CHEMWATCH

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ASIA PACIFIC

How Australia's tougher limits on airborne hazards impact mining

2025-11-27

Australia's approach to airborne hazards in mining has evolved significantly, with new standards and technologies driving safer workplaces and healthier outcomes.

It was 30 years ago that Australia took a vital first step in improving air quality by adopting workplace exposure standards for airborne contaminants.

That move in 1995 marked the beginning of a journey to protect workers from harmful substances in the air – dust, gases, fumes and vapours that can go unnoticed but cause serious health problems.

Understanding of these hazards has grown over the ensuing three decades; regulations have tightened and technology has advanced in leaps and bounds.

But airborne contaminants remain one of the most complex health and safety risks in mining. They do not need to be seen or smelled to reach harmful levels, yet their presence can lead to serious and long-term consequences, including occupational lung diseases, respiratory illnesses and cancers.

Read More

Safetowork, 27-11-25

https://safetowork.com.au/how-australias-tougher-limits-on-airborne-hazards-impact-mining/

Timelines for decisions on chemical reconsiderations

2025-11-26

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has released new timelines for decisions on 3 chemical reconsiderations.

The Proposed Regulatory Decision on anticoagulant rodenticides will be handed down prior to the end of this year. Publication had been forecast for mid-October. We have completed all assessments of the 8 active ingredients captured by the review and are now finalising the appropriate regulatory response to those assessments.

The Final Regulatory Decisions on paraquat and diquat will be handed down in mid-2026. Publication of the Final Decisions on paraquat and diquat had been expected prior to the end of this year. This has been deferred following the release by the U.S. Environmental Protection Agency (U.S. EPA) of an updated review of a recent study.

Released on 13 November 2025, the updated review presents U.S. EPA's conclusion that there is greater uncertainty regarding the potential for paraquat to volatilise than previously considered. The APVMA is reviewing its assessments of the volatility of paraquat and ensuring we have appropriately taken into account any concerns raised in the updated review from the U.S. EPA. This additional time will allow consideration of the updated review and, if necessary, refinements to the APVMA's risk assessments.

Content last updated: 26 November 2025

Content last reviewed: 26 November 2025

Read More

APVMA, 26-11-25

https://www.apvma.gov.au/news-and-publications/news/timelines-decisions-chemical-reconsiderations

AMERICA

FACT CHECK: EPA Debunks False Claims that Agency Recently Approved "Forever Chemical" Pesticides

2025-11-26

U.S. Environmental Protection Agency (EPA) Office of Chemical Safety and Pollution Prevention experts with decades of experience in pesticide evaluation, today issued a comprehensive fact-check addressing dangerous misinformation circulating about EPA's recent pesticide approvals.

Yesterday, EPA Administrator Lee Zeldin corrected the record on the fake news from Democrats and their media allies. In an X post, Administrator Zeldin reaffirmed the EPA's unwavering commitment to rigorous, science-based standards and full compliance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The Administrator made clear that protecting American families remains the top priority—ensuring that every approved pesticide undergoes thorough safety evaluation and poses no health risks when used as directed.

FACT #1: It was Actually the Biden EPA That Officially Ruled Single Fluorinated Compounds Are NOT PFAS or "Forever Chemicals"

In 2023, EPA's Office of Pollution Prevention and Toxics officially defined PFAS, after conducting a comprehensive public rulemaking process, as chemicals containing two or more fluorinated carbons. This deliberate exclusion of single fluorinated carbons was based on extensive scientific evidence and public input demonstrating that molecules with only one fluorinated carbon lack the persistence and bioaccumulation properties that are commonly associated with forever chemicals. The recent false claims that EPA approved a "forever chemical" represents a fundamental misunderstanding of chemistry and toxicology.

Read More

US EPA, 26-11-25

https://www.epa.gov/newsreleases/fact-check-epa-debunks-false-claims-agency-recently-approved-forever-chemical

WorkSafeBC sees good compliance with new tower crane regulation after one year, but risks remain

2025-11-25

The Notice of Project–Tower Crane regulation is part of an enhanced crane safety strategy

One year after a new tower crane regulation came into effect, WorkSafeBC is reporting good compliance across tower crane operations in B.C., although risks remain.

Since Oct. 1, 2024, employers have been required to submit a Notice of Project (NOP) to WorkSafeBC at least two weeks before any tower crane work begins, including assembly, climbing, repositioning, or dismantling. The NOP–Tower Crane requirements enable WorkSafeBC to understand who will perform the work, and when, where, and how it will be carried out.

Among the information that must be confirmed in the NOP–Tower Crane regulation are names of all employers responsible for the crane activity, the nature and scope of the crane activity, safe-work procedures specific to the workplace, the qualifications of the qualified supervisor, and identification information for the tower crane.

Read More

WorksafeBC, 25-11-25

https://www.worksafebc.com/en/about-us/news-events/news-releases/2025/November/worksafebc-sees-good-compliance-with-new-lower-crane-regulation-after-one-year-but-risks-remain

Lead pipe replacement is focus of EPA funding

2025-11-26

Pipe makers and contractors who engage in utility work soon could benefit from $3 billion in United States Environmental Protection Agency (EPA) funding.

The $3 billion in new funding for states is earmarked through the EPA's State Revolving Fund (SRF) programs to reduce exposure to lead in drinking water.

The agency says it conducted a thorough review of previously awarded funding and assessed updated lead service line data to achieve maximum impact in removing lead pipes and reducing lead contamination in drinking water systems.

The funding is intended to accelerate progress in finding and removing lead pipes (also known as lead service lines that deliver water to homes, schools and businesses) and is being deployed along with a new lead service line inventories dashboard that aggregates information provided by states.

"This investment represents the EPA's unwavering commitment to protecting America's children from the dangers of lead exposure in their drinking water," EPA Administrator Lee Zeldin says. "With our updated data, we can tackle this challenge more efficiently than ever before, and we're ensuring every dollar goes directly toward replacing the lead pipes that threaten our communities."

Read More

Recycling Today, 26-11-25

https://www.recyclingtoday.com/news/epa-lead-drinking-water-pipe-replacement-funding-dashboard/

EUROPE

TPO in Nail Products – Questions & Answers

2025-08-07

Subject: Prohibition of Trimethylbenzoyl Diphenylphosphine Oxide (TPO) in cosmetic products as of 1 September 2025.

Legal basis: Article 15 of Regulation (EC) No 1223/2009 (Cosmetics Regulation)

Any views expressed in the Q&A are the views of the Commission services, and may not in any circumstances be regarded as stating an official position of the Commission. The information here is intended only for information purposes. Only the Court of Justice of the European Union is competent to authoritatively interpret EU law.

Introduction

Following the adoption of Commission Regulation (EU) 2025/877, which prohibits among others the use of Trimethylbenzoyl Diphenylphosphine Oxide (TPO) in cosmetic products as of 1 September 2025, the Commission has received a significant number of queries from EU countries, industry associations, and individual companies.

These questions often relate to the scope of the prohibition, its application to professional users, and the absence of a transitional period for the sale or use of existing stock. In addition, differing interpretations have been reported at national level, creating uncertainty among stakeholders and raising concerns about consistent enforcement across the EU.

To ensure a common understanding of this prohibition, this Q&A intends to clarify frequently misunderstood points such as the treatment of professional use, the role of CLP classification data, and the difference between the Cosmetics Regulation and REACH.

The aim is to provide clear, consistent, and factual guidance for Member States, enforcement authorities, and businesses, to support the coherent application of the TPO prohibition in all jurisdictions.

Read More

European Commission, 07-08-25

https://single-market-economy.ec.europa.eu/sectors/cosmetics/tpo-nail-products-questions-answers_en?utm_source=chatgpt.com

Changes to Article 95 of GB Biocidal Products Regulation

2025-11-25

Regulations have been laid in Parliament to change the data protection end date in Article 95(5) to 31 December 2030.

The Biocidal Products (Data Protection Periods) (Amendment) 2025 were laid in Parliament on 25 November 2025.

These Regulations will come into force on 30 December 2025, subject to successful completion of Parliamentary processes.

The purpose of these Regulations is to change the date that regulatory data protection ends for active substances in the GB Review Programme, as set out in Article 95(5) of GB Biocidal Products Regulation (GB BPR). The data protection period has been increased by 5 years, from 31 December 2025 to 31 December 2030.

Therefore, data submitted for the first time in support of an active substance in the GB Review Programme is protected until either:

- 10 years from the first day of the month following the date of approval or inclusion onto the GB Simplified Active Substance List
- 31 December 2030

The Regulations also make minor technical changes to ensure Article 95(5) works as intended and updates the references in Article 95(5) and Article 95(3) to assimilated Regulation (EU) No 1062/2014.

Read More

UK HSE, 27-11-25

https://www.hse.gov.uk/biocides/about/regulations-decisions.htm

Toy safety: Parliament adopts new rules to enhance child health protection

2025-11-27

- Ban on endocrine disruptors, skin sensitisers and PFAS (“forever chemicals”)
- Digital passports for all toys to speed customs checks and ease access to safety warnings
- €6.5 billion worth of toys imported into the EU in 2023, 80% from China
- Toys are the second most notified dangerous consumer product in the EU rapid alert system

The new rules seek to decrease the number of unsafe toys sold in the EU and to protect children from toy-related risks.

Despite the EU having some of the world’s strictest rules on toy safety, dangerous toys still find their way into children’s hands. On Tuesday, MEPs confirmed an agreement with member states on new toy safety rules to improve the protection of children’s health and development. The update of an existing 2009 directive comes in response to the rise in online shopping (including from outside the EU) and the use of digital technologies. Member states and industry actors will have a 4 ½ year transition period to implement the new measures.

Stricter requirements on chemicals

The existing ban on carcinogenic and mutagenic substances and substances toxic for reproduction (CRM) is extended to chemicals that are particularly harmful to children, such as endocrine disruptors, substances that harm the respiratory system, and chemicals that are toxic for the skin and other organs. The new rules also ban the intentional use of per- and polyfluorinated alkyl substances (PFAS) and the most dangerous types of bisphenols. Allergenic fragrances will be prohibited in toys for children under 3 and in toys designed to be placed in the mouth.

Read More

European Parliament, 27-11-25

https://www.europarl.europa.eu/news/en/press-room/20251120IPR31494/toy-safety-parliament-adopts-new-rules-to-enhance-child-health-protection

Literature review on micro- and nanoplastic release from food contact materials during their use

2025-10-21

To search for evidence of micro- and nanoplastics (MNP) release during the uses of food contact materials (FCM), a structured literature review was carried out on studies published between 2015 and 20th January 2025. It identified 1711 publications of which 122 were selected for data extraction. Eight additional publications were added to provide more context. Most studies concern microplastics, while data on nanoplastics are almost entirely absent. Most publications use water or aqueous food simulants as FCM contact medium for suspension and subsequent isolation of released MNP. Foods other than mineral water were tested in only few cases. Despite the large number of publications investigating the release of MNP from FCM, the available evidence concerning the characteristics and quantities of released MNP from FCM remains limited. Many publications are affected by methodological shortcomings in test conditions, in sample preparation, and by deficiencies in the reliability of analytical data, with the consequence of frequent misidentification and miscounting. Based on the findings on release mechanisms, contaminations, mimicking substances, particle numbers and masses generated during the use of FCMs, it is concluded that (i) there is evidence of microplastics released during the uses of FCM, (ii) this release is due to mechanical stress, such as abrasion or friction, or due to materials with open or fibrous structures, (iii) despite the uncertainties, the actual release is much lower than the results presented in many publications. In view of all this, there is no sufficient basis at this stage to estimate MNP exposure from FCM during their uses. This review identifies methodological shortcomings and data gaps, and makes recommendations on related future research needs.

Read More

EFSA, 21-10-25

https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/sp.efsa.2025.EN-9733

Packaging waste statistics

2025-10-10

In 2023, 79.7 million tonnes of packaging waste were generated in the EU. This corresponded to 177.8 kg per inhabitant, a reduction of 8.7 kg per capita compared with 2022.

On average, each person in the EU consumed 65 lightweight plastic carrier bags in 2023. Compared with 2018, consumption fell by 30 bags per person. Sweden (-131 bags per person), Lithuania (-125) and Latvia (-118) achieved the largest reductions.

In 2023, Belgium, Netherlands, Italy, Czechia, Slovenia, Slovakia and Spain recycled more than 70% of the packaging waste generated, the target to be reached by 2030. Another 6 countries were close, with recycling rates above 65%.

This article presents recent statistics on packaging waste in the Member States of the European Union (EU) and in available EFTA countries. Information and data are based on Directive 94/62/EC, which lays down recycling and recovery targets, aiming at providing a high level of environmental protection and harmonising national measures concerning packaging and packaging waste. Furthermore, the article presents statistics on the consumption of lightweight plastic carrier bags based on Directive 2015/720 (The Plastic Bags Directive), which aims to reduce the consumption of plastic carrier bags.

Read More

Eurostat, 10-10-25

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Packaging_waste_statistics

ECHA ready to receive reports on microplastics emissions

2025-11-26

Companies can start reporting to the European Chemicals Agency (ECHA) their annual microplastics releases under the EU's microplastics restriction. These reporting obligations apply to uses that are exempt from the EU-wide ban. The first reports must be submitted by 31 May 2026 covering estimated emissions for year 2025.

Helsinki, 26 November 2025 – The latest releases of our chemical data software IUCLID and submission tool REACH-IT support companies in complying with the EU-wide microplastics restriction, which came into force in 2023.

The reporting system, developed in collaboration with stakeholders, ensures standardised and transparent data collection, enabling regulators to monitor emissions and assess the effectiveness of risk management measures. The data may also inform future policy decisions on microplastics.

Reporting obligations

The annual reporting obligation applies to uses of synthetic polymer microparticles (SPMs) that are exempt from the ban, such as in veterinary and human medicines, food additives, in vitro diagnostic devices, and uses at industrial sites. The obligations apply to manufacturers, importers and downstream users alike. Also, suppliers of SPMs and SPMs-containing products are affected under certain conditions.

Companies affected need to prepare the report on annual releases in IUCLID format and submit it to ECHA through REACH-IT. The first deadlines are:

- 31 May 2026 – for manufacturers and industrial downstream users of SPMs in form of pellets, flakes and powders, used as raw material in plastic production at industrial sites; and
- 31 May 2027 – for all other manufacturers and industrial downstream users of SPMs at industrial sites, as well as for suppliers placing products containing SPMs on the market for the first time for specific exempted uses by professionals or the public.

Reports must cover emissions from the previous calendar year. For now, only initial submissions are possible in REACH-IT. Updates will be allowed from the second quarter of 2026.

ECHA has published guidelines, a IUCLID manual, and a video tutorial to help companies prepare and submit their reports. In addition, a pre-filled IUCLID dataset (.i6z) is made available to help users prepare their IUCLID dossiers.

Affected companies are encouraged to familiarise themselves with the reporting requirements and ECHA's support materials well ahead of the deadlines.

Read More

ECHA, 26-11-25

https://echa.europa.eu/-/echa-ready-to-receive-reports-on-microplastics-emissions

Highlights of the November Forum meeting

2025-11-26

ECHA's Enforcement Forum agreed on a new work programme setting out its enforcement priorities for 2026-2027 and started work on new projects.

Helsinki, 24 November 2025 – The Forum adopted its new work programme for 2026-2027, which sets out enforcement priorities and outlines coordinated actions for the next two years. The focus will remain on enforcement on imports, online sales and integrated controls. More specific priorities include classification and labelling and controlling different risk management measures. There will also be more emphasis on collaboration with enforcement authorities from other sectors.

The Forum, seeking to support enforcement authorities in the long term, established a dedicated task force to further develop its compendium of analytical methods used to monitor restrictions on hazardous substances. The Forum will engage with European bodies or other networks working with analytical methods.

New projects launched

The Forum started work on new projects, including preparation and training for the next EU-wide harmonised enforcement project (REF-15). This project will focus on the safe use of chemicals in workplaces, in co-operation with occupational health and safety inspectors.

Preparations began for the pilot project on requirements of the Prior Informed Consent (PIC) Regulation, aimed at ensuring that exports of hazardous chemicals comply with the rules and are accompanied by the required information.

Read More

ECHA, 26-11-25

https://echa.europa.eu/-/highlights-of-the-november-forum-meeting

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Who am I?

2025-12-05

I am a highly reactive alkali metal that, like sodium, is vital to nerve function, but I am less reactive than Caesium (Cs).

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

I am a highly reactive alkali metal that, like sodium, is vital to nerve function, but I am less reactive than Caesium (Cs).

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Disulfoton

2025-12-05

USES [2,3]

Disulfoton is used to protect small grains, sorghum, corn, and other field crops; some vegetables, fruit, and nut crops; and ornamental and potted plants against certain insects. Although it is used primarily in agriculture, small quantities are used on home and garden plants. Small quantities also are used for other purposes, such as mosquito control in swamps. The use of disulfoton has decreased in recent years.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

- Breathing contaminated air;
- drinking contaminated water; and
- eating contaminated food.
- Disulfoton is rarely detected in air.
- Workers in industries that manufacture and formulate disulfoton are at a higher risk of exposure.
- Workers who spray the pesticide in fields and some farm workers who enter the fields following spraying also are at a higher risk of exposure than the general population.
- Among the general population, people who frequently use the pesticide in their homes and gardens are potentially at higher risk.
- People who live near hazardous waste sites that contain disulfoton also are potentially at a higher risk of exposure.
- Children playing at or near these hazardous waste sites may be exposed by touching and eating soil that contains disulfoton.

Routes of Exposure

The major routes of exposure to disulfoton are:

- inhalation;
- ingestion;
- contact with skin/eyes

Disulfoton is a manufactured substance used as a pesticide to control a variety of harmful pests that attack many field and vegetable crops. Disulfoton does not occur naturally. 1,2]

HEALTH EFFECTS [4]

Acute Health Effects

Disulfoton is very highly toxic to all mammals by all routes of exposure. It is labelled with a DANGER signal word. Whether absorbed through the skin, ingested, or inhaled, early symptoms in humans may include blurred vision, fatigue, headache, dizziness, sweating, tearing, and salivation. Symptoms occurring at high doses include defecation, urination, fluid accumulation in the lungs, convulsions, or coma. Death can occur if high enough doses lead to stoppage of respiratory muscles and/or constriction of the windpipes. Ingestion of high doses can lead to rapid onset of effects on the stomach while symptoms resulting from skin exposure may be delayed for up to 12 hours. Complete recovery from acute poisoning takes at least one week, but complete restoration of the blood to normal enzyme (cholinestrase) levels may take up to three months.

Carcinogenicity

Studies of rats and mice fed high doses for two years did not show significant tumour growth. The EPA has determined that there is no evidence that disulfoton is carcinogenic.

Other Effects

In a long-term reproduction study, 98.5% pure disulfoton was fed at doses ranging from 0.05 to 0.5 mg/kg/day to both male and female albino rats. At the high dose, the number of animals per litter was reduced by 21% in the first and third generations and a 10 to 25% lower pregnancy rate was noted. Some third-generation litters whose parents were exposed to this dose, developed fatty deposits and swelling in their livers. Exposed adults and litters had a 60% to 70% inhibition of red blood cell cholinesterase. This suggests that long-term exposures to high doses of disulfoton may cause reproductive effects in humans.

SAFETY

First Aid Measures [5]

- **General advice:** Consult a physician. Show this safety data sheet to the doctor in attendance.
- **If inhaled:** If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

- **In case of skin contact:** Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.
- **In case of eye contact:** Flush eyes with water as a precaution.
- **If swallowed:** Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

Personal Protective Equipment [4]

The following personal protective equipment is recommended when handling disulfoton:

- **Eye/face protection:** Face shield and safety glasses 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 ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

REGULATION

United States

NIOSH: The National Institute for Occupational Safety and Health (NIOSH) recommends an exposure limit of 0.1 mg disulfoton/m^3 of air for a 10-hour workday within a 40-hour workweek.

EPA: The Environmental Protection Agency recommends that no more than 10 parts of disulfoton per billion parts (ppb) of water be present in drinking water that children drink for periods of up to 10 days. Disulfoton in drinking water should not exceed 3 ppb for children or 9 ppb for adults if they drink the water for longer periods, and should not exceed 0.3 ppb for adults who will drink the water during an average lifetime. EPA has designated disulfoton as a hazardous substance, but it does not intend to cancel or restrict registration of pesticide products containing disulfoton. Federal regulations limit the amount of disulfoton that factories can release into wastewater. EPA requires industries to report releases or spills of 1 pound or more.

OSHA: The Occupational Safety & Health Administration has not established any regulation.

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Researchers Create Sustainable Smart Materials With Living Bacterial Spores

2025-11-14

Bacterial spores – the hardy survival structures formed by certain bacterial species – are proving to be a game changer in the field of engineered living materials (ELMs). By embedding Bacillus spores within ELMs, Jeong-Joo Oh, Franka van der Linden, Marie-Eve Aubin-Tam and their fellow researchers have created living materials that not only endure harsh environments but can also be programmed to perform specific tasks. In the future, these materials may be a sustainable replacement for fossil-based materials. Their findings were published in Science Advances.

These autonomously grown ELMs have a broad range of potential applications, such as detecting disease biomarkers and catalysing the breakdown of environmental pollutants. They might also function as self-healing composites. In the future, this latter application may be used for building materials, similarly to the self-healing concrete developed by TU Delft colleague Henk Jonkers. "Imagine asking bacteria to produce minerals that fill a crack in concrete, we could have self-repairing walls," explains Jeong-Joo Oh, first co-author of the article. "Moreover, this approach could advance sustainability, since ELMs could replace fossil-based materials, like plastics, in our daily life."

Unique to these new materials is their on-demand programmable functionality. The ELMs can sleep, survive harsh conditions, and awaken on command. "Conventional living cells are able to perform useful functions like detecting biomarkers, but they only survive for a short time. We wanted a material we could use whenever we want to," Oh says.

Inspired by bacterial life cycle

"So, we looked for a way to keep the cells alive and got inspired by the life cycle of bacteria." Certain bacterial species can switch into a dormant and metabolically inactive state, called a spore. Spores are extremely resistant to heat, dryness, and chemical stress. "This dormant state allows us to 'wake up' the bacteria when the programmable functions are desired," Oh says. "Using normal bacteria, you can only use the material within a few days or a week. We found out that with spores it still works after six months without losing functionality."

Two species collaborate

To fabricate the material, the scientists combined two bacterial species: Komogataeibacter rhaeticus and Bacillus subtilis. K. rhaeticus produces strong bacterial cellulose fibers that act as a protective physical barrier. Bacillus contributes its spore-forming capacity. The mixture yields a robust living material. By genetically modifying the bacterial spores' surface, the team added the needed functionality. Also, the genetic engineering step enhanced the spores' binding to the cellulose.

Step by step to real-world use

Before these materials appear in our daily life, the ELMs' performance and long-term stability should meet standards of existing materials. "At this stage, our work is at a proof-of-concept-level in the laboratory," Oh notes. "To use these materials in concrete, for instance, they should match the strength of existing building materials. But the results are already very promising. Step by step, I hope to replace unsustainable materials with living, self-sustaining ones."

Technology Networks, 14 November 2025

https://technologynetworks.com

Scientists Create 7 Remarkable New Ceramic Materials by Simply Removing Oxygen

2025-11-28

Penn State scientists discovered seven new ceramics by simply removing oxygen—opening a path to materials once beyond reach.

Sometimes, less truly is more. By removing oxygen during the synthesis process, a team of materials scientists at Penn State successfully created seven new high-entropy oxides (HEOs)—a class of ceramics made from five or more metals that show promise for use in energy storage, electronics, and protective coatings.

During their experiments, the researchers also established a framework for designing future materials based on thermodynamic principles. Their findings were published in Nature Communications.

"By carefully removing oxygen from the atmosphere of the tube furnace during synthesis, we stabilized two metals, iron and manganese, into the ceramics that would not otherwise stabilize in the ambient atmosphere," said corresponding and first author Saeed Almishal, research professor at

Penn State working under Jon-Paul Maria, Dorothy Pate Enright Professor of Materials Science.

Machine learning expands material possibilities

Almishal first succeeded in stabilizing a manganese- and iron-containing compound by precisely controlling oxygen levels in a material he called J52, composed of magnesium, cobalt, nickel, manganese, and iron. Building on this, he used newly developed machine learning tools—an artificial intelligence technique capable of screening thousands of possible material combinations within seconds—to identify six additional metal combinations capable of forming stable HEOs.

With the assistance of a team of undergraduate students who processed, fabricated, and characterized the samples, Almishal produced bulk ceramic pellets of all seven novel, stable, and potentially functional HEO compositions. The students' work was supported by the Department of Materials Science and Engineering and Penn State's Center for Nanoscale Science, a U.S. National Science Foundation–funded Materials Research Science and Engineering Center.

Thermodynamic principles behind stabilization

"In a single step, we stabilized all seven compositions that are possible given our current framework," Almishal said. "Although this was previously treated this as a complex problem in the field of HEOs, the solution was simple in the end. With a careful understanding of the fundamentals of material and ceramic synthesis science — and particularly the principles of thermodynamics — we found the answer."

Stabilizing these materials, Almishal explained, involves "coercing" the manganese and iron atoms to stay in the 2+ oxidation state, also known as the rock salt structure, where each atom bonds with only two oxygen atoms. Under normal oxygen levels, the materials would fail to stabilize because the manganese and iron atoms would keep binding with additional oxygen, shifting to a higher oxidation state. By reducing the amount of oxygen in the tube furnace, the researchers restricted how much oxygen the material could absorb, allowing it to form and remain in the stable rock salt structure.

"The main rule we followed in synthesizing these materials is the role that oxygen plays in stabilizing such ceramic materials," Almishal said.

Confirming results and future directions

To make sure that manganese and iron in each new material were stable in the target oxidation state, Almishal collaborated with researchers from Virginia Tech. They performed an advanced imaging technique to measure how X-rays are absorbed by the atoms in the material. By analyzing the resulting data, researchers could determine the oxidation state of specific elements and confirm the stability of manganese and iron in the new materials.

In the next phase of research, the researchers said they will test all seven new materials for their magnetism. They also aim to apply their thermodynamic framework for controlling oxygen during synthesis to other material classes currently considered unstable and challenging to synthesize.

"This paper, which has already been accessed online thousands of times, seems to resonate with researchers because of its simplicity," Almishal said. "Although we focus on rock salt HEOs, our methods provide a broad adaptable framework for enabling uncharted, promising chemically disordered complex oxides."

As a result of his extensive lab work on the new materials, co-author and undergraduate materials science and engineering major Matthew Furst was invited to present the research at the American Ceramic Society's (ACerS) Annual Meeting with Materials Science and Technology 2025 — an honor usually reserved for faculty or senior graduate students — which took place Sept. 28 through Oct. 1 in Columbus, Ohio.

"I am so grateful for the opportunities that I have had on this project and to be involved in every step of the research and publication process," Furst said. "Being able to present this material to a broad audience as an invited talk reflects my involvement and the excellent guidance I have received from my mentors. It means a lot to me to develop important communication skills as an undergraduate student, and I look forward to pushing myself further in the future!"

Sci Tech Daily, 28 November 2025

https://scitechdaily.com

Precise catalyst design boosts hydrogen gas production efficiency and affordability

2025-12-03

A recent advance in the science of hydrogen fuel production could enable higher output and more sustainable production of this renewable energy source, researchers with Stockholm's KTH Royal Institute of Technology report.

The findings result from unprecedented atomic-scale observations of how catalysts perform in the slow and expensive process of water splitting, or breaking the bond of oxygen and hydrogen. Using a unique set-up, they were able to produce hydrogen gas at rates comparable to or faster than state-of-the-art conventional catalysts.

What's more, the catalyst remained in good condition after extended operation—a positive sign for commercial viability.

The research was reported in Nature Chemistry, led by KTH Professor Lichen Sun with contributions from KTH Professor Mårten Ahlquist and doctoral researcher Hao Yang.

How the catalyst innovation works

Water splitting with electrolysis depends on electricity to break the bond of H_2O into hydrogen and oxygen gases. Nickel–iron oxides are widely used as catalysts to lower the amount of electricity required and speed up the formation of H_2 and O_2 gases. While effective, these materials are also complicated, making it difficult for scientists to see exactly how the chemical reactions happen.

The team cracked the challenge by engineering a molecular scaffold—a specially designed organic structure that holds nickel and iron atoms in fixed positions. In contrast to the random scattering of nickel and iron in a conventional catalyst, this precise arrangement allowed the researchers to study the transfer of electrons and protons at the heart of the process.

And in doing so, they discovered how positioning iron and nickel atoms closer together helps hydrogen ions move away from the iron parts of the catalyst to enable oxygen to form—the hardest part of splitting water. Sun says the observations revealed hydroxyl groups (chemical units of oxygen and hydrogen) attached to nickel act as proton relays, which expedites their movement.

The researchers also found an optimal balance of pH to speed up the formation of the O-O bond while maintaining its synchronization with electron transfer.

Implications for hydrogen fuel production

"The molecular scaffold enabled us to finally see the proton relay in action," Sun says. "This insight explains why nickel and iron work so well together—and how we can make them even better."

The researchers caution that direct comparisons with conventional state-of-the-art catalysts are difficult to make, given the variety of systems and experimental conditions. Nevertheless, they say the catalytic activity they achieved approximated an order-of-magnitude enhancement operating at similar voltage.

"That's important because higher turnover rates reduce energy losses and operating time, which then lowers the cost per kilogram of hydrogen," Ahlquist says.

"Our findings connect the dots between real-world nickel–iron oxide catalysts and a detailed molecular understanding," Ahlquist says. "This opens a path to create next-generation materials that work even better and last longer. For hydrogen technology, that means faster, more efficient and more sustainable ways to produce clean fuel."

Phys Org, 3 December 2025

https://phys.org

Everyday Microplastics Exposure Linked to Atherosclerosis in Males

2025-11-19

Microplastics may accelerate the artery-clogging process that leads to heart attacks and strokes, but seemingly only in male mice.

A mouse study led by University of California, Riverside biomedical scientists suggests that everyday exposure to microplastics — tiny fragments shed from packaging, clothing, and countless plastic products — may accelerate the development of atherosclerosis, the artery-clogging process that leads to heart attacks and strokes. The harmful effects were seen only in male mice, offering new clues about how microplastics may affect cardiovascular health in humans.

"Our findings fit into a broader pattern seen in cardiovascular research, where males and females often respond differently," said lead researcher Changcheng Zhou, a professor of biomedical sciences in the UCR School of Medicine. "Although the precise mechanism isn't yet known, factors like sex chromosomes and hormones, particularly the protective effects of estrogen, may play a role."

Microplastics are now found nearly everywhere: in food, water, the air, and even inside the human body. Recent human studies have detected microplastics in atherosclerotic plaques and linked higher levels to increased risk of cardiovascular disease. However, scientists didn't understand whether or how microplastics directly contribute to artery damage.

"It's nearly impossible to avoid microplastics completely," Zhou said. "Still, the best strategy is to reduce exposure by limiting plastic use in food and water containers, reducing single-use plastics, and avoiding highly-processed foods. There are currently no effective ways to remove microplastics from the body, so minimizing exposure and maintaining overall cardiovascular health — through diet, exercise, and managing risk factors — remains essential."

In a paper published in Environment International, Zhou and his team report their use of a well-established mouse model for studying heart disease: LDLR-deficient mice, which are prone to developing atherosclerosis. They fed both male and female mice a low-fat, low-cholesterol diet, similar to a lean, healthy person's diet.

The researchers then gave the mice a daily dose of microplastics (10 milligrams per kilogram of body weight) for nine weeks at levels considered environmentally relevant and similar to what humans may encounter through contaminated food and water.

The researchers found microplastics dramatically worsened atherosclerosis, but only in males. In male mice, microplastic exposure increased plaque buildup by 63% in the aortic root, the first section of the aorta that attaches to the heart; and 624% in the brachiocephalic artery, a blood vessel that branches off the aorta in the upper chest. In female mice, the same exposure did not significantly worsen plaque formation.

The study found microplastics did not make the mice obese or raise their cholesterol. The mice remained lean, and their blood lipid levels did not change, meaning the increased artery damage was not due to traditional risk factors like weight gain or high cholesterol.

The study also found microplastics altered key cells that line the arteries. Using single-cell RNA sequencing, a technology that helps identify which genes are expressed in each cell and at what level, the team found that microplastics disrupted the activity and proportions of several types of cells involved in atherosclerosis, especially endothelial cells — the cells that line blood vessels and regulate inflammation and blood flow.

"We found endothelial cells were the most affected by microplastic exposure," Zhou said. "Since endothelial cells are the first to encounter circulating microplastics, their dysfunction can initiate inflammation and plaque formation."

In the team's experiments, fluorescent microplastics were found to enter plaques and localize within the endothelial layer — findings consistent with recent human studies showing microplastics in arterial lesions.

Another finding the researchers report from their experiments is that microplastics triggered harmful gene activity in both mouse and human endothelial cells. Exposure to microplastics was found to activate pro-atherogenic (plaque-promoting) genes in endothelial cells from mice and humans, suggesting a shared biological response.

"Our study provides some of the strongest evidence so far that microplastics may directly contribute to cardiovascular disease, not just correlate with it," Zhou said. "The surprising sex-specific effect — harming males but not females — could help researchers uncover protective factors or mechanisms that differ between men and women."

Zhou and his team acknowledge that more research is needed to understand why males are more vulnerable. The researchers plan to perform studies to determine if similar effects occur in humans.

"We would like to investigate how different types or sizes of microplastics affect vascular cells," Zhou said. "We will also look into the molecular mechanisms behind endothelial dysfunction and explore how microplastics affect male and female arteries differently. As microplastic pollution continues to rise worldwide, understanding its impacts on human health — including heart disease — is becoming more urgent than ever."

Zhou was joined in the study by colleagues at UCR, Boston Children's Hospital and Harvard Medical School in Massachusetts, and the University of New Mexico Health Sciences.

The study was partially supported by grants from the National Institutes of Health.

Technology Networks, 19 November 2025

https://technologynetworks.com

New Algorithm Reveals the Secret Chemistry Behind Cheaper, Cleaner Propylene

2025-11-30

Scientists have mapped the atomic interactions that make nanoscale catalysts so effective at converting propane into propylene.

Propane's Transformation Into Propylene

Many everyday goods, including plastic squeeze bottles and outdoor furniture, depend on a chemical process that converts propane into propylene. A 2021 report in Science showed that chemists could use tandem nanoscale catalysts to merge several stages of this conversion into a single reaction—a method that raises efficiency and reduces costs for manufacturers. However, the precise atomic activity behind this combined process was still unknown, which made it difficult to extend the method to other major industrial reactions.

Algorithms Uncover Atomic-Level Details

Scientists at the University of Rochester created algorithms that highlight the atomic-scale features guiding the reaction when nanoscale catalysts convert propane into propylene. Their findings, published in the Journal of the American Chemical Society, describe the complex interplay of materials that shift between multiple states during the reaction.

"There are so many different possibilities of what's happening at the catalytic active sites, so we need an algorithmic approach to very easily yet logically screen through the large amount of possibilities that exist and focus on the most important ones," says Siddharth Deshpande, an assistant professor in the Department of Chemical and Sustainability Engineering. "We refined our algorithms and used them to do a very detailed analysis of the metallic phase and oxide phase driving this very complex reaction."

Oxide Behavior and Catalyst Stability

During their investigation, Deshpande and chemical engineering PhD student Snehitha Srirangam uncovered unexpected patterns. They observed that the oxide in the reaction tended to form around defective metal sites in a highly selective way, a feature that played a crucial role in keeping the catalyst stable.

Even though the oxide can appear in several chemical compositions, it consistently remained positioned around those defective metal sites.

Expanding the Approach to Other Industrial Reactions

Deshpande says this deeper understanding, along with the team's algorithmic tools, can help scientists examine the atomic structures of other important reactions, including methanol synthesis that supports products ranging from paints to fuel cells. He believes that over time, this knowledge could guide companies toward more efficient strategies for producing propylene and other industrial chemicals so they can move away from the trial-and-error methods commonly used today.

"Our approach is very general and can open the doors to understand many of these processes that have remained an enigma for decades," says Deshpande. "We know these processes work, and we produce tons of these chemicals, but we have much to learn about why exactly they're working."

Sci Tech Daily, 30 November 2025

https://scitechdaily.com

A surprising new method finally makes teflon recyclable

2025-11-27

New research has identified a straightforward and environmentally friendly way to decompose Teflon, one of the most resilient plastics in use today, and convert it into valuable chemical ingredients.

Scientists at Newcastle University and the University of Birmingham have created a clean, energy-saving process for recycling Teflon (PTFE), which is widely recognized for its role in non-stick cookware and in products that must withstand high temperatures and harsh chemicals.

The team found that discarded Teflon can be broken apart and reused with only sodium metal and mechanical movement by shaking -- all at room temperature and without toxic solvents.

Their study, published in the Journal of the American Chemical Society (JACS), outlines a low-energy and waste-free alternative to standard fluorine recovery techniques.

Breaking Carbon-Fluorine Bonds to Recover Useful Fluoride

Dr. Roly Armstrong, Lecturer in Chemistry at Newcastle University and corresponding author said: "The process we have discovered breaks the strong carbon-fluorine bonds in Teflon, converting it into sodium fluoride which is used in fluoride toothpastes and added to drinking water.

"Hundreds of thousands of tonnes of Teflon are produced globally each year -- it's used in everything from lubricants to coatings on cookware, and currently there are very few ways to get rid of it. As those products come to the end of their lives they currently end up in landfill -- but this process allows us to extract the fluorine and upcycle it into useful new materials."

Associate Professor Dr. Erli Lu of the University of Birmingham added: "Fluorine is a vital element in modern life -- it's found in around one-third of all new medicines and in many advanced materials. Yet fluorine is traditionally obtained through energy-intensive and heavily polluting mining and chemical processes. Our method shows that we can recover it from everyday waste and reuse it directly -- turning a disposal problem into a resource opportunity."

Why Recycling PTFE Is So Difficult

Polytetrafluoroethylene (PTFE), often called Teflon, is valued for its resistance to heat and chemicals, making it a key material in cookware, electronics, and laboratory tools. However, those same strengths have made it extremely difficult to recycle.

When PTFE is burned or incinerated, it releases persistent pollutants known as 'forever chemicals' (PFAS), which remain in ecosystems for decades. As a result, traditional disposal methods pose significant environmental and public health risks.

Mechanochemistry Provides a Cleaner Path Forward

To address this challenge, the researchers used mechanochemistry, a sustainable approach in which mechanical force drives chemical reactions rather than high heat.

Inside a sealed steel container called a ball mill, small pieces of sodium metal are ground together with Teflon. This grinding causes the materials to react at room temperature, breaking the carbon-fluorine bonds within Teflon and producing harmless carbon along with sodium fluoride, a stable salt widely used in fluoride toothpaste.

The team also demonstrated that the sodium fluoride generated through this method can be used immediately, without additional purification, to synthesize other valuable fluorine-containing compounds used in pharmaceuticals, diagnostic tools, and specialty chemicals.

Confirming Clean Reactions With Advanced NMR Analysis

Associate Professor Dr. Dominik Kubicki, who leads the University of Birmingham's solid-state Nuclear Magnetic Resonance (NMR) team, explained: "We used advanced solid-state NMR spectroscopy -- one of our specialities at Birmingham -- to look inside the reaction mixture at the atomic level. This allowed us to prove that the process produces clean sodium fluoride without any by-products. It's a perfect example of how state-of-the-art materials characterization can accelerate progress toward sustainability."

Toward a Circular Fluorine Economy

This discovery points toward a circular system in which fluorine can be recovered from industrial waste instead of being lost through disposal. Such a model could greatly reduce the environmental impact of fluorine-based chemicals that play essential roles in medicine, electronics, and renewable energy systems.

"Our approach is simple, fast, and uses inexpensive materials," said Dr. Lu. "We hope it will inspire further work on reusing other kinds of fluorinated waste and help make the production of vital fluorine-containing compounds more sustainable."

The study also underscores the expanding role of mechanochemistry in green chemistry. This emerging field replaces high-temperature or solvent-heavy reactions with mechanical motion, opening new opportunities for sustainable innovation.

Dr. Kubicki added: "This research shows how interdisciplinary science, combining materials chemistry with advanced spectroscopy, can turn one of the most persistent plastics into something useful again. It's a small but important step toward sustainable fluorine chemistry."

Science Daily, 27 November 2025

https://sciencedaily.com

Unprecedented Levels of Forever Chemicals Found in Dolphins and Whales

2025-11-28

World-first study shows deep sea habitat does not protect marine mammals from devastation of PFAS contamination.

Groundbreaking research has revealed that marine mammals who live far below the ocean's surface are not immune from the burden of toxic forever chemicals, with whales and dolphins showing unprecedented levels of PFAS contamination.

Dr Katharina Peters, a marine ecologist and research leader of the University of Wollongong's (UOW) Marine Vertebrate Ecology Lab, contributed to the world-first study, led by Te Kunenga ki Pūrehuroa Massey University. The findings challenge the assumption that a deep-sea habitat offers protection from human-made per- and polyfluoroalkyl substances, otherwise known as PFAS.

"Whales and dolphins are considered indicator species because they reflect their ecosystem. We expected that species feeding mainly in deep water, like sperm whales, would have lower PFAS contamination than coastal species like Hector's dolphins which are closer to pollution sources. Our analyses show that this is not the case: there really seems to be no place to hide from PFAS," said Dr Peters, from UOW's Environmental Futures research group.

Published in Science of the Total Environment, the findings raise concerns about the long-term health of marine species and the invisible legacy that forever chemicals are leaving in the environment. PFAS are human-made chemicals that accumulate through the food chain and can disrupt immune, endocrine and reproductive systems, raising concerns for both individual and population health in humans and animals, including cetaceans.

The scientists analysed tissues from 127 animals across 16 species of toothed whales and dolphins in New Zealand waters, from bottlenose dolphins to deep-diving sperm whales. For eight of the 16 species, including New Zealand's endemic Hector's dolphin and three species of beaked whales, this was a global first for PFAS assessment. The researchers looked at how the acquisition of forever chemicals varied according to species, sex, age and the habitat in which they predominantly live and feed.

Study co-author Dr Frédérik Saltré, a researcher with the University of Technology Sydney (UTS) and the Australian Museum, said they found that habitat is a poor predictor of PFAS concentrations.

"Even offshore and deep-diving species are exposed to similar levels of PFAS, highlighting how widespread pollution, compounded by climate-driven stressors, poses a growing threat to marine biodiversity," he said.

The trans-Tasman collaboration involving UOW, Massey University, Manaaki Whenua — Landcare Research, University of Auckland, UTS, and the Australian Museum, is the first of its kind to assess PFAS across a wide range of species, over the same period, living in different marine habitats.

Technology Networks, 28 November 2025

https://technologynetworks.com

Common aldehydes transformed by light could accelerate drug discovery and material development

2025-12-04

A new chemical method that could speed up the creation of medicines, materials and products people rely on every day has been developed by University of Hawaiʻ i at Mānoa Department of Chemistry researchers. The work, published in Angewandte Chemie International Edition, shows how common ingredients called aldehydes can be transformed into more complex molecules using visible light and a specialized catalyst.

Lighting the way

Aldehydes are simple, widely available starting materials used across many chemical processes. Traditionally, turning them into useful advanced compounds requires multiple steps, harsh conditions or costly materials. The UH Mānoa team introduced a light-powered, energy-efficient approach that guides aldehydes through a controlled reaction, producing valuable molecular structures used in drug development, natural product research and chemical manufacturing.

The process relies on light and a specialized palladium catalyst to drive the chemical changes. It enables chemists to quickly and reliably make two useful types of molecules. The approach is also flexible, working on a wide range of starting materials, including complex molecules found in pharmaceuticals.

Making a big impact

For the general public, the importance lies in what this advancement could make possible. Faster and more efficient ways to build complex molecules can shorten the development timeline for new medicines, reduce costs in chemical manufacturing and improve access to products ranging from therapeutics to advanced materials. By enabling more sustainable and streamlined chemistry, the study offers a step toward innovations that could benefit health, technology and everyday life.

"We're always looking for ways to make complex chemistry feel less like a barrier and more like an opportunity," said Assistant Professor and co-author Zuxiao Zhang. "What excites us most is how this platform opens a new creative space for scientists—giving them tools to build molecules in ways that simply weren't practical before. Discoveries like this help lay the groundwork for future breakthroughs we can't yet imagine."

Phys Org, 4 November 2025

https://phys.org

This Common Metal Has an Unusual Power

2025-11-09

A new manganese(I) complex sets a record for the longest excited-state lifetime, opening the door to future large-scale applications in photochemistry.

Chemical reactions are often powered by heat, but scientists have increasingly turned to light as an energy source because it allows reactions to be guided with remarkable precision. This light-based process is called photochemistry.

Until recently, photochemical reactions depended on rare and costly metals such as ruthenium, osmium, or iridium, which also pose environmental challenges during extraction. Now, researchers at Johannes Gutenberg University Mainz (JGU) have created a groundbreaking metal complex that uses manganese—an element that is both abundant and inexpensive.

"This metal complex sets a new standard in photochemistry: it combines a record-breaking excited-state lifetime with simple synthesis," stated Professor Katja Heinze from the JGU Department of Chemistry. "It thus offers a powerful and sustainable alternative to the noble metal complexes that have long dominated light-driven chemistry."

Their findings were recently published in Nature Communications.

Single-step synthesis and strong absorption

Although manganese is more than 100,000 times more common on Earth than ruthenium, its use in photochemistry has long been limited. This was largely due to the complex, multi-step synthesis process, often requiring nine or ten stages, and the very short lifetime of its excited state.

"The newly developed manganese complex overcomes both challenges," explained Dr. Nathan East, a former doctoral student in the Heinze group who carried out the original synthesis. The new material is synthesized directly from commercially available starting materials – in just a single synthesis step.

In addition to manganese, the researchers use a ligand, which allows the properties of the complex to be tuned.

"The combination of a colorless manganese salt and the colorless ligand in solution immediately produces a deep purple color, just like ink. This is a very unusual color for a manganese complex, which showed us that something unique was happening," added Sandra Kronenberger, who further investigated this novel manganese complex as a doctoral student in the Heinze group at the Max Planck Graduate Center (MPGC).

The resulting manganese complex not only looks impressive, it also exhibits remarkable properties: "Its light absorption is exceptionally strong, meaning the probability of capturing a light particle is very high – the complex thus uses light very efficiently," explained Dr. Christoph Förster, who supported the project with quantum chemical calculations.

Excited state lifetime exceeds the 190-nanosecond mark

"The lifetime of the complex of 190 nanoseconds is also remarkable. This is two orders of magnitude longer than any previously known complexes containing common metals such as iron or manganese," said lead scientist and spectroscopist Dr. Robert Naumann, who characterized the dynamics of the excited state of the complex using luminescence spectroscopy.

In photochemistry, the catalyst, in this case the manganese complex, is excited by light. When it encounters another molecule through diffusion, it transfers an electron to it. Since it can take nanoseconds for the particles to find each other, the excited state must last as long as possible.

But does the complex actually do what the researchers hope it will, i.e., transfer an electron to another molecule? "We were able to detect the initial product of the photoreaction – the electron transfer that occurred – and thus prove that the complex reacts as desired," summarized Professor Katja Heinze.

This discovery expands the boundaries of sustainable photochemistry. Thanks to its scalable one-step synthesis, efficient light absorption, robust photophysical behavior, and long-lasting excited state, the new manganese-containing material paves the way for future large-scale applications of photoreactions. This could be important for future applications, for example, for sustainable hydrogen production.

Sci Tech Daily, 9 November 2025

https://scitechdaily.com

Fish freshness easily monitored with a new sensor

2025-12-03

To see if a fish is fresh, people recommend looking at its eyes and gills or giving it a sniff. But a more accurate check for food quality and safety is to look for compounds that form when decomposition starts.

Now, researchers reporting in ACS Sensors have developed a simple, effective electronic device that quickly measures one of these compounds. The prototype sensor can determine how fresh a fish is in less than two minutes.

For fish, signs of spoilage (cloudy eyes, bruised gills, foul or fishy odors) might take hours or even days to appear. In contrast, compounds such as hypoxanthine (HX) start forming almost immediately after death because nucleic acids and other molecules begin to break down. Therefore, researchers consider the level of HX a more reliable "freshness indicator" for both whole fish and individual filets.

Currently, measuring HX requires time-consuming processes and specialized laboratory equipment. So, to make HX monitoring simpler and portable, Nicolas Voelcker, Azadeh Nilghaz, Muamer Dervisevic and colleagues created a microneedle-based freshness sensor. While microneedles are typically used in products for drug delivery or skincare, here they serve to boost the device's sensitivity.

To build the sensor, the team created a four-by-four microneedle array and coated it with specialized gold nanoparticles and an enzyme that breaks down HX. The sensor is pressed into the surface of a piece of fish and anchored by the microneedles. As the enzyme breaks down HX, the electric potential within the fish changes, and the sensor measures and interprets these changes.

The researchers validated the sensor's performance with salmon steaks cut into small pieces and left to spoil for up to 48 hours at room temperature. The sensor detected concentrations of HX down to less than 500 parts per billion, which is a level consistent with fish samples considered to be "very fresh."

Results were returned in around 100 seconds. Additionally, the new sensor's sensitivity was comparable to that of a commercially available laboratory-based testing kit.

Though further development is needed before the sensor will be available for use as a portable food safety tool, the researchers say that this demonstration shows its potential for real-time food-quality monitoring.

Phys Org, 12 December 2025

https://phys.org

Solid-State Sodium Batteries Could Be Safer, Cheaper, More Powerful Option

2025-11-14

We rely on batteries now more than ever, from our phones and laptops to electric vehicles. But the ones powering today's technologies aren't without their shortcomings. They can be expensive, flammable, and they rely on increasingly in-demand materials that must be mined and processed.

Researchers at Western University are working on a new type of battery – called solid-state sodium batteries – that show considerable promise in addressing these challenges.

"Right now, most of the batteries we use contain flammable liquid electrolytes and rare elements like lithium," says Dr. Yang Zhao, professor in the Department of Mechanical and Materials Engineering at Western. "Sodium is much more abundant and cheaper, and if we can make it work in a solid-state form of the electrolyte, it could be cheaper, safer, and long lasting."

Solid-state electrolytes replace the flammable liquids in conventional batteries with solid materials. These solids are inherently safer and promise higher energy density, meaning batteries last longer between charges. But getting the sodium ions to move quickly and reliably through solids has been a tough scientific puzzle.

Zhao and colleagues formulated a new material that contains sulfur and chlorine. While traditional electrolytes are chemically stable, they tend to move sodium ions poorly from the positive end of the battery to the negative. The sulfur component in the new design boosts conductivity by making it easier for ions to hop through the structure, and strengthens the material overall. They published their findings in the journals Advanced Functional Materials and Advanced Materials.

In addition to its high sodium-ion conductivity, the material developed by Zhao and his team has excellent thermal and mechanical stability. This is a big deal for batteries that need to last for countless charge-discharge cycles and perform reliably across a wide temperature range. In many solid-state designs, the electrolyte can degrade when it comes in contact with other battery components. That's not the case with the material developed by the team at Western.

Zhao and his colleagues used the powerful X-rays of the Canadian Light Source (CLS) at the University of Saskatchewan to observe how ions move inside the solid electrolyte.

"These X-ray tools allow us to see the local chemical environment, ion pathways, and bonding structures in ways that regular lab instruments can't," said Zhao. "They're absolutely essential for developing solid-state battery materials."

While solid-state batteries are likely still a few years away from widespread commercial use, Dr. Zhao is optimistic. "We're making real progress toward safer, more cost-effective batteries," he said.

Technology Networks, 14 November 2025

https://technologynetworks.com

Catalyst insight may unlock safer, on-demand ozone water disinfection

2025-12-04

University of Pittsburgh researchers have made an important step toward providing hospitals and water treatment facilities with a safer, greener alternative to chlorine-based disinfection.

The team, which includes scientists from Drexel University and Brookhaven National Laboratory, uncovered key design principles for catalysts that can generate ozone, a disinfecting agent, on demand. The research is published in the journal ACS Catalysis.

This breakthrough addresses a critical challenge in water sanitation. Chlorine, commonly used to kill bacteria on surfaces and in water—including most municipal drinking water—is hazardous to transport and store, and its byproducts can be carcinogenic. These risks limit its use and motivate the search for safer disinfectants.

With the right catalyst, water electrolysis can generate the less hazardous and more sustainable ozone, but limited understanding of how ozone-forming catalysts work has hindered progress. By identifying which surface defects accelerate ozone formation and which trigger corrosion that stops ozone formation, the team has revealed the characteristics necessary for active and stable next-generation catalysts.

"Catalysts can make exciting chemistry possible, but catalysts themselves break down over time," said John Keith, R.K. Mellon Faculty Fellow in Energy at Pitt's Swanson School of Engineering. "Under extreme electrolysis conditions, exciting chemistry can start happening, but catalysts can also start breaking down quicker, too.

"In the oxide-based catalysts we have studied, what forms ozone is paradoxically also suppressing its formation. Now that we understand that, it becomes a fun puzzle to solve how to design ozone-generating sites that do not also cause corrosion reactions that ruin the catalyst."

The research team, led by Keith and Drexel Associate Professor Maureen Tang, studied fundamental electrochemical mechanisms of multielectron oxidations. They targeted ozone as a replacement for chlorine because it decomposes into oxygen, eliminating long-term residue concerns. Technologies that generate ozone directly in water wherever disinfection is needed could revolutionize water sanitation practices.

Water electrolysis, a high-energy process where electric currents split water into oxygen and hydrogen gases, can produce ozone instead of oxygen when the right catalyst is used. Among the few known examples, nickel- and antimony-doped tin oxide (NATO) catalysts have been considered the safest and most cost-effective option for electrolysis-based ozone generation. However, they have been observed to degrade too quickly for widespread use.

Solving the catalyst puzzle

Computational work by Lingyan Zhao, then a Pitt chemical engineering Ph.D. student using resources at Brookhaven National Lab's Center for Functional Nanomaterials, provided clues to why NATO catalysts break down so rapidly.

Quantum chemistry models pinpointed that defect sites on the catalyst surface play two distinct but critical roles: They enhance ozone generation by enabling rapid electron transfer, but also make the catalyst susceptible to corrosion when water attaches to the surface. There it forms proton-rich networks of hydroxides and water, which are known to be reactive and corrosive.

The lead author of the work, Rayan Alaufey, an international Ph.D. student at Drexel, performed a wide series of experiments to test and validate these hypotheses, leading to the final conclusions.

"This work is a testament to how fundamental science and engineering come together to answer long-standing questions and concoct new routes to improved water sanitation technologies," Keith said.

Phys Org, 4 December 2025

https://phys.org

'Plumbyne' compound featuring multiple carbon–lead bonds synthesised

2025-11-28

A compound which features multiple bonds between lead and carbon has been isolated and characterised. This heteronuclear 'plumbyne' fills a gap among group 14 alkyne analogues and could offer a starting point to create rarer main group species.

Bonding in organo-lead compounds is typically limited to single lead–carbon bonds, owing to lead's large atomic size and poor orbital energy match to other atoms. Relativistic effects also suppress lead's ability to form higher-order π bonds. Compounds where lead forms multiple bonds to other lead, transition metal or non-metal atoms exist, but are rare.

By balancing electronic and steric factors, researchers in China have now created a compound that features multiple bonds between lead and carbon.1 An aryl group with bulky substituents and an N-heterocyclic carbene containing phosphorus are connected to the ends of a central lead–carbon bond. The team previously used a similar structure to create the lighter tin 'stannyne' equivalent.2

X-ray diffraction showed that the lead–based compound adopted a trans bonding arrangement, with a central carbon–lead bond length of 2.172Å. The substituents were shown to be nearly orthogonal to each other, which is thought to improve orbital overlap and increase stability of the P–C–Pb linkage. Computational analysis of a simplified structure revealed that the most prevalent resonance form features a P=C=Pb bonding pattern.

Reactions using the compound were possible, where addition of ammonium hydrochloride easily saturated the multiple carbon–lead bond, which the researchers attribute to the bond's relatively weak nature. Using a tin-based reagent saw bond–metathesis occur, creating a new tin compound and lead byproduct, though the exact reaction mechanism remains unclear. The researchers hope that this plumbyne compound will act as platform to access other rare main group species.

Chemistry World, 28 November 2025

https://chemistryworld.com

Paper Mill Trash Could Be the Secret to Cheap Clean Energy

2025-12-03

A new study showcases a catalyst made from lignin, a plant-based waste material, that dramatically improves a key step in water electrolysis.

Researchers have introduced a new type of catalyst made from renewable plant waste that could greatly speed up the production of clean hydrogen. The material is produced by embedding nickel oxide and iron oxide nanoparticles within carbon fibers derived from lignin. This design improves both the efficiency and stability of the oxygen evolution reaction, which is an essential step in water electrolysis.

According to the study published in Biochar X, the catalyst operates with a low overpotential of 250 mV at 10 mA cm^2 and continues to perform reliably for more than 50 hours at high current density. These findings point to a practical and affordable option that could replace the precious metal catalysts commonly used in industrial water splitting.

"Oxygen evolution is one of the biggest barriers to efficient hydrogen production," said corresponding author Yanlin Qin of the Guangdong University of Technology. "Our work shows that a catalyst made from lignin, a low-value byproduct of the paper and biorefinery industries, can deliver high activity and exceptional durability. This provides a greener and more economical route to large-scale hydrogen generation."

Structural Advantages of the NiO/Fe3O4@LCFs Catalyst

Lignin is one of the planet's most abundant biopolymers, yet it is often burned for low-grade heat rather than used for higher-value applications. In this study, the researchers transformed lignin-based waste into carbon fibers through electrospinning and thermal treatment.

The resulting conductive framework helps hold and protect the active metal oxide particles. The final material, known as NiO/Fe3O4@LCFs, contains a network of nitrogen-doped carbon fibers that improves charge transfer, increases surface area, and provides strong mechanical stability.

High-resolution microscopy revealed that the nickel and iron oxides form a nanoscale heterojunction inside the carbon fiber network. This interface plays a crucial role in accelerating oxygen evolution by promoting balanced adsorption and release of reaction intermediates. The combination of the metal oxides with the conductive carbon support enhances electron transport and suppresses particle agglomeration, two common limitations of traditional base metal catalysts.

Electrochemical Performance and Mechanistic Insights

Electrochemical tests confirmed that the catalyst outperforms single-metal versions, particularly at high current densities needed for practical water electrolysis. The material also shows a Tafel slope of only 138 mV per decade, indicating faster kinetics. In situ Raman measurements and density functional theory calculations support the proposed mechanism, revealing that the engineered interface facilitates key steps in the oxygen evolution pathway.

"Our goal was to develop a catalyst that not only performs well but is scalable and rooted in sustainable materials," said co-corresponding author Xueqing Qiu. "Because lignin is produced in huge quantities worldwide, the approach offers a realistic path toward greener industrial hydrogen production technologies."

The study highlights the growing potential of biomass-derived materials in energy conversion systems. By combining renewable carbon supports with rational engineering of metal oxide interfaces, the approach aligns with global efforts to develop low-cost and environmentally friendly solutions for clean energy.

The researchers believe that the strategy can be extended to other metal combinations and catalytic processes, opening new possibilities for designing next-generation electrocatalysts from abundant natural resources.

Sci Tech Daily, 3 December 2025

https://scitechdaily.com

New Lightweight Polymer Film Can Prevent Corrosion

2025-12-12

MIT researchers have developed a lightweight polymer film that is nearly impenetrable to gas molecules, raising the possibility that it could be used as a protective coating to prevent solar cells and other infrastructure from corrosion, and to slow the aging of packaged food and medicines.

The polymer, which can be applied as a film mere nanometers thick, completely repels nitrogen and other gases, as far as can be detected by laboratory equipment, the researchers found. That degree of impermeability has never been seen before in any polymer, and rivals the impermeability of molecularly-thin crystalline materials such as graphene.

“Our polymer is quite unusual. It’s obviously produced from a solution-phase polymerization reaction, but the product behaves like graphene, which is gas-impermeable because it’s a perfect crystal. However, when you examine this material, one would never confuse it with a perfect crystal,” says Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering at MIT.

The polymer film, which the researchers describe today in Nature, is made using a process that can be scaled up to large quantities and applied to surfaces much more easily than graphene.

Strano and Scott Bunch, an associate professor of mechanical engineering at Boston University, are the senior authors of the new study. The paper’s lead authors are Cody Ritt, a former MIT postdoc who is now an assistant professor at the University of Colorado at Boulder; Michelle Quien, an MIT graduate student; and Zitang Wei, an MIT research scientist.

Bubbles that don’t collapse

Strano’s lab first reported the novel material — a two-dimensional polymer called a 2D polyaramid that self-assembles into molecular sheets using hydrogen bonds — in 2022. To create such 2D polymer sheets, which had never been done before, the researchers used a building block called melamine, which contains a ring of carbon and nitrogen atoms. Under the right conditions, these monomers can expand in two dimensions, forming nanometer-sized disks. These disks stack on top of each other, held together by hydrogen bonds between the layers, which make the structure very stable and strong.

That polymer, which the researchers call 2DPA-1, is stronger than steel but has only one-sixth the density of steel.

In their 2022 study, the researchers focused on testing the material’s strength, but they also did some preliminary studies of its gas permeability. For those studies, they created “bubbles” out of the films and filled them with gas. With most polymers, such as plastics, gas that is

trapped inside will seep out through the material, causing the bubble to deflate quickly.

However, the researchers found that bubbles made of 2DPA-1 did not collapse — in fact, bubbles that they made in 2021 are still inflated. “I was quite surprised initially,” Ritt says. “The behavior of the bubbles didn’t follow what you’d expect for a typical, permeable polymer. This required us to rethink how to properly study and understand molecular transport across this new material.”

“We set up a series of careful experiments to first prove that the material is molecularly impermeable to nitrogen,” Strano says. “It could be considered tedious work. We had to make micro-bubbles of the polymer and fill them with a pure gas like nitrogen, and then wait. We had to repeatedly check over an exceedingly long period of time that they weren’t collapsed, in order to report the record impermeability value.”

Traditional polymers allow gases through because they consist of a tangle of spaghetti-like molecules that are loosely joined together. This leaves tiny gaps between the strands. Gas molecules can seep through these gaps, which is why polymers always have at least some degree of gas permeability.

However, the new 2D polymer is essentially impermeable because of the way that the layers of disks stick to each other.

“The fact that they can pack flat means there’s no volume between the two-dimensional disks, and that’s unusual. With other polymers, there’s still space between the one-dimensional chains, so most polymer films allow at least a little bit of gas to get through,” Strano says.

George Schatz, a professor of chemistry and chemical and biological engineering at Northwestern University, described the results as “remarkable.”

“Normally polymers are reasonably permeable to gases, but the polyaramids reported in this paper are orders of magnitude less permeable to most gases under conditions with industrial relevance,” says Schatz, who was not involved in the study.

A protective coating

In addition to nitrogen, the researchers also exposed the polymer to helium, argon, oxygen, methane, and sulfur hexafluoride. They found that 2DPA-1’s permeability to those gases was at least 1/10,000 that of any other existing polymer. That makes it nearly as impermeable as graphene, which is completely impermeable to gases because of its defect-free crystalline structure.

Scientists have been working on developing graphene coatings as a barrier to prevent corrosion in solar cells and other devices. However, scaling up the creation of graphene films is difficult, in large part because they can't be simply painted onto surfaces.

"We can only make crystal graphene in very small patches," Strano says. "A little patch of graphene is molecularly impermeable, but it doesn't scale. People have tried to paint it on, but graphene does not stick to itself but slides when sheared. Graphene sheets moving past each other are considered almost frictionless."

On the other hand, the 2DPA-1 polymer sticks easily because of the strong hydrogen bonds between the layered disks. In this paper, the researchers showed that a layer just 60 nanometers thick could extend the lifetime of a perovskite crystal by weeks. Perovskites are materials that hold promise as cheap and lightweight solar cells, but they tend to break down much faster than the silicon solar panels that are now widely used.

A 60-nanometer coating extended the perovskite's lifetime to about three weeks, but a thicker coating would offer longer protection, the researchers say. The films could also be applied to a variety of other structures.

"Using an impermeable coating such as this one, you could protect infrastructure such as bridges, buildings, rail lines — basically anything outside exposed to the elements. Automotive vehicles, aircraft and ocean vessels could also benefit. Anything that needs to be sheltered from corrosion. The shelf life of food and medications can also be extended using such materials," Strano says.

The other application demonstrated in this paper is a nanoscale resonator — essentially a tiny drum that vibrates at a particular frequency. Larger resonators, with sizes around 1 millimeter or less, are found in cell phones, where they allow the phone to pick up the frequency bands it uses to transmit and receive signals.

"In this paper, we made the first polymer 2D resonator, which you can do with our material because it's impermeable and quite strong, like graphene," Strano says. "Right now, the resonators in your phone and other communications devices are large, but there's an effort to shrink them using nanotechnology. To make them less than a micron in size would be revolutionary. Cell phones and other devices could be smaller and reduce the power expenditures needed for signal processing."

Resonators can also be used as sensors to detect very tiny molecules, including gas molecules.

The research was funded, in part, by the Center for Enhanced Nanofluidic Transport-Phase 2, an Energy Frontier Research Center funded by the U.S. Department of Energy Office of Science, as well as the National Science Foundation.

Technology Networks, 12 November 2025

https://technologynetworks.com

Alternative to BPA passes toxicity and sustainability standards set by EU innovation guidelines

2025-12-04

Polyester and a host of other plastic products could potentially be manufactured with non-toxic and sustainable BPA alternatives identified in a multidisciplinary study published in Nature Sustainability by researchers in Sweden.

The identification of safe bisphenol alternatives resulted from a design, assessment and development workflow introduced by a team of chemists, data scientists, toxicologists and material experts at KTH Royal Institute of Technology and Stockholm University.

Their aim was to find safe, non-estrogenic alternatives to Bisphenol A (BPA) and its analogs, which are key ingredients in—among other things—polycarbonate plastics used to make scores of consumer and industrial products. The study paid particular attention to bisphenols that could be made from renewable resources.

By aligning with the European Commission's Safe-and-Sustainable-by-Design (SSbD) framework, their approach puts these bisphenols on track for regulatory approval and eventually industrial adoption. SSbD is a voluntary framework to guide the innovation process for safe chemicals and materials.

Promising results and potential applications

The study identified three bisphenols with negligible estrogenic effects, all of which are obtainable from renewable biomaterials. One of these compounds—bisguaiacol F (BGF)—was incorporated into a polyester matrix. The synthesized polyester demonstrated thermal stability and mechanical properties comparable to or better than BPA-based plastics.

All three were identified as potential substitutes for BPA in a wide range of applications, including consumer products such as water bottles, furniture and eyeglasses.

Lead author Helena Lundberg, associate professor of organic chemistry at KTH Royal Institute of Technology, says the study demonstrates the advantages of working in a multidisciplinary team to minimize negative health and environmental impacts of new chemicals and materials.

"The workflow we delivered is a key point of this research. The way we collaborate between different disciplines to align with the SSbD framework can be generalized for various types of toxicity and for various kinds of chemical compounds meant for consumer products."

Research process and future steps

Beginning with more than 170 potential bisphenols, the researchers combined computational screening, sustainable synthetic chemistry and in vitro toxicology to eventually winnow down the field of candidates.

Senior authors Oskar Karlsson (toxicology, Stockholm University), Minna Hakkarainen (polymer technology, KTH) and Ulf Norinder (data science, Stockholm University) say the project's multidisciplinary structure was essential for evaluating both safety and performance of the candidate bisphenols.

"High-throughput toxicology allows us to rapidly evaluate many candidates, which is essential to ensure that only the safest options progress," Karlsson says.

Further testing, including long-term toxicology and full life-cycle assessments, must be carried out before the BGF-based materials can be brought to market. However, Lundberg says the research marks a significant contribution towards eliminating harmful chemicals in our daily lives, particularly by demonstrating an example of an effective SSbD workflow.

"The Safe-and-Sustainable-by-Design approach helps scientists to provide new materials for everyday products that are free from hidden health risks and produced with minimal environmental impact," she says.

"That means that consumers are provided with better products without compromising quality or convenience."

Phys Org, 4 December 2025

https://phys.org

New MOF binds two gas molecules at each metal site

2025-11-26

A new metal–organic framework (MOF) selectively adsorbs two molecules of carbon monoxide at each metal site. The US-based researchers that developed it believe that the underlying chemistry may enable the design of MOFs that capture other gases with greater efficacy.

MOFs were the focus of this year's Nobel prize in chemistry due to their ability to bind specific molecules, which makes them particularly useful for storage and filtration. In the vast majority of MOFs, each site in the framework can adsorb a maximum of one target molecule.

However, some very rare examples show 'co-operative adsorption'. 'There are some examples … when one molecule would be adsorbed it would undergo a chemical reaction that made it easier for the second and even easier for the third,' explains synthetic inorganic chemist Kurtis Carsch at the University of Texas at Austin. However, the design principles behind these MOFs are difficult to generalise for the adsorption of other molecules.

In the new work, Carsch and colleagues led by Jeffrey Long at the University of California, Berkeley, synthesised CoMe-MFU-4l, a MOF that contains cobalt(II)–methyl sites. At ambient temperature and partial pressure of just 10 millibars, the structure adsorbed around 1.6 times more carbon monoxide than if every single site were occupied by one molecule. It was also extremely selective, requiring much higher pressures to adsorb other gases. The adsorption was reversible under vacuum, and the material retained 98% of its activity after 50 cycles.

The researchers' analysis suggests that adsorption of one carbon monoxide molecule triggers a spin transition in the cobalt ion. This facilitates the insertion of a second carbon monoxide molecule between the cobalt and the methyl group. The process does not require the involvement of any other bonding sites in the MOF. 'The Long group are thinking of other opportunities for very different gases that can bind to a site,' says Carsch, 'Can you have multiple oxygen atoms? Can you have multiple acetylene molecules?'

The researchers are also looking at uses for the material in applications such as hydrogen purification. 'A lot of fuel cells, which use hydrogen, will be irreversibly poisoned by carbon dioxide,' says Carsch. 'These trailing decimals at parts per million levels can lead to complete deactivation of the catalyst.'

Chemical engineer Andrew Medford from the Georgia Institute of Technology in Atlanta, who helped develop the ODAC25 database exploring MOFs as potential carbon capture materials, is intrigued. He is surprised, he says, that a mechanism involving formation of a covalent bond is so readily reversible. 'The thing that I think is most interesting from a computational screening standpoint is the role of spin,' he says, adding that this is normally treated as a fixed property in MOFs. 'On the one hand it points to things that could be missed even in the highest end high-throughput databases, but on the other hand it's exciting because it means that if we do go through and really carefully check for spin-state optimisation, we could discover some of these exotic binding modes,' he says.

Chemistry World, 26 November 2025

https://chemistryworld.com

Scientists Develop New Plastics That Break Down Safely Instead of Polluting

2025-12-02

Rutgers scientists have developed plastics that can be programmed to break down at specific rates by drawing on a natural principle. Their approach could provide a meaningful new way to tackle the growing problem of plastic pollution.

Yuwei Gu was on a hike in Bear Mountain State Park in New York when an unexpected idea took shape.

As he walked, he noticed plastic bottles scattered along the path and drifting on a nearby lake. The clash between the scenic landscape and the plastic trash caused the Rutgers chemist to pause and reflect.

In nature, many essential substances are made of long chains of repeating units called polymers, such as DNA and RNA, and these natural polymers eventually break apart. Man-made polymers like plastic, however, tend to remain in the environment instead of breaking down. Why is that?

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

As he stood in the woods, the answer came to him.

"The difference has to lie in chemistry," he said.

Gu reasoned that if living systems can create polymers that do their job and then naturally decompose, perhaps plastics designed by people could be reimagined to behave in a similar way. From his training, he knew that many natural polymers contain small chemical groups built into their structure that help loosen chemical bonds when conditions are right, making it easier for those materials to break down.

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

Borrowing Nature's Blueprint

The idea worked. In a study published in Nature Chemistry, Gu and a team of Rutgers scientists have shown that by borrowing this principle from nature, they can create plastics that break down under everyday conditions without heat or harsh chemicals.

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

A polymer is a substance made of many repeating units linked together, like beads on a string. Plastics are polymers, and so are natural materials such as DNA, RNA, and proteins. DNA and RNA are polymers because they are long chains of smaller units called nucleotides. Proteins are polymers made of amino acids.

Chemical bonds are the "glue" that holds atoms together in molecules. In polymers, these bonds connect each building block to the next. Strong bonds make plastics durable, but they make them difficult to break down. Gu's research focused on making these bonds easier to break when needed, without weakening the material during use.

The advance does more than make plastics degradable: It makes the process programmable.

A Structural "Pre-Fold"

The key to the discovery was how the researchers arranged components of the plastic's chemical structure so they were in the perfect position to start breaking down when triggered.

The process can be likened to folding a piece of paper, so it tears easily along the crease. By "pre-folding" the structure, the plastic can break apart thousands of times faster than normal. Even though the plastic is easier to break when activated, its basic chemical makeup stays the same, so it remains strong and useful until the moment the user wants it to degrade.

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

This fine-tuning capability means different products can have lifetimes matched to their purpose. Take-out food packaging might only need to last a day before it disintegrates, while car parts must endure for years. The team demonstrated that breakdown can be built-in or can be switched on or off using ultraviolet light or metal ions, adding another layer of control.

Beyond Environmental Cleanup

The implications go beyond solving the global plastics crisis. Gu said the principle could enable innovations such as timed drug-release capsules and self-erasing coatings.

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

For Gu, the ultimate goal is clear: Plastics should serve their purpose and then disappear.

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

Early lab tests have shown that the liquid produced by the breakdown is not toxic. But Gu said that more research needs to be done to ensure that is the case.

Looking back, Gu said he was surprised that the idea sparked on a quiet mountain trail actually worked.

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

Next Steps

Gu and his team are now taking their research in several new directions.

They are studying in detail whether the tiny pieces that plastics break down into are harmful to living things or the environment. This will help make sure the materials are safe for their entire life cycle.

The team also is looking at how their chemical process could work with regular plastics and fit into current manufacturing methods. At the same time, they are testing whether this approach can be used to make capsules that release medicine at controlled times.

There are still a few technical challenges, but Gu said that with more development, along with working with plastic makers who understand the need for sustainable plastics, their chemistry could eventually be used in everyday products.

Sci Tech Daily, 2 December 2025

https://scitechdaily.com

Seeing inside smart gels: Scientists capture dynamic behavior under stress

2025-12-04

Advances in materials science have led to the development of "smart materials," whose properties do not remain static but change in response to external stimuli. One such material is poly(N-isopropylacrylamide), or PNIPAM, a polymer gel that alters its solubility with temperature. The polymer contains hydrophilic amide groups and hydrophobic isopropyl groups.

Temperature effects and biomedical relevance

At low temperatures, the amide groups form strong hydrogen bonds with water, keeping the material well-swollen and soluble. However, as the temperature increases, these hydrogen bonds weaken while hydrophobic interactions strengthen, causing the polymer chains to collapse into compact globules.

This transition occurs at the lower critical solution temperature (LCST), which is approximately 32 °C, close to human body temperature. This makes PNIPAM especially attractive for biomedical applications. For instance, it can carry bioactive molecules while swollen and release them into the body by deswelling.

Furthermore, since shear forces from bodily fluids are present inside the human body, investigating PNIPAM behavior under specific conditions is crucial.

Though there are multiple studies on the phase transitions of these smart gels, research on internal structure and electrical conductivity remains unelucidated.

New research and experimental methods

Against this backdrop, a new study was conducted by Associate Professor Isao Shitanda of the Department of Advanced Chemistry at Tokyo University of Science (TUS), Japan, in collaboration with Master's student Mr. Haruna Tsunegi, TUS; Dr. Yuichi Takasaki, Anton Paar Japan K. K.; Visiting Professor Yoshifumi Yamagata, Anton Paar Japan K. K. and Research Institute for Science and Technology; Dr. Keisuke Miyamoto, Anton Paar Japan K.; and Professor Kazutake Takada, Nagoya Institute of Technology, Japan.

The findings are published in the journal Langmuir.

"No studies have observed microscopic structural changes within the gel under shear stress conditions, or variations in electrical conductivity within the gel arising from macroscopic structural changes during phase transitions. Our findings are expected to be highly useful for understanding the functional mechanisms of temperature-responsive polymer gels under flow conditions," says Dr. Shitanda.

To investigate this behavior, the researchers built a rheo-impedance device. It combines a rheometer and a potentiostat. The rheometer measures how stiff or soft the gel becomes under force and potentiostat measures the movement of electrical charges through the gel. They also used small-angle X-ray scattering (SAXS) to directly observe how the gel's internal structure rearranged during heating.

Key findings on gel behavior

In their experiments, the team repeatedly heated and cooled the gel between 20–50 °C while applying controlled shear strains to the material, simulating real-time applications. During these cycles, they continuously

measured how the gel's electrical impedance changed across a broad spectrum of frequencies.

Below the LCST, the gel behaves like a hydrated, flexible network where ions move easily, which results in good electrical conductivity. Once the temperature rises above the LCST, hydrophobic regions form inside the gel. These regions act like tiny insulating patches that block ion movement, causing charge to build up and altering both resistance and capacitance.

Shear strain produced additional effects. At low strains between 1–5%, the applied force pushed the electrolyte solution out of the hydrophobic regions, opening up more conductive pathways. At moderate strains between 5–10%, continued shear expelled even more electrolyte from inside the gel, lowering conductivity.

At high strains between 10–20%, the internal hydrophobic domains began to break apart. This created new gaps and rearranged the network in ways that increased conductivity once again.

These structural changes were confirmed using rheo SAXS measurements, which showed the gel shifting from a uniform network to a phase-separated structure with distinct hydrophilic and hydrophobic domains under stress.

Applications and future potential

PNIPAM is already used in drug delivery systems, cell scaffolds, and micro actuators because of its temperature-sensitive mechanical and electrical behavior. PNIPAM is highly biocompatible and could be loaded with drug. During delivery, the microgels are gathered at the target site and upon slight heating, phase transition occurs, leading to drug release.

As the gel's internal structure is related to mechanical strength, PNIPAM could be used to design soft robots and flexible sensors. This novel rheo-impedance method provides a noninvasive way to probe the internal network of such gels and offers valuable guidance for developing the next generation of smart polymers.

The researchers note that this approach could be applied to quality control in gel-based products such as cosmetics, foods, and pharmaceuticals, as well as to polymer electrolytes.

"Unlike conventional static measurements, this approach enables dynamic in situ evaluation of functional transitions within hydrogels and establishes a methodological foundation for extending rheo-impedance analysis. This is expected to become a new evaluation method for improving the durability of materials," says Dr. Shitanda.

Phys Org, 4 December 2025

https://phys.org

The mystery of highly reactive oxygen has finally been solved

2025-10-01

Chemical additions to plastic that mimic natural polymers like DNA can create materials that break down in days, months or years rather than littering the environment for centuries. Researchers hope their new technique will lead to plastic products that serve their purpose and then safely self-destruct.

In 2022, more than a quarter of a billion tonnes of plastic was discarded globally, and only 14 per cent was recycled – the rest was either burned or buried. The promise of a practical, biodegradable plastic has been around for at least 35 years, and there have been efforts to make such materials using everything from bamboo to seaweed. But, in truth, many such materials are difficult to compost and their producers make unrealistic claims.

Now, Yuwei Gu and his colleagues at Rutgers, The State University of New Jersey, are developing a technique to create plastics with finely-tuned lifespans that could quickly break down either in compost or in the natural environment.

Gu wondered why natural, long-stranded polymers like DNA and RNA can break down relatively quickly, but synthetic ones, such as plastics, can't, and if there was a way to replicate their process.

Natural polymers contain chemical structures called neighbouring groups that aid in deconstruction. These structures power internal reactions called nucleophilic attacks that sever the bonds in polymer chains – something that requires a great deal of energy with normal plastics.

Gu and his team created artificial chemical structures that mimic these neighbouring groups and added them when making new plastics. They found that the resulting material could break down easily and that by altering the structure of the additions, they could fine-tune how long the material remained intact before deconstructing.

After the plastic breaks down, the long polymer chains are converted into small fragments, which Gu hopes will either be used to make new plastics or will safely dissolve into the environment.

"This strategy works best for plastics that benefit from controlled degradation over days to months, so we see strong potential for applications like food packaging and other short-lived consumer materials," says Gu. "At the moment, it is less suited for plastics that must remain stable for decades before breaking down – such as construction materials or long-term structural components."

New Scientist, 1 October 2025

https://newscientist.com

CHEMWATCH

Bulletin Board

Technical Notes

DEC. 05, 2025

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

CHEMICAL EFFECTS

Benzalkonium chloride accumulates and causes toxicity in the heart and pancreas following the repeated inhalation exposures

Unsymmetrical Dimethylhydrazine Induces Dose-Dependent Liver Toxicity in Rats via Oxidative Stress and PI3K/Akt Pathway-Mediated Apoptosis

A bioreporter-toxicity-characteristic-leaching-procedure (Bio-TCLP) test battery approach for risk assessment and Cr-remediation performance optimization

ENVIRONMENTAL RESEARCH

Association among persistent chemical pollutants and infectious encephalitis: a mixture exposure and mediation approach

Environmental pollutant-induced cholinergic disruption: Advances and perspectives in mechanistic insights, target heterogeneity, and neurotoxic synergy

Comparing activated carbon and graphene-based electrodes using electrosorption process to quantify environmental impact associated with thorium extraction via LCA framework

PHARMACEUTICAL/TOXICOLOGY

Bisphenol A triggers adipocyte dysfunction, thereby fostering triple-negative breast cancer aggressiveness

Aflatoxin B1-induced lipid disturbance and neuroinflammation contribute to Alzheimer’s disease-like neuropathology in C57BL/6J mice

OCCUPATIONAL

Low-dose radiation exposure and health outcomes among healthcare workers: a multi-center prospective cohort study

Association between prenatal phthalate exposure and preschoolers’ blood pressure: Mediating role of DNA methylation in hypertension-related genes