transport chain", a simplified term for the set of protein complexes that work together to help generate cellular energy in the form of ATP. While individual mitochondrial complexes I and II were not directly impaired, electron transfer between complexes I–III and II–III, as well as the activity of complex IV, was significantly inhibited.

And although some of the concentrations of PS-NPs used in the study were higher than current estimates of human exposure the scientists found that electron transfer between complex I–III and complex II–III was potently inhibited at much lower concentrations, suggesting environmentally relevant exposures could also impair bioenergetic function over chronic timeframes.

Interestingly, the same broad effects were seen in synaptic mitochondria, which are essential for communication between brain cells. This suggests

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that nanoplastics could also interfere with synaptic plasticity, a process fundamental to learning and memory.

Dr Gavin Davey, who is based in the Trinity Biomedical Sciences Institute, said: "Importantly, the rise of synthetic plastics in the mid-20th century coincided with an increased global exposure to nanoplastics, so this newly discovered mitochondrial mechanism of nanoplastic-induced neurotoxicity may therefore help to explain why rates of neurodegenerative diseases have risen in recent decades, likely adding an environmental dimension to the known genetic and lifestyle risk factors."

"Our results here show a clear mitochondrial mechanism by which nanoplastics can impair brain energy metabolism. This could therefore have major implications for how environmental pollutants contribute to neurological disease and ageing."

The project was originally conceived by Devin in 2023, during his time as a Neuroscience degree student. Supported by the Laidlaw Foundation via a Laidlaw Undergraduate Research and Leadership scholarship, Devin carried out the Devin said: "Coming up with this idea and then being able to develop it in Dr Davey's lab with the support of the Laidlaw Foundation has been an incredible experience. It has given me the opportunity to contribute to important research on environmental health at an early stage in my career, and it's exciting to see our findings published."

The study underscores the urgent need to better understand the health consequences of plastic pollution, while also highlighting the impact of undergraduate-led research supported by the Laidlaw Foundation at Trinity.work in Dr Davey's laboratory in the School of Biochemistry and Immunology.

Technology Networks, 16 September 2025

https://technologynetworks.com

Novel catalyst design could make green hydrogen production more efficient and durable

2025-09-18

A new type of catalyst—a material that speeds up chemical reactions—that could make the production of clean hydrogen fuel more efficient and long-lasting has been developed by a team led by City University of Hong Kong, including researchers from Hong Kong, mainland China, and Japan.

This breakthrough uses high-density single atoms of iridium (a rare metal) to greatly improve the process of splitting water into hydrogen and oxygen, which is key to renewable energy technologies like hydrogen fuel cells and large-scale energy storage.

The researchers created a highly stable and active catalyst by placing single iridium atoms on ultra-thin sheets made of cobalt and cerium compounds. Called CoCe–O–IrSA, the final product performs exceptionally well in the water-splitting process. It requires very little extra energy (just 187 mV of overpotential at 100 mA cm-2) to drive the oxygen evolution reaction at a high rate, and it stays stable for more than 1,000 hours under demanding conditions.

"This research is important because it tackles one of the central challenges in catalysis: how to stabilize high-density single-atom catalysts under working conditions," says Professor Johnny Ho, Associate Vice President (Enterprise) and Professor of the Department of Materials Science and Engineering, who is leading the research.

"By guiding the self-reconstruction of metastable precursors, we achieve atomically dispersed iridium anchored on a well-designed CoCe matrix, maximizing metal-substrate interactions," he adds. This strategy not only enhances catalytic activity but also significantly improves the long-term durability of catalysts for oxygen evolution, a key reaction in water splitting and renewable energy technologies."

One of the biggest challenges in this field has been keeping single metal atoms from clumping together during the reaction, which makes them less effective. The team solved this problem using an innovative method that allows the iridium atoms to arrange themselves into a stable structure under normal conditions.

They tested the catalyst in a real-world setup, using it as part of a system that splits seawater into hydrogen and oxygen. It worked continuously and efficiently for more than 150 hours, showing great promise for practical applications.

The scientists uncovered how the catalyst works at the atomic level through detailed experiments and computer modeling. They found that the single iridium atoms are the key "active sites" where the reaction happens, helping electrons move more easily and boosting the overall efficiency of oxygen production—an essential step in many clean energy systems. Although it may seem far from daily life, this research directly

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supports the development of efficient, sustainable hydrogen production through water electrolysis, even from seawater.

"Hydrogen is a clean fuel with zero carbon emissions when used. As the world shifts away from fossil fuels, our work contributes to making large-scale green hydrogen production more practical, cost-effective, and durable, paving the way for cleaner transportation, energy storage, and industrial processes," explains Professor Ho.

The article, titled "Atomic-scale self-rearrangement of hetero-metastable phases into high-density single-atom catalysts for the oxygen evolution reaction," has been published in Nature Communications .

The next step is to extend this self-reconstruction strategy to other earth-abundant metals and complex multimetallic systems to further reduce the reliance on scarce noble metals. The team aims to integrate these catalysts into full electrolyzer systems and explore their performance in real-world conditions, such as fluctuating power supplies or natural seawater environments, to push the boundaries of practical green hydrogen production.

Phys Org, 18 September 2025

https://phys.org

Why did the EU ban gel nail polish? 3 things to know

2025-09-05

Many people love gel nail polish for its durability and shiny gloss, but a new ban in Europe may have left mani-pedi devotees with some not-so-pretty concerns.

On Sept. 1, the European Union banned one of the key ingredients from being manufactured, sold or commercially used. Nail technicians in salons across the continent need to dispose of polishes containing trimethylbenzoyl diphenylphosphine oxide, or TPO, and switch to alternatives.

The chemical was classified as "carcinogenic, mutagenic, or toxic to reproduction" by European regulators after it was found to have reproductive toxicity effects in animal studies. In the United States, TPO remains legal and unrestricted in its use and sale.

So is gel nail polish safe to use?

Experts told PBS News that the amount of exposure to TPO that people experience with gel nail polish is very low, and that most applications of the beauty product put the user at minimal risk of the harmful effects found by the animal study.

"Every ingredient at some point is going to cause harm. It's just a matter of dose," said Michelle Wong, chemistry P.h.D and science communicator at Lab Muffin Beauty Science.

Here's what you need to know about the safety of TPO and gel nail polish.

What is gel nail polish?

Gel nail polish is known for its long-lasting shine and quick drying time in comparison to regular nail polish. When cured under a UV lamp, acrylic polymers form, coming together as a film on the nail. This transformation occurs with the help of a photoinitiator like TPO.

"In the gel polish, it's all broken up into smaller chunks, … and the photoinitiator is what starts the chain reaction that makes them all join up," Wong said.

Gel nail polish was invented in the 1980s alongside the introduction of UV lights for nails. The product has become a favorite for many nail salon customers, with a global market value of nearly $6 billion in 2024, according to one estimate. Some consumer brands now offer at-home gel nail kits complete with curing lamps.

Why did the EU ban gel nail polish?

The animal studies referenced in the ban found that when the animals ingested high levels of TPO, they experienced fertility and reproductive health issues.

That kind of exposure is completely different from what happens when humans typically apply gel nail polish, said Julian Sass, a cosmetic scientist.

"In isolation, this ingredient can be harmful when it's fed to rats," but it's important to ask what the exposure looks like in real life, Sass said.

Realistically, humans are not ingesting the chemical when they put on nail polish, not even by accident, Wong said.

The EU banned TPO because of how their standards are structured, Sass said. The EU took a hazard-based approach to their study, meaning they

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looked at the intrinsic harm of the chemical or product in isolation. In comparison, the U.S. takes a risk-based approach, taking into account both the risk and exposure.

"That specific part of the FDA, when it comes to banning certain ingredients, is more of a 'do no harm' situation, versus 'here's a list of every ingredient that you absolutely cannot have in products,' like what the EU does," Sass said.

A chemical is banned by the EU as a precaution if it potentially causes cancer, damages DNA and/or adversely affects the reproductive, regardless of whether it has been put through a risk assessment. Because the animal study found reproductive harm, the EU prohibited the use of TPO.

"I think if they did a risk assessment, it wouldn't have been banned," Wong said.

Sass suggested that people might see overreactions to the EU's ban on social media. "The social media thing is, 'Oh, the U.S. has no regulations. We're allowing these toxic chemicals in our products.' And that's not at all what's happening in real life."

Is gel nail polish still safe to use?

Currently TPO is not banned in the U.S., and it is unclear whether the Food and Drug Administration will follow suit. Since the ban was announced in May, Sass said brands have had time to reformulate their polishes.

Before the ban, TPO was considered safe by the EU at a level of up to 5% in polishes, with "usually at least with a 100-fold margin of safety," Wong said. This means "you would have to have over 100 times the amount you would have been exposed to" before experiencing negative effects.

When curing the polish, the chemical gets rendered into a "completely different thing that can't [physically] get through your skin," Wong said. She estimated that 1% of TPO is left after curing, but added that the nail polish can also continue to absorb natural light.

"If you've cured your nails and you are also going into the sun afterwards, [the TPO is] all going to be gone. It's all going to be reacted away," Wong said.

For people painting their nails at home, the only real potential risk could be if you paint outside of the nail or if you don't realize what kind of product you're using. Even then, Wong said, "that would be very safe."

"You think your gel polish is normal nail polish, you put it all over your fingers, you don't cure it. Later on, you realize, oh, it's still liquid, and then you wash it off. That's probably, like, the worst-case scenario where you would get exposed to it."

If you are concerned about TPO, regular nail polish does not have this ingredient and there are TPO-free gel nail polishes.

Despite this, Dr. Rita Linkner, a double-board certified dermatologist, does not recommend gel manicures to her patients because of the potential aging effects on the skin.

The risk is "incredibly low," Wong said, but there are studies linking UV lights used to cure gel polish to cause mutations in human cells which can increase risk of skin cancer and damage DNA. The Skin Cancer Foundation recommends putting on sunscreen before exposure to the light.

To avoid gel all together, Linkner recommends a regular nail manicure and opting to leave your nails bare every now and then to prevent brittleness.

Hannah Grabenstein contributed reporting.

PBS, 5 September 2025

https://pbs.org

Nuclear waste might one day be used to create tritium to fuel fusion power plants

2025-09-13

A team of scientists at the US government's Los Alamos National Laboratory is working to turn nuclear waste into tritium, an isotope of hydrogen that could one day fuel nuclear fusion power plants. The work was presented by Terence Tarnowsky, a physicist from Los Alamos, at the autumn meeting of the American Chemical Society in Washington DC.

A nuclear fusion power plant would take deuterium and tritium, two isotopes of hydrogen, and fuse them creating helium and releasing large amounts of energy while producing very little radioactive waste. While deuterium is readily extracted from seawater, tritium is vanishingly rare on Earth.

'The initial fusion power plants are going to be based on the deuterium-tritium (D–T) fusion process,' Tarnowsky explains. 'The easiest path to fusion power is through D–T fusion, because it's the lowest temperature

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that's reachable here on Earth since we don't have a big ball of gravity like the sun.' During D–T fusion a deuterium nucleus fuses with a tritium nucleus to produce helium-4, a high-energy neutron and significant amounts of energy.

There is no large-scale commercial tritium production in the US because dedicated production facilities were shut down in 1988. 'There was no push to do commercial tritium because there wasn't really a market for it outside of the weapons conference,' Tarnowsky notes.

He estimates the total tritium inventory on the planet is about 25kg and that figure has a large margin of error. Right now, the major commercial source of tritium in the western world is in Canada. The Canada Deuterium Uranium reactor (Candu), is Canada's heavy water reactor that de-tritiates nuclear wastewater.

If fusion power plants are one day going to power the world then they're going to need a lot of tritium, Tarnowsky states. 'As they start up, these reactors are going to require tens of kilograms of tritium, and this is a difficult proposition when tritium doesn't really exist naturally on Earth but is only formed in the upper atmosphere by cosmic rays and then drifts down to the ocean,' he explains.

Computer simulations

Tarnowsky is currently in the process of conducting computer simulations of reactors that use particle accelerators to produce tritium using nuclear waste. His next step will be to refine these simulations to more precisely evaluate the efficiency and safety of the proposed reactor's design.

These putative accelerator-driven reactors would use spent nuclear fuel dissolved in a molten lithium salt that would help to cool the fuel. A gigaelectronvolt accelerator would then be used to fire a proton beam at the salt to create spallation neutrons, which would initiative fission in the spent fuel, which would act as a neutron multiplier reducing the energy the process needs. Neutrons released by this reaction could then be harnessed to turn lithium into tritium and helium-4.

Tarnowsky estimates that his theoretical system could create about 2kg of tritium per year. 'It's scalable, so you can go up in yield or down in yield … if you have enough accelerators to drive that,' Tarnowsky states. This is on par with the total yearly output from all reactors in Canada. However, with a 2GW fusion reactor calculated to require 112kg of tritium a year, many of tritium-producing reactors would be required.

'If it turns out that this is feasible, we'd like to take the project to the wider world, because … it will really need buy-in from somebody on the federal level – that's where the interface is going to happen,' he states.

David Krofcheck, a nuclear physicist at the University of Auckland in New Zealand, is supportive of such proposals. 'Harvesting of tritium would be a major side benefit from this process for planned D–T fusion reactors, particularly since Canada's Candu reactors, North America's major tritium supplier, will approach their 50-year lifetime in the next decade,' he states.

Chemistry World, 13 September 2025

https://chemistryworld.com

America is throwing away the minerals that could power its future

2025-09-18

All the critical minerals the U.S. needs annually for energy, defense and technology applications are already being mined at existing U.S. facilities, according to a new analysis published recently in the journal Science.

The catch? These minerals, such as cobalt, lithium, gallium and rare earth elements like neodymium and yttrium, are currently being discarded as tailings of other mineral streams like gold and zinc, said Elizabeth Holley, associate professor of mining engineering at Colorado School of Mines and lead author of the new paper.

"The challenge lies in recovery," Holley said. "It's like getting salt out of bread dough - we need to do a lot more research, development and policy to make the recovery of these critical minerals economically feasible."

To conduct the analysis, Holley and her team built a database of annual production from federally permitted metal mines in the U.S. They used a statistical resampling technique to pair these data with the geochemical concentrations of critical minerals in ores, recently compiled by the U.S. Geological Survey, Geoscience Australia and the Geologic Survey of Canada.

Using this approach, Holley's team was able to estimate the quantities of critical minerals being mined and processed every year at U.S. metal mines but not being recovered. Instead, these valuable minerals are ending up as discarded tailings that must be stored and monitored to prevent environmental contamination.

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"This is a brand-new view of 'low hanging fruit' - we show where each critical mineral exists and the sites at which even 1 percent recovery of a particular critical mineral could make a huge difference, in many cases dramatically reducing or even eliminating the need to import that mineral," Holley said.

The analysis in Science looks at a total of 70 elements used in applications ranging from consumer electronics like cell phones to medical devices to satellites to renewable energy to fighter jets and shows that unrecovered byproducts from other U.S. mines could meet the demand for all but two - platinum and palladium.

Among the elements included in the analysis are:

- **Cobalt (Co):** The lustrous bluish-gray metal, a key component in electric car batteries, is a byproduct of nickel and copper mining. Recovering less than 10 percent of the cobalt currently being mined and processed but not recovered would be more than enough to fuel the entire U.S. battery market.
- **Germanium (Ge):** The brittle silvery-white semi-metal used for electronics and infrared optics, including sensors on missiles and defense satellites, is present in zinc and molybdenum mines. If the U.S. recovered less than 1 percent of the germanium currently mined and processed but not recovered from U.S. mines, it would not have to import any germanium to meet industry needs.

The benefits of enhanced recovery are not only economic and geopolitical but also environmental, Holley said - recovering these critical minerals instead of sending them to tailings piles would reduce the environmental impact of mine waste and open more opportunities for reuse in construction and other industries.

"Now that we know which sites are low-hanging fruit, we need to conduct detailed analyses of the minerals in which these chemical elements reside and then test the technologies suitable for recovery of those elements from those specific minerals," Holley said. "We also need policies that incentivize mine operators to incorporate additional processing infrastructure. Although these elements are needed, their market value may not be sufficient to motivate operators to invest in new equipment and processes without the right policies in place."

Co-authors on the paper are Karlie Hadden, PhD candidate in geology; Dorit Hammerling, associate professor of applied mathematics and statistics; Rod Eggert, research professor of economics and business; Erik

Spiller, research professor of mining engineering; and Priscilla Nelson, professor of mining engineering.

Science Daily, 18 September 2025

https://sciencedaily.com

Copper alloy catalysts' surface changes mapped during CO_2 conversion reactions

2025-09-18

Seoul National University College of Engineering announced that a joint research team has become the first in the world to elucidate the reconstruction mechanism of copper alloy catalysts during electrochemical CO_2 conversion reactions.

The research sheds light on atomic rearrangements in catalyst surface structures during reaction and presents a methodology for predicting and designing actual active sites in operando conditions. The findings were published in Nature Catalysis and selected as the cover article. The team was led by Professor Young-Chang Joo (Department of Materials Science and Engineering) and Professor Jungwon Park (School of Chemical and Biological Engineering) has, in collaboration with Professors Dae-Hyun Nam (Department of Materials Science and Engineering) and Seoin Baek (KU-KIST Graduate School) at Korea University.

Electrochemical reduction of CO_2 has emerged as a pivotal technology in achieving carbon neutrality, enabling the transformation of greenhouse gas CO_2 into clean and valuable chemical feedstocks. Copper (Cu)-based catalysts are particularly notable for producing high-value multi-carbon compounds such as ethylene (C_2H_4) and ethanol (C_2H_5OH).

However, single-metal Cu catalysts face intrinsic limitations in selectively controlling the reaction pathways. Alloying Cu with other metals to create multiple active sites has been a strategy to enhance product selectivity and catalytic efficiency. While previous studies have focused on synthetic control of surface composition and nanostructure, they have overlooked dynamic changes under actual reaction conditions.

During CO_2 electroreduction, dynamic reconstruction of the catalyst surface—due to repeated metal dissolution and redeposition—becomes inevitable. This often disrupts the finely tuned surface structure originally designed for optimal activity, making it difficult to predict or optimize catalyst performance.

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The complexity is amplified in bimetallic or multimetallic systems, where the roles of different metal species in the reconstruction process remain largely unexplored. Therefore, understanding and controlling reconstruction phenomena in such systems is a critical step toward advancing CO_2 reduction catalyst design.

The researchers established a material selection map based on the oxophilicity and miscibility between Cu and the secondary metal X, and fabricated four representative Cu–X alloy catalysts (X = Ag, Fe, Zn, Pd). These catalysts were integrated into gas-diffusion electrodes and subjected to industrially relevant high-current CO_2 electroreduction conditions to induce surface reconstruction.

Using cross-sectional transmission electron microscopy (TEM), they succeeded in capturing the surface structure changes—an achievement that overcomes the limitations of previous low-current-density catalyst reconstruction studies.

Notably, Cu–Ag catalysts exhibited surface formation of Cu nanoparticles during the reaction, while Cu–Zn alloys maintained a uniform elemental distribution. Despite similar CO-producing capabilities, the reconstruction behavior yielded stark differences in product selectivity. In Cu–Ag, the Cu nanoparticles promoted further conversion of CO intermediates to ethanol, preserving high ethanol selectivity even at high Ag content. In contrast, Cu–Zn showed a decline in ethanol production due to a lack of Cu-rich active sites, favoring CO desorption instead.

Furthermore, through in-situ liquid-phase TEM, the researchers directly observed the nucleation and growth of Cu nanoparticles and identified a selective dissolution–redeposition mechanism induced by intermediate adsorption. They also demonstrated that the rearrangement behavior of redeposited atoms was determined by the miscibility of alloy components. Crucially, they applied a pulsed potential strategy to control dissolution–redeposition kinetics and successfully shifted product selectivity in Cu–Zn from CO toward ethanol.

This study provides a "design map" for understanding and predicting surface reconstruction in Cu-based bimetallic catalysts, offering a theoretical foundation for designing catalysts that dynamically adapt during operation. The design principles may be generalized to more complex multimetallic systems, ultimately advancing the commercialization of CO_2 conversion technologies by improving catalytic performance and durability.

Professor Young-Chang Joo remarked, "This is the first study to systematically unveil the dynamic reconstruction behavior of alloy catalysts during electrochemical CO_2 reduction. By moving beyond optimization of synthesis conditions and incorporating in-situ structural evolution into catalyst design, we present a new paradigm in high-performance catalyst development."

Lead author Intae Kim, a combined Master-Ph.D. student in the SNU Department of Materials Science and Engineering, plans to expand the framework of dynamic catalyst design by investigating the kinetics of reconstruction under pulsed CO_2 reduction conditions.

Phys Org, 18 September 2025

https://phys.org

New Catalyst Could Make Plastic Recycling a Whole Lot Less Complicated

2025-09-17

A new catalyst may enable mixed plastic recycling

The future of plastic recycling could soon become far simpler and more efficient.

Researchers at Northwestern University have developed a new plastic upcycling method that greatly reduces — and may even eliminate — the need to pre-sort mixed plastic waste.

At the heart of the process is a low-cost nickel-based catalyst that selectively targets polyolefin plastics, including polyethylenes and polypropylenes, which make up nearly two-thirds of global single-use plastic consumption. This means the catalyst could be applied to large volumes of unsorted polyolefin waste.

When activated, the catalyst converts these low-value solid plastics into liquid oils and waxes that can be repurposed into higher-value products such as fuels, lubricants, and candles. The catalyst can be reused multiple times and, notably, is also capable of breaking down plastics contaminated with polyvinyl chloride (PVC), a toxic material long considered to make plastics "unrecyclable."

Key challenges and breakthrough potential

The study was recently published in the journal Nature Chemistry.

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"One of the biggest hurdles in plastic recycling has always been the necessity of meticulously sorting plastic waste by type," said Northwestern's Tobin Marks, the study's senior author. "Our new catalyst could bypass this costly and labor-intensive step for common polyolefin plastics, making recycling more efficient, practical, and economically viable than current strategies."

"When people think of plastic, they likely are thinking about polyolefins," said Northwestern's Yosi Kratish, a co-corresponding author on the paper. "Basically, almost everything in your refrigerator is polyolefin-based — squeeze bottles for condiments and salad dressings, milk jugs, plastic wrap, trash bags, disposable utensils, juice cartons and much more. These plastics have a very short lifetime, so they are mostly single-use. If we don't have an efficient way to recycle them, then they end up in landfills and in the environment, where they linger for decades before degrading into harmful microplastics."

A world-renowned catalysis expert, Marks is the 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. He is also a faculty affiliate at the Paula M. Trienens Institute for Sustainability and Energy. Kratish is a research assistant professor in Marks' group, and an affiliated faculty member at the Trienens Institute. Qingheng Lai, a research associate in Marks' group, is the study's first author. Marks, Kratish and Lai co-led the study with Jeffrey Miller, a professor of chemical engineering at Purdue University; Michael Wasielewski, Clare Hamilton Hall Professor of Chemistry at Weinberg; and Takeshi Kobayashi a research scientist at Ames National Laboratory.

The polyolefin predicament

From yogurt cups and snack wrappers to shampoo bottles and medical masks, polyolefin plastics are part of everyday life. They are the most widely used plastics in the world, produced in enormous quantities. By some estimates, more than 220 million tons of polyolefin products are manufactured globally each year. Yet, according to a 2023 report in the journal Nature, recycling rates for these plastics remain troublingly low, falling between less than 1% and 10% worldwide.

This poor recycling record is largely due to the durability of polyolefins. Their structure is made up of small molecules connected by carbon-carbon bonds, which are notoriously strong and difficult to break apart.

"When we design catalysts, we target weak spots," Kratish said. "But polyolefins don't have any weak links. Every bond is incredibly strong and chemically unreactive."

Problems with current processes

Currently, only a few, less-than-ideal processes exist that can recycle polyolefin. It can be shredded into flakes, which are then melted and downcycled to form low-quality plastic pellets. But because different types of plastics have different properties and melting points, the process requires workers to scrupulously separate various types of plastics. Even small amounts of other plastics, food residue, or non-plastic materials can compromise an entire batch. And those compromised batches go straight into the landfill.

Another option involves heating plastics to incredibly high temperatures, reaching 400 to 700 degrees Celsius. Although this process degrades polyolefin plastics into a useful mixture of gases and liquids, it's extremely energy-intensive.

"Everything can be burned, of course," Kratish said. "If you apply enough energy, you can convert anything to carbon dioxide and water. But we wanted to find an elegant way to add the minimum amount of energy to derive the maximum value product."

Precision engineering

To uncover that elegant solution, Marks, Kratish, and their team looked to hydrogenolysis, a process that uses hydrogen gas and a catalyst to break down polyolefin plastics into smaller, useful hydrocarbons. While hydrogenolysis approaches already exist, they typically require extremely high temperatures and expensive catalysts made from noble metals like platinum and palladium.

"The polyolefin production scale is huge, but the global noble metal reserves are very limited," Lai said. "We cannot use the entire metal supply for chemistry. And, even if we did, there still would not be enough to address the plastic problem. That's why we're interested in Earth-abundant metals."

For its polyolefin recycling catalyst, the Northwestern team pinpointed cationic nickel, which is synthesized from an abundant, inexpensive, and commercially available nickel compound. While other nickel nanoparticle-based catalysts have multiple reaction sites, the team designed a single-site molecular catalyst.

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The single-site design enables the catalyst to act like a highly specialized scalpel — preferentially cutting carbon-carbon bonds — rather than a less controlled blunt instrument that indiscriminately breaks down the plastic's entire structure. As a result, the catalyst allows for the selective breakdown of branched polyolefins (such as isotactic polypropylene) when they are mixed with unbranched polyolefins — effectively separating them chemically.

"Compared to other nickel-based catalysts, our process uses a single-site catalyst that operates at a temperature 100 degrees lower and at half the hydrogen gas pressure," Kratish said. "We also use 10 times less catalyst loading, and our activity is 10 times greater. So, we are winning across all categories."

Accelerated by contamination

With its single, precisely defined, and isolated active site, the nickel-based catalyst possesses unprecedented activity and stability. The catalyst is so thermally and chemically stable, in fact, that it maintains control even when exposed to contaminants like PVC. Used in pipes, flooring, and medical devices, PVC is visually similar to other types of plastics but significantly less stable upon heating. Upon decomposition, PVC releases hydrogen chloride gas, a highly corrosive byproduct that typically deactivates catalysts and disrupts the recycling process.

Amazingly, not only did Northwestern's catalyst withstand PVC contamination, PVC actually accelerated its activity. Even when the total weight of the waste mixture is made up of 25% PVC, the scientists found their catalyst still worked with improved performance. This unexpected result suggests the team's method might overcome one of the biggest hurdles in mixed plastic recycling — breaking down waste currently deemed "unrecyclable" due to PVC contamination. The catalyst also can be regenerated over multiple cycles through a simple treatment with inexpensive alkylaluminium.

"Adding PVC to a recycling mixture has always been forbidden," Kratish said. "But apparently, it makes our process even better. That is crazy. It's definitely not something anybody expected."

Sci Tech Daily, 17 September 2025

https://scitechdaily.com

Tiny magnetic spirals unlock the future of spintronics

2025-09-14

Spintronics, or spin-electronics, is a revolutionary approach to information processing that utilizes the intrinsic angular momentum (spin) of electrons, rather than solely relying on electric charge flow. This technology promises faster, more energy-efficient data storage and logic devices. A central challenge in fully realizing spintronics has been the development of materials that can precisely control electron spin direction.

In a groundbreaking development for spin-nanotechnology, researchers led by Professor Young Keun Kim of Korea University and Professor Ki Tae Nam of Seoul National University have successfully created magnetic nanohelices that can control electron spin. This technology, which utilizes chiral magnetic materials to regulate electron spin at room temperature, has been published in Science.

"These nanohelices achieve spin polarization exceeding ~80% -- just by their geometry and magnetism," stated Professor Young Keun Kim of Korea University, a co-corresponding author of the study. He further emphasized, "This is a rare combination of structural chirality and intrinsic ferromagnetism, enabling spin filtering at room temperature without complex magnetic circuitry or cryogenics, and provides a new way to engineer electron behavior using structural design."

The research team successfully fabricated left- and right-handed chiral magnetic nanohelices by electrochemically controlling the metal crystallization process. A critical innovation involved introducing trace amounts of chiral organic molecules, such as cinchonine or cinchonidine, which guided the formation of helices with precisely defined handedness -- a feat rarely achieved in inorganic systems. Also, the team experimentally demonstrated that when these nanohelices exhibit a right-handedness, they preferentially allow one direction of spin to pass, while the opposite spin cannot. The above marks the discovery of a 3D inorganic helical nanostructure capable of electron spin control.

"Chirality is well-understood in organic molecules, where the handedness of a structure often determines its biological or chemical function," noted Professor Ki Tae Nam of Seoul National University, also a co-corresponding author. "But in metals and inorganic materials, controlling chirality during synthesis is extremely difficult, especially at the nanoscale. The fact that we could program the direction of inorganic helices simply by adding chiral molecules is a breakthrough in materials chemistry."

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To confirm the chirality of nanohelices, the researchers developed an electromotive force (emf)-based chirality evaluation method and measured the emf generated by the helices under rotating magnetic fields. The left- and right-handed helices produced opposite emf signals, allowing for quantitative verification of chirality even in materials that do not strongly interact with light.

The research team also found that the magnetic material itself, through its inherent magnetization (spin alignment), enables long-distance spin transport at room temperature. This effect, maintained by strong exchange energy, is constant regardless of the angle between the chiral axis and the spin injection direction, and was not observed in non-magnetic nanohelices of the same scale. The above marks the first measurement of asymmetric spin transport in a relatively macro-scaled chiral body. The team also demonstrated a solid-state device that showed chirality-dependent conduction signals, paving the way for practical spintronic applications.

Professor Kim highlighted the potential impact: "We believe this system could become a platform for chiral spintronics and architecture of chiral magnetic nanostructures." This work represents a powerful convergence of geometry, magnetism, and spin transport, built from scalable, inorganic materials. The ability to control the handedness (left/right) and even the number of strands (double, multiple helices) using this versatile electrochemical method is expected to contribute significantly to new application areas.

Science Daily, 14 September 2025

https://sciencedaily.com

Color-changing organogel stretches 46 times its size and self-heals

2025-09-17

Scientists from Taiwan have developed a new material that can stretch up to 4,600% of its original length before breaking. Even if it does break, gently pressing the pieces together at room temperature allows it to heal, fully restoring its shape and stretchability within 10 minutes.

The sticky and stretchy polyurethane (PU) organogels were designed by combining covalently linked cellulose nanocrystals (CNCs) and modified mechanically interlocked molecules (MIMs) that act as artificial molecular muscles.

The muscles make the gel sensitive to external forces such as stretching or heat, where its color changes from orange to blue based on whether the material is at rest or stimulated. Thanks to these unique properties, the gels hold great promise for next-generation technologies—from flexible electronic skins and soft robots to anti-counterfeiting solutions.

The findings are published in Advanced Functional Materials.

MIMs, such as rotaxanes and daisy chains, are promising because their molecular motion enhances toughness and flexibility. MIMs have also opened up the world of mechanochromic materials—substances that fluoresce or change colors in response to a stimulus.

These materials contain molecular switches called mechanophores, which respond to force by breaking and reforming chemical bonds, leading to small but dramatic structural shifts.

Studies show that even small amounts of MIMs can greatly enhance the stretchability and toughness of polymers. While mechanophores are commonly used for temperature and force sensing, incorporating them into self-healing systems has proven challenging.

To address this, the researchers experimented with a range of compositions to develop novel PU organogels. They achieved their desired strength, stretch, self-repair, adhesion, and color-changing properties in organogels by incorporating MIMs modified with special fluorescent groups called DPAC and cellulose nanocrystals via a step-growth polymerization process.

The PU organogels containing about 1.5 wt.% MIMs exhibited excellent toughness of 142 MJ/m3 and stretchability 46 times its own size. The organogels emitted orange or blue fluorescence depending on how stretched the material was.

When relaxed, DPAC units in the material vibrated in an unconstricted way with a frequency of 603 nm, resulting in orange light. Stretching applied force that drove the DPAC units to slide, constraining the vibrations and shifting the emission to blue at 451 nm.

The gels autonomously self-healed at room temperature, recovering more than 90% of their original strength and stretchability. This self-repair was supported by hydrogen bonding introduced through cellulose nanocrystals.

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Scaled for mass production, this material could enable sustainable technologies by signaling repairs and extending product lifetimes.

Phys Org, 17 September 2025

https://phys.org

Recycling plastic without sorting? A cheap new catalyst makes it possible

2025-09-07

One of the biggest challenges in recycling plastic is that there are several kinds of plastic that end up in our bins – and those variations in composition necessitate sorting out waste before processing it. Sorting is expensive and time-consuming, even with tech involved, and it greatly reduces the effectiveness and efficiency of recycling programs.

Researchers at Illinois' Northwestern University might have a way to largely skip sorting plastic. Their process uses an inexpensive catalyst that selectively breaks down the most common single-use kind of plastics into liquid oils and waxes that can be upcycled into lubricants and fuels.

Tobin Marks, senior author of the study that appeared in Nature Chemistry this week, explained, "Our new catalyst could bypass this costly and labor-intensive step for common polyolefin plastics, making recycling more efficient, practical and economically viable than current strategies."

The polyolefins Marks is referring to are what trash bags, plastic wrap, squeeze bottles, and other disposable single-use packaging are made of. It's estimated that more than 220 million tons of polyolefin products are manufactured annually around the world – but only 1% to 10% of it is recycled globally, in part because this material is awfully hard to break down.

With its single-site design, the nickel-based catalyst preferentially cuts carbon-carbon bonds when used in plastic recycling processes. As such, it selectively breaks down only branched polyolefins for easier upcycling. It's especially remarkable because, as co-corresponding author Yosi Kratish notes, "polyolefins don't have any weak links. Every bond is incredibly strong and chemically unreactive."

This catalyst also happens to operate at a lower temperature and require less hydrogen gas to act on plastics. It also remains stable when exposed to polyvinyl chloride (PVC), a compound commonly found in pipes and flooring that contaminates plastics in the recycling process to the point

where the entire batch becomes unusable and must be discarded. In fact, the inclusion of PVC actually accelerated the catalyst-driven process further.

Hopefully, the team's catalyst will soon figure in global recycling efforts, especially since the amount of plastic we produce each year is expected to skyrocket in the next couple of decades – going from 464 million tons in 2020 up to 884 million tons in 2050.

New Atlas, 7 September 2025

https://newatlas.com

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

CHEMICAL EFFECTS

Carbon dots as dual-action nanotools for metal toxicity recognition and mitigation

Aluminum Induced Higher Neurotoxicity than Nano-Alumina During Early Development in Zebrafish, Exacerbated by Trem2 Knockdown

Identification of key factors bioconcentration potential of organic chemicals in fish by integrating multimodal learning and ensemble learning strategies

ENVIRONMENTAL RESEARCH

Environmental impacts and optimization strategies for integrating carbon capture and anammox-based processes in municipal wastewater treatment under uncertain influent parameters

Ambient air pollution and incident dementia: exploration of relevant exposure windows

PHARMACEUTICAL/TOXICOLOGY

Per- and polyfluoroalkyl substances (PFAS) in landfill leachate, condensate, and groundwater: Characterization by landfill age and evaluation of activated carbon, ion exchange, and electrochemical treatment

Beyond smoking: A geospatial investigation of factors associated with lung and bronchus cancer risk in Pennsylvania

The effects of e-cigarette use on asthma severity in adult BALB/c mice

OCCUPATIONAL

Advancements in Artificial Intelligence and Machine Learning for Occupational Risk Prevention: A Systematic Review on Predictive Risk Modeling and Prevention Strategies

Exposure to Metal Mixtures and Childhood Adiposity: An Examination of Periods of Heightened Susceptibility Between Gestation and Late Childhood