CHEMWATCH

Bulletin Board

Contents

JUL. 04, 2025

(click on page numbers for links)

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HAZARD ALERT

GOSSIP

CURIOSITIES

CHEMWATCH
Bulletin Board
Contents
JUL. 04, 2025

TECHNICAL NOTES

ASIA PACIFIC

Australian Drinking Water Guidelines

2025-06-25

The Australian Drinking Water Guidelines (the Guidelines) provide a basis for determining the quality of water to be supplied to consumers in all parts of Australia. They are intended to provide a framework for the good management of drinking water supplies that if implemented will assure safety at the point of use. The Guidelines are not mandatory legally enforceable standards and the implementation of the guidelines is at the discretion of each state and territory. The Guidelines are used by state and territory health departments and drinking water regulators, local health authorities and water utilities.

The Guidelines undergo a rolling revision to ensure they represent the latest scientific evidence on good quality drinking water. As sections of the Guidelines are revised, the Table of updates will be updated to provide the latest information.

For specific information on how these Guidelines are implemented in the states and territories, please contact the relevant drinking water regulator or health department.

Update 25 June 2025

Publication of updated guidance in the Australian Drinking Water Guidelines (the Guidelines), including:

- Review and update of 4 chemical fact sheets: per- and polyfluoroalkyl substances (PFAS), selenium, lead and manganese
- New guidance on metals and metalloids leaching from plumbing products
- Two new chemical fact sheets: bismuth, silicon and silica
- Consequential edits to the Guidelines to align advice and ensure consistency.

Read More

NHMRC, 25-06-25

https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 04, 2025

Agricultural chemical products and approved labels

2025-06-24

Pursuant to the Agricultural and Veterinary Chemicals Code scheduled to the Agricultural and Veterinary Chemicals Code Act 1994, the APVMA hereby gives notice that it has registered or varied the relevant particulars or conditions of the registration in respect of the following products and has approved the label or varied the relevant particulars or conditions of the approval in respect of the containers for the chemical product, with effect from the dates shown.

Table 1: Agricultural products based on existing active constituents

Application no.	143191
Product name	Sleep-Easy Mosquito & Fly Control Plug-In Unit
Active constituent	6.8 g/L transfluthrin
Applicant name	Lifeguard Sciences (Pty) Ltd
Applicant ACN	N/A
Date of registration	3 June 2025
Product registration no.	94693
Label approval no.	94693/143191
Description of the application and its purpose, including the intended use of the chemical product	Registration of a 6.8 g/L transfluthrin liquid vaporiser for the control of mosquitoes for up to 45 nights used 10 hours per night

Read More

APVMA, 24-06-25

https://www.apvma.gov.au/sites/default/files/2025-06/Gazette%20No%2013%2C%20Tuesday%2024%20June%202025%20_0.docx

Diving, snorkelling and recreational water activities laws

2025-06-26

In order to understand the work health and safety requirements for diving and your obligations under the law you must understand relevant legislation and codes of practice.

Persons conducting a business or undertaking (PCBUs) such as dive operators and other duty holders, such as workers, must comply with duties contained in the Acts and Regulations.

Codes of practice offer practical advice to PCBUs and workers about how to meet your duties under the legislation. However, you may adopt other processes and methods that are more suited to your business or work activity as long as they give the same level of protection or higher against the risk.

The Safety in Recreational Water Activities Regulation 2024 and the Recreational Diving, Recreational Technical Diving and Snorkelling Code of Practice 2024 (PDF, 0.59 MB) may not outline every risk at your workplace (e.g. electrical safety or manual tasks risks). So, you must ensure you are familiar with all relevant legislation and codes of practice. General advice on risk management can be found in How to manage work health and safety risks Code of Practice 2021 (PDF, 0.65 MB)

Read More

Queensland Worksafe, 26-06-25

https://www.worksafe.qld.gov.au/laws-and-compliance/diving,-snorkelling-and-recreational-water-activities-laws

Veterinary chemical products and approved labels

2025-06-24

Pursuant to the Agricultural and Veterinary Chemicals Code scheduled to the Agricultural and Veterinary Chemicals Code Act 1994, the APVMA hereby gives notice that it has registered or varied the relevant particulars or conditions of the registration in respect of the following products and has approved the label or varied the relevant particulars or conditions of the approval in respect of the containers for the chemical product, with effect from the dates shown.

Table 4: Veterinary products based on existing active constituents

Application no.	141297
Product name	Bayvarol Strips
Active constituent	Contains 0.54 g/kg flumethrin in the form of an impregnated polymer strip (Each strip contains 3.6 mg flumethrin)
Applicant name	Elanco Australasia Pty Ltd

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 04, 2025

Application no.	141297
Applicant ACN	076 745 198
Date of registration	13 June 2025
Product registration no.	94029
Label approval no.	94029/141297
Description of the application and its purpose, including the intended use of the chemical product	Registration of a 0.54 g/kg flumethrin impregnated polymer strip product and label approval for the control of Varroa mites (Varroa destructor) on European Honeybees (Apis mellifera)

Read More

APVMA, 24-06-25

https://www.apvma.gov.au/sites/default/files/2025-06/Gazette%20No%2013%2C%20Tuesday%2024%20June%202025%20_0.docx

Approved active constituents

2025-06-24

Pursuant to the Agricultural and Veterinary Chemicals Code scheduled to the Agricultural and Veterinary Chemicals Code Act 1994, the APVMA hereby gives notice that it has approved or varied the relevant particulars or conditions of the approval of the following active constituents, with effect from the dates shown.

Table 6: Approved active constituents

Application no.	145736
Active constituent	Spirotetramat
Applicant name	ADAMA Australia Pty Limited
Applicant ACN	050 328 973
Date of approval	4 June 2025
Approval no.	95463
Description of the application and its purpose, including the intended use of the active constituent	Approval of the active constituent spirotetramat for use in agricultural chemical products

Application no.	147197
Active constituent	Diethyltoluamide
Applicant name	New Australia Agricultural Development Company Pty Ltd
Applicant ACN	138 055 553
Date of approval	4 June 2025
Approval no.	95800
Description of the application and its purpose, including the intended use of the active constituent	Approval of diethyltoluamide for use in agricultural and veterinary chemical products

Read More

APVMA, 24-06-25

https://www.apvma.gov.au/sites/default/files/2025-06/Gazette%20No%2013%2C%20Tuesday%2024%20June%202025%20_0.docx

AMERICA

Colorado preparing to approve new health-based standards on some air emissions

2025-06-25

Business and environmental leaders are gearing up for a September regulatory hearing that will mark the next flash point over Colorado air-pollution regulation — the establishment of health-based standards for air contaminants that can sicken state residents.

Colorado Air Quality Control Commission members identified five priority toxic air contaminants in January; determining the levels of those contaminants that constitute threats to the public health is the next step in the process. Only after that is done at a hearing scheduled for Sept. 17-19 will the same body come back later and determine, in conjunction with the Legislature, how the new standards will be used in permitting.

The five priority TACs — formaldehyde, benzene, hexavalent chromium, ethylene oxide and hydrogen sulfide — come from a wide variety of sources, including oil-and-gas wells, medical-instrument-manufacturing facilities and wastewater-treatment plants. Colorado's effort to regulate and limit them, stemming from a 2022 law, makes a significant new step

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 04, 2025

for a state government that's focused its air-pollution efforts so far almost solely on greenhouse-gas emissions.

Read More

The Sum & substance, 25-0625

https://tsscolorado.com/colorado-preparing-to-approve-new-health-based-standards-on-some-air-emissions/

Supreme Court rules fuel producers can sue EPA over 'harming' regulations

2025-05-26

The Supreme Court decided last week that fuel producers do have standing to bring a lawsuit against the Environmental Protection Agency for allowing California's more strict standards for car emissions under federal air pollution regulations.

Overturning a lower court, the justices ruled 7-2 in favor of the fuel producers who mostly agreed that the case should not have been dismissed on the Constitution's Article III grounds, which determines whether or not a plaintiff has the right to sue.

"The government generally may not target a business or industry through stringent and allegedly unlawful regulation, and then evade the resulting lawsuits by claiming that the targets of its regulation should be locked out of court as unaffected bystanders," Justice Brett Kavanaugh wrote in the majority opinion.

Read More

Deseret News, 26-05-25

https://www.yahoo.com/news/supreme-court-rules-fuel-producers-224239194.html

EUROPE

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

2025-06-27

The next batch of GB MCL technical reports is now available.

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

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

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

These GB MCL technical reports relate to substances for which the Committee for Risk Assessment (RAC) published a RAC Opinion under Article 37(4) of EU CLP during 2024, based on information submitted under the EU CLP Regulation. The scientific information supporting the RAC Opinion is evaluated under the GB MCL system.

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

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

We expect to publish our next batch of technical reports in September 2025. CLP ebulletin alerts will be issued when technical reports are published on the HSE website.

Read More

HSE UK, 27-06-25

https://www.hse.gov.uk/chemical-classification/classification/gb-mcl-list.htm

Air pollution in Europe — 2025 reporting status under the National Emission reduction Commitments Directive

2025-06-27

This briefing describes progress made by the European Union and its Member States in reducing air pollutant emissions, as regulated by the National Emission reduction Commitments Directive (EU/2016/2284). It is based on data reported by EU Member States in 2025 for their 2023 emissions

In 2023, 19 Member States met their 2020-2029 national emission reduction commitments for each of the five main air pollutants. In

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 04, 2025

contrast, eight Member States failed to do so for at least one of the pollutants.

The biggest challenge is reducing ammonia (NH3) emissions: six Member States need to cut their emissions further to reach their 2020-2029 reduction commitments.

The most significant progress has been made in reducing sulphur dioxide (SO2) emissions, with 25 Member States having already met their 2030 reduction commitments.

Nearly all Member States will find it a significant challenge to achieve the more stringent emission reduction commitments for 2030 and beyond, with regard to almost all air pollutants.

Read More

European Environment Agency, 27-06-25

https://www.eea.europa.eu/en/analysis/publications/air-pollution-in-europe-2025-reporting-status-under-the-national-emission-reduction-commitments-directive

EUROPE: OSPAR ministerial meeting agrees first regional regulation to ban scrubber discharges in NE Atlantic waters

2025-06-25

At an OSPAR meeting in Brussels today (26 June), environmental ministers from the EU and 15 European governments decided to ban discharges from open loop scrubbers in internal waters and port areas throughout the North-East Atlantic (OSPAR Maritime Area) by July 2027.

In a further move, discharges from closed-loop scrubbers will also be banned by January 2029.

This is the first regional regulation on scrubber discharges to be agreed.

OSPAR started in 1972 with the Oslo Convention against dumping and was broadened to cover land-based sources of marine pollution and the offshore industry by the Paris Convention of 1974.

These two conventions were unified and extended by the 1992 OSPAR Convention.

The fifteen governments who are party to OSPAR are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Sian Prior, Shipping Director, Seas At Risk, called the ban 'a landmark moment for marine protection,' which shows that regional cooperation can deliver environmental progress in the maritime sector.

As Seas At Risk reported, a majority of OSPAR states had pressed for a ban to extend to the 12-nautical miles area for territorial waters, but full consensus was not reached on this proposal.

A review of the impact for territorial seas of OSPAR Members will take place in the coming year, with a view to reaching a decision by 2027.

Maarten Verdaasdonk, Project Manager, North Sea Foundation, commented: 'Turning air pollution into ocean pollution is not an acceptable trade-off. It is vital that all OSPAR Members support the proposal to extend the ban to territorial waters, especially as cleaner, widely available alternatives exist.

'Such a ban will improve water quality and protect marine life in the coastal areas of the entire North-East Atlantic.'

Read More

Bunkerspot, 26-06-25

https://www.bunkerspot.com/europe/65535-europe-ospar-ministerial-meeting-agrees-first-regional-regulation-to-ban-scrubber-discharges-in-ne-atlantic-waters

Upcoming GB active substance renewal submission deadlines

2025-06-25

Apply for active substance renewal by the deadlines to keep products on the GB market.

Under the GB Biocidal Products Regulation (GB BPR), active substance approvals will expire unless a renewal application is submitted at least 550 days before their expiry date.

The 550-day deadlines are coming up for the following active substance/product type combinations under GB BPR:

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 04, 2025

27 December 2025

- Biphenyl-2-ol (CAS 90-43-7 EC 201-993-5) in product types 1, 2, 4, 6 and 13
- Epsilon-momfluorothrin (CAS 1065124-65-3 EC N/A) in product type 18
- L-(+)-lactic acid (CAS 79-33-4 EC 201-196-2) in product type 1
- Mixture of 5-chloro-2-methyl-2H-isothiazol-3-one (EINECS 247-500-7) and 2-methyl-2H-isothiazol-3-one (EINECS 220-239-6) (Mixture of CMIT/MIT) (CAS 55965-84-9 EC N/A) in product types 2, 4, 6, 11, 12 and 13
- Polyhexamethylene biguanide hydrochloride with a mean number-average molecular weight (Mn) of 1600 and a mean polydispersity (PDI) of 1.8 (PHMB (1600;1.8)) (CAS 27083-27-8 / 32289-58-0 EC N/A) in product type 4

29 June 2026

- 2-bromo-2-(bromomethyl)pentanedinitrile (DBDCB) (CAS 35691-65-7 EC 252-681-0) in product type 6
- 2-octyl-2H-isothiazol-3-one (OIT) (CAS 26530-20-1 EC 247-761-7) in product type 8
- Amines, N-C10-16-alkyltrimethylenedi-, reaction products with chloroacetic acid (ampholyt 20) (CAS 139734-65-9 EC 701-317-3) in product types 2, 3 and 4
- Bacillus amyloliquefaciens strain ISB06 (CAS N/A EC N/A) in product type 3
- Biphenyl-2-ol (CAS 90-43-7 EC 201-993-5) in product type 3
- N-cyclopropyl-1,3,5-triazine-2,4,6-triamine (cyromazine) (CAS 66215-27-8 EC 266-257-8) in product type 18
- Reaction mass of N,N-didecyl-N-(2-hydroxyethyl)-N-methylammonium propionate and N,N-didecyl-N-(2-(2-hydroxyethoxy)ethyl)-N-methylammonium propionate and N,N-didecyl-N-(2-(2-(2-hydroxyethoxy)ethoxy)ethyl)-N-methylammonium propionate (CAS N/A EC N/A) in product type 8
- Dichloro-N-[(dimethylamino)sulphonyl] fluoro-N-(ptolyl) methanesulphenamide (tolylfluanid) (CAS 731-27-1 EC 211-986-9) in product type 7

28 December 2026

- 2-(2-butoxyethoxy)ethyl 6-propylpiperonyl ether (piperonyl butoxide/PBO) (CAS 51-03-6 EC 200-076-7) in product type 18

- 2-methyl-1,2-benzothiazol-3(2H)-one (MBIT) (CAS 2527-66-4 EC 695-989-4) in product type 6
- Peracetic acid (CAS 79-21-0 EC 201-186-8) in product types 11 and 12

Any person, company or task force/consortium can support an active substance/product type combination for renewal – it doesn't have to be the original supporter.

Check the GB Article 95 List to see who the original supporters were.

If any of these active substance/product type combinations are important to you, consider contacting your supplier to let them know.

If a renewal application is not submitted for the above active substance/product type combinations under GB BPR, the approvals will expire. This means the active substances will no longer be able to be used in biocidal products of the relevant product types in GB. In addition articles treated with such products will no longer be able to be placed on the market in GB.

Read More

UK HSE, 25-06-25

https://www.hse.gov.uk/biocides/active-substances/uk-article-95-list.htm

INTERNATIONAL

New FPF study and dashboard show that food contact articles are a source of micro- and nanoplastics in food

2025-06-24

New research published by the Food Packaging Forum (FPF) finds that normal and intended use of plastic food packaging and other food contact articles (FCAs) can release micro- and nanoplastics (MNPs) into food; identifies research gaps; suggests need for harmonized testing and reporting to improve data reliability; recommends regulations to mandate MNP migration testing for FCAs

A new research article published by the Food Packaging Forum together with researchers from the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and the Norwegian University of Science and Technology in the peer-reviewed journal npj Science of Food on June 24, 2025, shows that the normal and intended use of food packaging

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 04, 2025

and other food contact articles (FCAs) can contaminate foodstuffs with micro- and nanoplastics (MNPs). Examples of normal use include opening a plastic bottle, steeping a plastic tea bag, or chopping on a plastic cutting board.

Read More

FPF, 24-06-25

https://foodpackagingforum.org/news/new-fpf-study-and-dashboard-show-that-food-contact-articles-are-a-source-of-micro-and-nanoplastics-in-food

ECHA adds three hazardous chemicals to the Candidate List

2025-06-2025

The Candidate List of substances of very high concern (SVHC) now contains 250 entries for chemicals that can harm people or the environment. Companies are responsible for managing the risks of these chemicals and giving customers and consumers information on their safe use.

Helsinki, 25 June 2025 – Two newly added substances are very persistent and very bioaccumulative. They are used, for example, in cosmetics, personal care products and in automotive care products. One substance is toxic for reproduction and is used in textile treatment products and dyes.

Entries added to the Candidate List on 25 June 2025:

Substance name	EC number	CAS number	Reason for inclusion	Examples of uses
	241-867-7	17928-28-8	Very persistent	Used as a laboratory reagent, in cosmetics and personal care products and perfumes and fragrances
	205-491-7	141-62-8	Very persistent	Used in cosmetics and personal care products, in lubricants and greases and in automotive care products

CHEMWATCH
Bulletin Board
REACH Update
JUL. 04, 2025

Substance name	EC number	CAS number	Reason for inclusion	Examples of uses
Tetra(sodium/potassium) 7-[(E)-{2-acetamido-4-[(E)-(4-{[4-chloro-6-({2-[(4-fluoro-6-{[4-(vinylsulfonyl) phenyl] amino}-1,3,5-triazine-2-yl) amino]propyl} amino)-1,3,5-triazine-2-yl] amino}-5-sulfonato-1-naphthyl)	466-490-7	-	Toxic for reproduction (Article 57c)	Used in textile treatment products and dyes

The list now contains 250 entries – some are groups of chemicals so the overall number of impacted chemicals is higher.

These substances may be placed on the Authorisation List in the future. If a substance is on this list, companies cannot use it unless they apply for authorisation and the European Commission authorises its continued use.

Read More

ECHA, 25-06-25

https://echa.europa.eu/-/echa-adds-three-hazardous-chemicals-to-the-candidate-list#msdynmkt_trackingcontext=69b96825-595f-4213-8eed-45934bd00100

Janet's Corner

JUL. 04, 2025

Who Am I?

2025-07-04

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

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

CHEMWATCH
Bulletin Board

Hazard Alert

JUL. 04, 2025

Formaldehyde

2025-07-04

In pure form, formaldehyde is a gas but is often used in liquid form after diluting with water. It is a colourless highly flammable liquid or gas with a pungent odour that is detectable at 1 part per million (ppm). Formaldehyde mixes with water, acetone, benzene, diethyl ether, chloroform and ethanol. It reacts with strong oxidisers, alkalis and acids, phenols and urea. Poisonous gases are produced if formaldehyde catches fire. It is very reactive, combines with many substances and polymerises easily.

In view of its widespread use, toxicity and volatility, exposure to formaldehyde is a significant consideration for human health. In 2011, the United States National Toxicology Program described formaldehyde as "known to be a human carcinogen". [1,2]

Formaldehyde is a naturally-occurring organic compound with the chemical formula CH2O. It is the simplest aldehyde and is also known by its systematic name methanal.

USES [2,3]

Water-based solutions containing dissolved formaldehyde, known as 'formalin', are used in:

- forensic/hospital mortuaries and pathology laboratories
- funeral (embalming) industry
- resins manufacture
- leather and fur tanning
- photographic film processing
- sanitising treatments
- lubricants
- analytical laboratories
- fumigation

Resins manufactured with formalin are used in:

- pressed wood manufacture
- paper and textile treatments
- fibreglass industry
- foam insulation
- foundry industry
- firelighter manufacture
- anti-graffiti wall sealer

The major use of formalin is in adhesives used in the manufacture of resins used to make pressed wood products, particularly particleboard and medium-density fibreboard.

Another major use is in medicine-related laboratories where it is used to fix tissues and organs, and in the funeral industry, in embalming processes, where it functions as a disinfectant and preservative.

Formaldehyde is also present at low concentrations as a preservative in a range of personal care and consumer products including hair straightening treatments.

Formaldehyde is naturally produced during burning of organic matter and by a variety of natural biological and chemical processes. It is found in cigarette smoke, and is emitted from cooking and heating appliances such as gas stoves and heaters.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

- **Industry sources:** The major industrial sources include manufacturing plants that produce or use formaldehyde, or substances that contain formaldehyde. Mining, wood and paper industries and electricity supply are those that produce the most formaldehyde. Catalytic cracking, coking operations and fuel combustion sources such as boilers, furnaces and engines in manufacturing processes also generate formaldehyde. Formaldehyde is present in urea-formaldehyde and phenol-formaldehyde resins and copper plating solutions.
- **Diffuse sources:** Formaldehyde is released from burning fuel in homes, and is in products such as carpets and pressed wood products. It is directly emitted into the atmosphere and can also be formed in the atmosphere as a result of the photochemical oxidation of reactive organic gases in polluted atmospheres containing ozone and nitrogen oxides.
- **Natural sources:** Formaldehyde can form as a result of forest fires, and is also present in animal wastes and the microbial products of biological systems. It can also be formed in seawater by photochemical processes.
- **Transport sources:** Vehicle exhaust is a major source of formaldehyde.
- **Consumer products:** Formaldehyde may be present in glues, fibreboard, particle board, furniture, textiles and some insulation.

CHEMWATCH
Bulletin Board
Hazard Alert
JUL. 04, 2025

Formaldehyde-based resins are used in pressed wood, permanent press fabrics (clothing, manchester, draperies), wallpaper, paint, grocery bags and waxed paper. Detergents, cosmetics and other domestic chemicals (shampoos, hair conditioners and bubble baths) contain formaldehyde as an antimicrobial agent. Cigarettes, cigars and other tobacco products also contain formaldehyde.

Routes of Exposure

Formaldehyde can enter the body by inhaling fumes (from smog, cigarettes and other tobacco products, gas cookers and open fireplaces), contact with solutions containing formaldehyde, or by eating and drinking foods containing formaldehyde. Eating formaldehyde-tainted foods may have a different effect than inhaling formaldehyde vapours.

HEALTH EFFECTS [4]

Acute Health Effects

- Occupational studies have noted statistically significant associations between exposure to formaldehyde and increased incidence of lung and nasopharyngeal cancer. This evidence is considered to be "limited," rather than "sufficient," due to possible exposure to other agents that may have contributed to the excess cancers.
- Animal studies have reported an increased incidence of nasal squamous cell carcinomas by inhalation exposure.
- EPA considers formaldehyde to be a probable human carcinogen (cancer-causing agent) and has ranked it in EPA's Group B1.

Carcinogenicity

- Occupational studies have noted statistically significant associations between exposure to formaldehyde and increased incidence of lung and nasopharyngeal cancer. This evidence is considered to be "limited," rather than "sufficient," due to possible exposure to other agents that may have contributed to the excess cancers.
- Animal studies have reported an increased incidence of nasal squamous cell carcinomas by inhalation exposure.
- EPA considers formaldehyde to be a probable human carcinogen (cancer-causing agent) and has ranked it in EPA's Group B1.

Other Effects

- Occupational studies have noted statistically significant associations between exposure to formaldehyde and increased incidence of lung and nasopharyngeal cancer. This evidence is considered to be "limited," rather than "sufficient," due to possible exposure to other agents that may have contributed to the excess cancers.
- Animal studies have reported an increased incidence of nasal squamous cell carcinomas by inhalation exposure.
- EPA considers formaldehyde to be a probable human carcinogen (cancer-causing agent) and has ranked it in EPA's Group B1.

SAFETY

First Aid Measures [5]

- Occupational studies have noted statistically significant associations between exposure to formaldehyde and increased incidence of lung and nasopharyngeal cancer. This evidence is considered to be "limited," rather than "sufficient," due to possible exposure to other agents that may have contributed to the excess cancers.
- Animal studies have reported an increased incidence of nasal squamous cell carcinomas by inhalation exposure.
- EPA considers formaldehyde to be a probable human carcinogen (cancer-causing agent) and has ranked it in EPA's Group B1.
- Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.
- Serious Inhalation: Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.
- Ingestion: If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

CHEMWATCH
Bulletin Board
Hazard Alert
JUL. 04, 2025

Workplace Controls & Practices [4]

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

Personal Protective Equipment [5]

The following personal protective equipment is recommended when handling formaldehyde:

- Safety glasses;
- Lab coat;
- Vapour respirator (be sure to use an approved/certified respirator or equivalent);
- Gloves (impervious).

Personal Protection in Case of a Large Spill:

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

REGULATION

United States

EPA: The United States Environmental Protection Agency has determined that a limit of formaldehyde in drinking water at concentrations of 10 milligrams/litre (mg/L) for 1 day or 5 mg/L for 10 days is not expected to cause any adverse effects in children. A lifetime exposure to 1 mg/L of formaldehyde in drinking water is not expected to cause any adverse health effects.

Hazard Alert

JUL. 04, 2025

OSHA: The Occupational Health and Safety Administration has limited workers' exposure to an average of 0.75 ppm for an 8-hour workday, 40-hour workweek.

The U.S. Department of Housing and Urban Development (HUD) has set standards for formaldehyde emissions in manufactured housing of less than 0.2 ppm for plywood and 0.3 ppm for particle board. The HUD standards are designed to provide an ambient air level of 0.4 ppm or less in manufactured housing.

NIOSH: The National Institute for Occupational Safety & Health has set a recommended exposure limit (REL) for formaldehyde of Ca (carcinogenic) TWA 0.016 ppm C (ceiling) 0.1 ppm [15-minute]

REFERENCES

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2. http://www.npi.gov.au/resource/formaldehyde-methyl-aldehyde
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4. http://www.epa.gov/ttn/atw/hlthef/formalde.html
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CHEMWATCH
Bulletin Board

Gossip

JUL. 04, 2025

From glass and steel to rare earth metals, new materials have changed society throughout history

2025-07-03

Many modern devices—from cellphones and computers to electric vehicles and wind turbines—rely on strong magnets made from types of minerals called rare earths. As the systems and infrastructure used in daily life have turned digital and the United States has moved toward renewable energy, accessing these minerals has become critical—and the markets for these elements have grown rapidly.

Modern society now uses rare earth magnets in everything from national defense, where magnet-based systems are integral to missile guidance and aircraft, to the clean energy transition, which depends on wind turbines and electric vehicles.

The rapid growth of the rare earth metal trade and its effects on society isn't the only case study of its kind. Throughout history, materials have quietly shaped the trajectory of human civilization. They form the tools people use, the buildings they inhabit, the devices that mediate their relationships and the systems that structure economies. Newly discovered materials can set off ripple effects that shape industries, shift geopolitical balances and transform people's daily habits.

Materials science is the study of the atomic structure, properties, processing and performance of materials. In many ways, materials science is a discipline of immense social consequence.

As a materials scientist, I'm interested in what can happen when new materials become available. Glass, steel and rare earth magnets are all examples of how innovation in materials science has driven technological change and, as a result, shaped global economies, politics and the environment.

Glass lenses and the scientific revolution

In the early 13th century, after the sacking of Constantinople, some excellent Byzantine glassmakers left their homes to settle in Venice—at the time a powerful economic and political center. The local nobility welcomed the glassmakers' beautiful wares. However, to prevent the glass furnaces from causing fires, the nobles exiled the glassmakers—under penalty of death—to the island of Murano.

Murano became a center for glass craftsmanship. In the 15th century, the glassmaker Angelo Barovier experimented with adding the ash from

burned plants, which contained a chemical substance called potash, to the glass.

The potash reduced the melting temperature and made liquid glass more fluid. It also eliminated bubbles in the glass and improved optical clarity. This transparent glass was later used in magnifying lenses and spectacles.

Johannes Gutenberg's printing press, completed in 1455, made reading more accessible to people across Europe. With it came a need for reading glasses, which grew popular among scholars, merchants and clergy—enough that spectacle-making became an established profession.

By the early 17th century, glass lenses evolved into compound optical devices. Galileo Galilei pointed a telescope toward celestial bodies, while Antonie van Leeuwenhoek discovered microbial life with a microscope.

Lens-based instruments have been transformative. Telescopes have redefined long-standing cosmological views. Microscopes have opened entirely new fields in biology and medicine.

These changes marked the dawn of empirical science, where observation and measurement drove the creation of knowledge. Today, the James Webb Space Telescope and the Vera C. Rubin Observatory continue those early telescopes' legacies of knowledge creation.

Steel and empires

In the late 18th and 19th centuries, the Industrial Revolution created demand for stronger, more reliable materials for machines, railroads, ships and infrastructure. The material that emerged was steel, which is strong, durable and cheap. Steel is a mixture of mostly iron, with small amounts of carbon and other elements added.

Countries with large-scale steel manufacturing once had outsized economic and political power and influence over geopolitical decisions. For example, the British Parliament intended to prevent the colonies from exporting finished steel with the iron act of 1750. They wanted the colonies' raw iron as supply for their steel industry in England.

Benjamin Huntsman invented a smelting process using 3-foot-tall ceramic vessels, called crucibles, in 18th-century Sheffield. Huntsman's crucible process produced higher-quality steel for tools and weapons.

One hundred years later, Henry Bessemer developed the oxygen-blowing steelmaking process, which drastically increased production speed and

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

lowered costs. In the United States, figures such as Andrew Carnegie created a vast industry based on Bessemer's process.

The widespread availability of steel transformed how societies built, traveled and defended themselves. Skyscrapers and transit systems made of steel allowed cities to grow, steel-built battleships and tanks empowered militaries, and cars containing steel became staples in consumer life.

Control over steel resources and infrastructure made steel a foundation of national power. China's 21st-century rise to steel dominance is a continuation of this pattern. From 1995 to 2015, China's contribution to the world steel production increased from about 10% to more than 50%. The White House responded in 2018 with massive tariffs on Chinese steel.

Rare earth metals and global trade

Early in the 21st century, the advance of digital technologies and the transition to an economy based on renewable energies created a demand for rare earth elements.

Rare earth elements are 17 chemically very similar elements, including neodymium, dysprosium, samarium and others. They occur in nature in bundles and are the ingredients that make magnets super strong and useful. They are necessary for highly efficient electric motors, wind turbines and electronic devices.

Because of their chemical similarity, separating and purifying rare earth elements involves complex and expensive processes.

China controls the majority of global rare earth processing capacity. Political tensions between countries, especially around trade tariffs and strategic competition, can risk shortages or disruptions in the supply chain.

The rare earth metals case illustrates how a single category of materials can shape trade policy, industrial planning and even diplomatic alliances.

Technological transformation begins with societal pressure. New materials create opportunities for scientific and engineering breakthroughs. Once a material proves useful, it quickly becomes woven into the fabric of daily life and broader systems. With each innovation, the material world subtly reorganizes the social world—redefining what is possible, desirable and normal.

Understanding how societies respond to new innovations in materials science can help today's engineers and scientists solve crises in sustainability and security. Every technical decision is, in some ways, a cultural one, and every material has a story that extends far beyond its molecular structure.

Phys Org, 3 July 2025

https://phys.org

Rice University breakthrough keeps CO_2 electrolyzers running 50x longer

2025-06-22

A team of researchers at Rice University have discovered a surprisingly simple method for vastly improving the stability of electrochemical devices that convert carbon dioxide into useful fuels and chemicals, and it involves nothing more than sending the CO2 through an acid bubbler.

Their study, published in Science, addresses a major bottleneck in the performance and stability of CO2 reduction systems: the buildup of salt that clogs gas flow channels, reduces efficiency and causes the devices to fail prematurely. Using a technique they call acid-humidified CO2, the researchers extended the operational life of a CO2 reduction system more than 50-fold, demonstrating more than 4,500 hours of stable operation in a scaled-up reactor -- a milestone for the field.

Electrochemical CO2 reduction, or CO2RR, is an emerging green technology that uses electricity, ideally from renewable sources, to transform climate-warming CO2 into valuable products like carbon monoxide, ethylene or alcohols. These products can be further refined into fuels or used in industrial processes, potentially turning a major pollutant into a feedstock.

However, practical implementation has been hindered by poor system stability. One persistent issue is the accumulation of potassium bicarbonate salts in the gas flow channels, which occurs when potassium ions migrate from the anolyte across the anion exchange membrane to the cathode reaction zone and combine with CO2 under high pH conditions.

"Salt precipitation blocks CO2 transport and floods the gas diffusion electrode, which leads to performance failure," said Haotian Wang , the corresponding author of the study and associate professor of chemical

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

and biomolecular engineering, materials science and nanoengineering and chemistry at Rice. "This typically happens within a few hundred hours, which is far from commercial viability."

To combat this, the Rice team tried an elegant twist on a standard procedure. Instead of using water to humidify the CO2 gas input into the reactor, they bubbled the gas through an acid solution such as hydrochloric, formic or acetic acid.

The vapor from the acid is carried into the cathode reaction chamber in trace amounts, just enough to alter the local chemistry. Because the salts formed with these acids are much more soluble than potassium bicarbonate, they don't crystallize and block the channels.

The effect was dramatic. In tests using a silver catalyst -- a common benchmark for converting CO2 to carbon monoxide -- the system operated stably for over 2,000 hours in a lab-scale device and more than 4,500 hours in a 100-square-centimeter, scaled-up electrolyzer. In contrast, systems using standard water-humidified CO2 failed after about 80 hours because of salt buildup.

Importantly, the acid-humidified method proved effective across multiple catalyst types, including zinc oxide, copper oxide and bismuth oxide, all of which are used to target different CO2RR products. The researchers also demonstrated that the method could be scaled without compromising performance with large-scale devices maintaining energy efficiency and avoiding salt blockage over extended periods.

They observed minimal corrosion or damage to the anion exchange membranes that are typically sensitive to chloride by keeping the acid concentrations low. The approach was also shown to be compatible with commonly used membranes and materials, reinforcing its potential for integration into existing systems.

To observe salt formation in real time, the team used custom-built reactors with transparent flow plates. Under conventional water humidification, salt crystals began forming within 48 hours. With acid-humidified CO2, however, no significant crystal accumulation was observed even after hundreds of hours, and any small deposits were eventually dissolved and carried out of the system.

"Using the traditional method of water-humidified CO2 could lead to salt formation in the cathode gas flow channels," said co-first author Shaoyun Hao, postdoctoral research associate in chemical and biomolecular

engineering at Rice. "We hypothesized -- and confirmed -- that acid vapor could dissolve the salt and convert the low solubility KHCO3 into salt with higher solubility, thus shifting the solubility balance just enough to avoid clogging without affecting catalyst performance."

The work opens the door to more durable, scalable CO2 electrolyzers, a critical need if the technology is to be deployed at industrial scales as part of carbon capture and utilization strategies. The simplicity of the approach, involving only small tweaks to existing humidification setups, means it can be adopted without significant redesigns or added costs.

"This is a major finding for CO2 electrolysis," said Ahmad Elgazzar, co-first author and graduate student in chemical and biomolecular engineering at Rice. "Our method addresses a long-standing obstacle with a low-cost, easily implementable solution. It's a step toward making carbon utilization technologies more commercially viable and more sustainable."

This work was supported by the Robert A. Welch Foundation, Rice, the National Science Foundation and the David and Lucile Packard Foundation.

Science Daily, 22 June 2025

https://sciencedaily.com

Forever Chemicals Linked to Anxiety and Memory Issues in Males

2025-07-03

"Forever chemicals" or per- and polyfluoroalkyl substances (PFAS) have been widely used in consumer and industrial products for the better part of a century, but do not break down in the natural environment. One PFAS, perfluorohexanoic acid or PFHxA, is made up of a shorter chain of molecules and is thought to have less of an impact on human health. New research from the Del Monte Institute for Neuroscience at the University of Rochester suggests otherwise, finding that early life exposure to PFHxA may increase anxiety-related behaviors and memory deficits in male mice.

"Although these effects were mild, finding behavioral effects only in males was reminiscent of the many neurodevelopmental disorders that are male-biased," said Ania Majewska, PhD, professor of Neuroscience and senior author of the study out today in the European Journal of Neuroscience. Research has shown, males are more often diagnosed with neurodevelopmental disorders such as autism and ADHD. "This finding

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

suggests that the male brain might be more vulnerable to environmental insults during neurodevelopment."

Researchers exposed mice to PFHxA through a mealworm treat given to the mother during gestation and lactation. They found that the male mice exposed to higher doses of PFHxA in utero and through the mother's breastmilk showed mild developmental changes, including a decrease in activity levels, increased anxiety-like behaviors, and memory deficits. They did not find any behavioral effects in females that were exposed to PFHxA in the same way.

"Finding that developmental exposure to PFHxA has long-term behavioral consequences in a mammalian model is concerning when considering short-chain PFAS are thought to be safer alternatives to the legacy PFAS that have been phased-out of production," said Elizabeth Plunk, PhD ('25), an alumna of the Toxicology graduate program at the University of Rochester School of Medicine and Dentistry and first author of the study. "Understanding the impacts of PFHxA on the developing brain is critical when proposing regulations around this chemical. Hopefully, this is the first of many studies evaluating the neurotoxicity of PFHxA."

Researchers followed these mice into adulthood and found that in the male mice PFHxA exposure affects behavior long after exposure stops, suggesting that PFHxA exposure could have effects on the developing brain that have long-term consequences.

"This work points to the need for more research in short-chain PFAS. To our knowledge, PFHxA has not been evaluated for developmental neurobehavioral toxicity in a rodent model," said Majewska. "Future studies should evaluate the cellular and molecular effects of PFHxA, including cell-type specific effects, in regions associated with motor, emotional/fear, and memory domains to elucidate mechanistic underpinnings."

Despite its shorter chain, PFHxA has been found to be persistent in water and was restricted by the European Union in 2024. This follows years of restrictions on longer chain PFAS. Last year, the Environmental Protection Agency set its first-ever national drinking water standard for PFAS, which will reduce PFAS exposure for millions of people. PFAS are man-made chemicals that have the unique ability to repel stains, oil, and water have been found in food, water, animals, and people. They are linked to a range

of health issues, including developmental issues in babies and kidney cancer.

Technology Networks, 3 July 2025

https://technologynetworks.com

A new platform for developing advanced metals at scale

2025-07-03

Companies building next-generation products and breakthrough technologies are often limited by the physical constraints of traditional materials. In aerospace, defense, energy, and industrial tooling, pushing those constraints introduces possible failure points into the system, but companies don't have better options, given that producing new materials at scale involves multiyear timelines and huge expenses.

Foundation Alloy wants to break the mold. The company, founded by a team from MIT, is capable of producing a new class of ultra-high-performance metal alloys using a novel production process that doesn't rely on melting raw materials. The company's solid-state metallurgy technology, which simplifies the development and manufacturing of next-generation alloys, was developed over many years of research by former MIT professor Chris Schuh and collaborators.

"This is an entirely new approach to making metals," says CEO Jake Guglin MBA '19, who co-founded Foundation Alloy with Schuh, Jasper Lienhard '15, Ph.D. '22, and Tim Rupert Ph.D. '11. "It gives us a broad set of rules on the materials engineering side that allows us to design a lot of different compositions with previously unattainable properties. We use that to make products that work better for advanced industrial applications."

Foundation Alloy says its metal alloys can be made twice as strong as traditional metals, with 10 times faster product development, allowing companies to test, iterate, and deploy new metals into products in months instead of years.

The company is already designing metals and shipping demonstration parts to companies manufacturing components for things like planes, bikes, and cars. It's also making test parts for partners in industries with longer development cycles, such as defense and aerospace.

Moving forward, the company believes its approach enables companies to build higher-performing, more reliable systems, from rockets to cars, nuclear fusion reactors, and artificial intelligence chips.

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

"For advanced systems like rocket and jet engines, if you can run them hotter, you can get more efficient use of fuel and a more powerful system," Guglin says. "The limiting factor is whether or not you have structural integrity at those higher temperatures, and that is fundamentally a materials problem.

"Right now, we're also doing a lot of work in advanced manufacturing and tooling, which is the unsexy but super critical backbone of the industrial world, where being able to push properties up without multiplying costs can unlock efficiencies in operations, performance, and capacity, all in a way that's only possible with different materials."

From MIT to the world

Schuh joined MIT's faculty in 2002 to study the processing, structure, and properties of metal and other materials. He was named head of the Department of Materials Science and Engineering in 2011 before becoming dean of engineering at Northwestern University in 2023, after more than 20 years at MIT.

"Chris wanted to look at metals from different perspectives and make things more economically efficient and higher performance than what's possible with traditional processes," Guglin says. "It wasn't just for academic papers—it was about making new methods that would be valuable for the industrial world."

Rupert and Lienhard conducted their Ph.D.s in Schuh's lab, and Rupert invented complementary technologies to the solid-state processes developed by Schuh and his collaborators as a professor at the University of California at Irvine.

Guglin came to MIT's Sloan School of Management in 2017 eager to work with high-impact technologies.

"I wanted to go somewhere where I could find the types of fundamental technological breakthroughs that create asymmetric value—the types of things where if they didn't happen here, they weren't going to happen anywhere else," Guglin recalls.

In one of his classes, a Ph.D. student in Schuh's lab practiced his thesis defense by describing his research on a new way to create metal alloys.

"I didn't understand any of it—I have a philosophy background," Guglin says. "But I heard 'stronger metals' and I saw the potential of this incredible

platform Chris's lab was working on, and it tied into exactly why I wanted to come to MIT."

Guglin connected with Schuh, and the pair stayed in touch over the next several years as Guglin graduated and went to work for aerospace companies SpaceX and Blue Origin, where he saw firsthand the problems being caused by the metal parts supply chain.

In 2022, the pair finally decided to launch a company, adding Rupert and Lienhard and licensing technology from MIT and UC Irvine.

The founders' first challenge was scaling up the technology.

"There's a lot of process engineering to go from doing something once at 5 grams to doing it 100 times a week at 100 kilograms per batch," Guglin says.

Today, Foundation Alloys starts with its customers' material requirements and decides on a precise mixture of the powdered raw materials that every metal starts out as. From there, it uses a specialized industrial mixer—Guglin calls it an industrial KitchenAid blender—to create a metal powder that is homogeneous down to the atomic level.

"In our process, from raw material all the way through to the final part, we never melt the metal," Guglin says. "That is uncommon if not unknown in traditional metal manufacturing.

From there, the company's material can be solidified using traditional methods like metal injection molding, pressing, or 3D printing. The final step is sintering in a furnace.

"We also do a lot of work around how the metal reacts in the sintering furnace," Guglin says. "Our materials are specifically designed to sinter at relatively low temperatures, relatively quickly, and all the way to full density."

The advanced sintering process uses an order of magnitude less heat, saving on costs while allowing the company to forgo secondary processes for quality control. It also gives Foundation Alloy more control over the microstructure of the final parts.

"That's where we get a lot of our performance boost from," Guglin says. "And by not needing those secondary processing steps, we're saving days if not weeks in addition to the costs and energy savings."

A foundation for industry

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

Foundation Alloy is currently piloting their metals across the industrial base and has also received grants to develop parts for critical components of nuclear fusion reactors.

"The name Foundation Alloy in a lot of ways came from wanting to be the foundation for the next generation of industry," Guglin says.

Unlike in traditional metals manufacturing, where new alloys require huge investments to scale, Guglin says the company's process for developing new alloys is nearly the same as its production processes, allowing it to scale new materials production far more quickly.

"At the core of our approach is looking at problems like material scientists with a new technology," Guglin says. "We're not beholden to the idea that this type of steel must solve this type of problem. We try to understand why that steel is failing and then use our technology to solve the problem in a way that produces not a 10% improvement, but a two- or five-times improvement in terms of performance."

Phys Org, 3 July 2025

https://phys.org

Path to carbon dioxide-based chemicals smoothed with a dash of acid

2025-07-27

The stability of the electrochemical reduction of carbon dioxide can be dramatically improved simply by adding a small amount of acid. This addresses a key stumbling block in the commercialisation of the reaction by dissolving the salts that block the reactor and rapidly lead to failure.

The electrochemical reduction of carbon dioxide is potentially a huge advance in green chemistry as it uses electricity to reduce carbon dioxide into important platform chemicals such as carbon monoxide and hydrocarbons. This could transform carbon-positive syntheses into carbon-negative ones.

An especially promising design for the electrolyser is the membrane electrode assembly. This incorporates two electrodes pressed against an anion exchange membrane. The cathode is a gas diffusion electrode continuously fed with carbon dioxide and water vapour. At the anode, oxygen evolution from water releases electrons that travel through the external circuit. However, these electrons can reduce either carbon dioxide

or hydrogen, and owing to the stability of carbon dioxide, in the absence of other influences hydrogen reduction is strongly favoured.

Researchers, therefore, usually add alkali metal salts to the anode electrolyte. 'What people have shown in the literature – and this is kind of an ongoing debate on the exact mechanism – is that the cations will have some electrostatic interactions … that would do this initial activation step [of carbon dioxide],' explains electrochemist Ahmad Elgazzar at Rice University in Texas. Unfortunately, at neutral pH the cations can also react with the carbon dioxide to form bicarbonates or carbonates, which have limited solubility in water and can clog the gas diffusion electrode, leading to pressure buildup and failure. Various solutions to this problem, such as membrane modification and pulsed electrolysis, have been investigated, but none have proved totally satisfactory.

In the new work, conducted with potassium salts, Elgazzar and colleagues in Haotian Wang's group at Rice University in Texas simply added hydrochloric acid to the water vapour. They found that, whereas membrane electrode assemblies run using pure water showed rapid degradation in activity and failed after less than 500 hours, assemblies supplied with a feed containing concentrations as low as 0.05M acid could work stably for up to 4500 hours. Moreover, although disassembly of the acid-humidified assemblies showed that some salt-deposition had occurred, the researchers do not believe that this was the cause of their eventual failure as they had not observed a sudden pressure drop in gas flow across the cell before it stopped working.

The researchers went on to demonstrate that the idea worked equally well with other, less corrosive acids. 'Potassium formate, potassium acetate – these salts all have much higher solubility than potassium bicarbonate,' says team member Shaoyun Hao. A technoeconomic analysis suggested that, owing to the tiny quantities of acid consumed, there was a clear cost benefit to implementing the scheme.

Chemical engineer Cao Thang Dinh at Queen's University, Canada, is impressed. 'Previously, we've tried to avoid this problem by minimising it,' he says. 'People have run [the reaction] at very low electrolyte concentration so they can avoid the salt formation. The downside of that is that when you run at very low salt concentrations you have a high cell resistance, so the overall energy conversion is low… Now they run at high salt concentrations but have similar or better stability.' He concludes: 'I'm surprised many people didn't try this before because it's so simple and yet it works. I think it will have a huge impact on practical applications.'

Chemistry World, 27 July 2025

https://chemistryworld.com

Laser technique revolutionizes ultra-high temperature ceramic manufacturing for space, defense applications

2025-05-29

Researchers have demonstrated a new technique that uses lasers to create ceramics that can withstand ultra-high temperatures, with applications ranging from nuclear power technologies to spacecraft and jet exhaust systems. The technique can be used to create ceramic coatings, tiles or complex three-dimensional structures, which allows for increased versatility when engineering new devices and technologies.

"Sintering is the process by which raw materials -- either powders or liquids -- are converted into a ceramic material," says Cheryl Xu, co-corresponding author of a paper on this research and a professor of mechanical and aerospace engineering at North Carolina State University. "For this work, we focused on an ultra-high temperature ceramic called hafnium carbide (HfC). Traditionally, sintering HfC requires placing the raw materials in a furnace that can reach temperatures of at least 2,200 degrees Celsius -- a process that is time-consuming and energy intensive.

"Our technique is faster, easier and requires less energy."

The new technique works by applying a 120-watt laser to the surface of a liquid polymer precursor in an inert environment, such as a vacuum chamber or a chamber filled with argon. The laser sinters the liquid, turning it into a solid ceramic. This can be used in two different ways.

First, the liquid precursor can be applied as a coating to an underlying structure, such as carbon composites used in hypersonic technologies like missiles and space exploration vehicles. The precursor can be applied to the surface of the structure and then sintered with the laser.

"Because the sintering process does not require exposing the entire structure to the heat of the furnace, the new technique holds promise for allowing us to apply ultra-high temperature ceramic coatings to materials that may be damaged by sintering in a furnace," Xu says.

The second way that engineers can make use of the new sintering technique involves additive manufacturing, also known as 3D printing. Specifically, the laser sintering method can be used in conjunction with a technique that is similar to stereolithography.

In this technique, a laser is mounted on a table that sits in a bath of the liquid precursor. To create a three-dimensional structure, researchers create a digital design of the structure and then "slice" that structure into layers. To begin, the laser draws the profile of the first layer of the structure in the polymer, filling the profile in as if coloring in a picture. As the laser "fills in" this area, thermal energy converts the liquid polymer into ceramic. The table then lowers a little bit further into the polymer bath, and a blade sweeps across the top to even out the surface. The laser then sinters the second layer of the structure, and this process repeats itself until you have a finished product made of the sintered ceramic.

"It's actually a bit of an oversimplification to say that the laser is only sintering the liquid precursor," Xu says. "It is more accurate to say that the laser first converts the liquid polymer into a solid polymer and then converts the solid polymer into a ceramic. However, all of this happens very quickly -- it's essentially a one-step process."

In proof-of-concept testing, the researchers demonstrated that the laser sintering technique produced crystalline, phase-pure HfC from a liquid polymer precursor.

"This is the first time we know of where someone was able to create HfC of this quality from a liquid polymer precursor," Xu says. "And ultra-high temperature ceramics, as the name suggests, are useful for a wide range of applications where technologies must withstand extreme temperatures, such as nuclear energy production."

The researchers also demonstrated that laser sintering could be used to create high quality HfC coatings of carbon-fiber reinforced carbon composites (C/C). Basically, the ceramic coating bonded to the underlying structure and didn't peel away.

"The HfC coatings on C/C substrates demonstrated strong adhesion, uniform coverage, and potential for use as thermal protection and an oxidation resistant layer," Xu says. "This is particularly useful because, in addition to hypersonic applications, carbon/carbon structures are used in rocket nozzles, brake discs and aerospace thermal protection systems such as nose cones and wing leading edges."

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

The new laser sintering technique is also significantly more efficient than conventional sintering in several ways.

"Our technique allows us to create ultra-high temperature ceramic structures and coatings in seconds or minutes, whereas conventional techniques take hours or days," Xu says. "And because laser sintering is faster and highly localized, it uses significantly less energy. What's more, our approach produces a higher yield. Specifically, laser sintering converts at least 50% of the precursor mass into ceramic. Conventional approaches typically convert only 20-40% of the precursor.

"Lastly, our technique is relatively portable," Xu says. "Yes, it has to be done in an inert environment, but transporting a vacuum chamber and additive manufacturing equipment is much easier than transporting a powerful, large-scale furnace.

"We are excited about this advance in ceramics and are open to working with public and private partners to transition this technology for use in practical applications," says Xu.

The paper, "Synthesis of Hafnium Carbide (HfC) via One-Step Selective Laser Reaction Pyrolysis from Liquid Polymer Precursor," is published in the Journal of the American Ceramic Society. Co-corresponding author of the paper is Tiegang Fang, a professor of mechanical and aerospace engineering at NC State. First author of the paper is Shalini Rajpoot, a postdoctoral researcher at NC State. The paper was co-authored by Kaushik Nonavinakere Vinod, a Ph.D. student at NC State.

The research was done with support from the Center for Additive Manufacture of Advanced Ceramics, which is based at the University of North Carolina at Charlotte.

Science Daily, 29 May 2025

https://sciencedaily.com

New protein-based system streamlines enzyme reuse for plastic recycling

2025-07-02

Enzymatic recycling has gained traction in recent years as a greener alternative to traditional plastic recycling techniques, which often rely on energy-intensive mechanical or chemical processes. Enzymes can selectively break down polymers like PET—commonly found in bottles and food packaging—into their basic building blocks.

In this new study, scientists have introduced an innovative strategy to trap these enzymes within nanoscale protein compartments produced naturally by bacteria, simplifying their use and extending their functional lifespan. The work is published in the Journal of Hazardous Materials.

One of the major barriers to industrial enzymatic recycling is the cost and complexity of producing and recovering the enzymes. Traditional immobilization methods involve multiple steps, including enzyme purification and attachment to solid carriers.

The system developed by the research team overcomes this by embedding the enzyme directly inside nanospheres during its expression in E. coli, using a single-step process that combines production, immobilization, and stabilization. This dramatically reduces costs and enhances reusability.

The technology builds on IC-Tagging, developed by Prof. José Manuel Martínez Costas and his group at CiQUS. It uses a viral protein, muNS-Mi, which self-assembles into nanostructures within bacterial cells.

Enzymes tagged with a short IC-sequence are spontaneously recruited into these compartments, resulting in fully functional, immobilized enzymes straight from the host cell—no chromatography or additional carriers needed. While IC-Tagging has previously been used for other biocatalysts, this is the first time it has been applied to a high-performance PET hydrolase.

The team used a genetically optimized version of the LCC enzyme, known for its high efficiency in PET degradation. Their system successfully broke down real post-consumer plastic samples—including food trays and lab packaging—achieving over 90% depolymerization in under 72 hours. Moreover, the same batch of enzyme could be reused for two consecutive reactions with minimal loss of activity.

"These results go beyond what has been achieved so far with immobilized enzymes at lab scale," says Adrián López Teijeiro, first author of the study. "Our system offers a powerful tool to support the industrial deployment of enzyme-based PET recycling and advance the circular economy for plastics."

The work is part of the PETzyme project and coordinated by Gemma Eibes (CRETUS) and José Martínez Costas (CiQUS). The team is currently working to scale up the method and explore its potential with other industrially

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

relevant enzymes in areas such as biocatalysis, waste processing and sustainable materials.

Provided by Center for Research in Biological Chemistry and Molecular Materials (CiQUS)

Phys Org, 2 July 2025

https://phys.org

Drinks in Glass Bottles Contain More Microplastics Than Those Plastic Bottles

2025-06-25

Drinks contained in glass bottles contain more microplastic particles than those in plastic bottles, cartons or cans. This was the surprising finding of a study conducted by the Boulogne-sur-Mer unit of the ANSES Laboratory for Food Safety. The scientists hypothesised that these plastic particles could come from the paint used on bottle caps. These findings have highlighted a source of microplastics in drinks that manufacturers can easily address.

The aim of the ANSES study was to determine the level of microplastic contamination in drinks such as water, soda, iced tea, wine and beer; it also sought to establish the impact of their containers on this level. For most of the drinks studied, the level of microplastics was found to be higher in glass bottles than in other containers. For example, on average, in glass bottles of cola, lemonade, iced tea and beer, there were around 100 microplastic particles per litre. This number was five to 50 times lower in plastic bottles and cans.

"We were expecting the opposite result when we compared the level of microplastics in different drinks sold in France" explains Iseline Chaïb, a PhD student in the Aquatic Food Safety Unit (SANAQUA, Boulogne-sur-Mer site), which conducted the study at the ANSES Laboratory for Food Safety. In the absence of toxicological reference data, it is not possible to say whether the levels of microplastics found pose a health risk. The thesis was co-funded by the Hauts-de-France Region and ANSES. The project also received support under the IDEAL State-Region plan contract and from the French National Research Agency (IFSEA University Research School).

In the specific case of water, the level of microplastics was relatively low regardless of the container, with an average of 4.5 particles per litre in glass bottles and 1.6 particles per litre in plastic bottles and cartons. Wine

also contained few microplastics, including in glass bottles with corks. The origin of these variations in the level of microplastics in drinks remains to be explored, except for drinks contained in glass bottles with caps.

Plastic particles in drinks come from the paint on the caps

The scientists investigated the origin of the microplastics found in drinks packaged in glass bottles with caps. Given their characteristics, they concluded that these particles probably came from the metal caps, and more specifically from the paint that covered them. The first clue: the microplastics found in the drinks were mostly the same colour and had the same composition as the paint on the caps. The second clue: the paint on these caps had tiny scratches that were invisible to the naked eye and had probably been caused by friction between the caps when they were stored before use. This friction, which released particles from the surface of the caps, was thought to be the source of the microplastics found.

Clean caps before sealing bottles to reduce the level of microplastics

To confirm the route of contamination of drinks in glass bottles and explore the possibility of reducing microplastic levels, the laboratory tested the effects of different cleaning operations. "We studied three scenarios" explains the PhD student. "We cleaned the bottles and filled them with filtered water so that no microplastics could be detected, then we placed caps on the bottles without treating the caps, after blowing on the caps with an air bomb, or after blowing air and rinsing the caps with filtered water and alcohol".

The result? While an average of 287 particles per litre were found in the water of the bottles sealed with uncleaned caps, this number decreased significantly, to 106 particles per litre, when air was blown on the caps before they were placed on the bottles. It fell further to 87 particles per litre when blowing was followed by rinsing.

To prevent plastic particles from being released into drinks contained in bottles sealed with caps, manufacturers could also explore other lines of action, such as changing the conditions in which the caps are stored before use, to avoid friction, or modifying the composition of the paint used on the caps.

Technology Networks, 25 June 2025

https://technologynetworks.com

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

Australia's TGA issues interim report to remove supplements high in B6 from shelves as toxicity cases rise

2025-06-28

Major changes have been proposed to restrict access to a common over-the-counter vitamin linked to a growing number of poisoning cases.

Vitamin B6 — often listed as pyridoxine, pyridoxal, or pyridoxamine — is present in thousands of products in Australia as an additive, including medicines, multivitamin and mineral supplements, energy drinks and weight loss shakes.

More than 170 reports of peripheral neuropathy, peripheral sensory neuropathy, small fibre neuropathy or chronic polyneuropathy for products containing B6 have been reported to the medicines regulator, the Therapeutic Goods Administration (TGA), though medical practitioners predict the true number is significantly higher.

"While most of them have no side effects, if you are taking large doses of B6 your risk of peripheral neuropathy goes up.

"We know that reported cases of peripheral neuropathy are a massive underestimate of the problem in the community because so many people are unaware that vitamins can cause these symptoms."

In a new development to improve public safety, several recommendations have been handed down in a report penned by a senior TGA medical officer known as "the delegate".

Called the "Interim Decision", the report acts on the advice of the government's Advisory Committee on Medicines Scheduling.

Most notably, it calls for the TGA to reclassify supplements containing more than 50mg of B6 as Schedule 3 (Pharmacist Only), by February 2027.

The move would affect about 100 products, requiring pharmacists to first speak with consumers before approving a purchase.

"Currently, preparations providing up to 200 mg of [B6] … are available for self-selection without any professional guidance or oversight," the report states, adding "almost 80 per cent of these products provide a dose of more than 2 mg/day, which is above the RDI for pyridoxine, pyridoxal or pyridoxamine.

A TGA spokesperson told 7.30 that the decision, if implemented, "will reduce the maximum amount of vitamin B6 allowed in oral products than currently available for general sale".

"The interim decision balances the risks and benefits of using vitamin B6, including the risk of peripheral neuropathy, acknowledging its potential for irreversible harm at higher doses and variability in individual metabolism," the spokesperson said.

But, as detailed in the report, the proposed changes only account for about 7 per cent of supplements containing B6 — there are more than 1,500 vitamins listed on the Australian Register of Therapeutic Goods, the majority of which are unscheduled and available over the counter.

The report also recommended supplements exceeding 200mg should be reclassified as prescription medicines or "schedule 4".

"It's a good thing that pharmacists will be able to have a really good counselling session with a patient to make sure the item they're taking doesn't interact with other medications," said Caroline Diamantis, vice-president of the Pharmaceutical Society of Australia.

Label changes needed

The interim decision also recommends tightening labelling rules, calling for clearer identification of vitamin B6 on packaging and stronger warnings to help consumers avoid accidental overexposure.

"Use of ingredient names in labelling is inconsistent and confusing for consumers … and not always described as vitamin B6," the report said.

"Of concern is that there are several products on the market where the front of the label provides no indication that vitamin B6 is an ingredient."

It suggested changing the language on warning labels to be more direct.

The report also calls on the multi-billion-dollar complementary medicines sector to take greater responsibility for educating consumers and reducing the risk of vitamin B6 overexposure, noting current labelling places too much burden on consumers to calculate total B6 intake.

"Estimating the total daily vitamin B6 intake … is likely to be beyond the health literacy capability of the typical consumer," it said.

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

The CEO of Complementary Medicines Australia, John O'Doherty, told 7.30: "We'll be carefully reviewing the interim decision and the recommendations of the Advisory Committee on Medicines Scheduling."

Mr O'Doherty argued adverse events relating to the use of vitamin B6 are "extremely rare".

"Based on a comparison of sales data with the TGA's public Database of Adverse Events, the chance of a reaction is less than one in half a million — this is extremely rare," he said.

However, previous 7.30 investigations have found dozens of Australians have had issues from B6 toxicity, with many only becoming aware of their illness after seeing our reports.

The TGA delegate also warns the prevalence could be much higher.

"The true rate of occurrence of an adverse event cannot be determined from spontaneous adverse event reporting systems due to both general under-reporting and a lack of usage data," its report read.

"A low number of spontaneous adverse event reports cannot be considered evidence of the absence of a safety issue."

Mr O'Doherty however agreed with some of the labelling recommendations, telling 7.30 his organisation has "been calling on the TGA to implement changes that allow labels and advertising to use terminology and ingredient names that consumers better understand".

"At CMA's request, this is now under internal review at the TGA", he said.

Class action investigation progressing

Medical negligence lawyer Nick Mann said the interim decision is a "small step in the right direction" but argued the TGA "can and should" go further.

Mr Mann told 7.30 his legal firm, Polaris, is pursuing a class action lawsuit against one of the largest companies in the complementary medicines industry, Blackmores, "as a matter of public interest and safety".

"We continue to investigate the potential class action, and given the response, the support and the evidence that's been pouring in … with over 140 people contacting us to date," Mr Mann said.

"We've also had at least 10 doctors contact us to tell us about their own experiences with B6, and to let us know that they have discovered B6

toxicity in several of their patients, after taking supplements containing higher than the RDI of the vitamin over weeks and months," he said.

The interim decision recommends the changes be made by February 1 2027 — offering an 18-month implementation period.

The News, 28 June 2025

https://abc.net.au

Record-Shattering Molecule Stores Data at "Dark Side of the Moon" Temperatures

2025-07-03

A new molecule may soon enable tiny hard drives that store vastly more data. Withstanding extreme cold, it paves the way for dense and efficient storage solutions.

Researchers from The University of Manchester and The Australian National University (ANU) have developed a novel molecule capable of storing data at extremely low temperatures, comparable to the frigid conditions on the moon's dark side at night.

Their results, published in Nature, point toward the potential for future data storage devices no larger than a postage stamp, yet capable of holding up to 100 times more information than today's leading technologies.

"The new single-molecule magnet developed by the research team can retain its magnetic memory up to 100 Kelvin, which is about minus 173 degrees Celsius, or as cold as an evening on the moon," co-lead author Professor Nicholas Chilton, from the ANU Research School of Chemistry, said.

"This is a significant advancement from the previous record of 80 Kelvin, which is around minus 193 degrees Celsius. If perfected, these molecules could pack large amounts of information into tiny spaces.

"Pink Floyd's The Dark Side of the Moon was released in 1973. Technology has come a long way since then and nowadays we listen to music through new digital mediums such as Spotify and even TikTok.

"This new molecule could lead to new technologies that could store about three terabytes of data per square centimeter. That's equivalent to around 40,000 CD copies of The Dark Side of the Moon album squeezed into a

CHEMWATCH
Bulletin Board
Gossip
JUL. 04, 2025

hard drive the size of a postage stamp, or around half a million TikTok videos."

Responding to massive data demands

As internet use continues to rise, with more people streaming content, using social media, and uploading data to the cloud, the need for advanced information technology systems capable of handling vast volumes of digital information is rapidly increasing.

Magnetic materials have traditionally been central to data storage, with current hard drives relying on the magnetization of small areas composed of many atoms that work collectively to preserve information.

In contrast, single-molecule magnets can store data within individual molecules, eliminating the need for neighboring atoms and opening the door to significantly higher storage densities.

Bringing magnets closer to practicality

But the challenge has always been the incredibly cold temperatures required for them to function.

"While still a long way from working in a standard freezer, or at room temperature, data storage at 100 Kelvin, or about minus 173 degrees Celsius, could be feasible in huge data centers, such as those used by Google," co-lead author Professor David Mills, from The University of Manchester, said.

"Although the new magnet still needs cooling far below room temperature, it is now well above the temperature of liquid nitrogen, a readily available coolant, which is 77 Kelvin, or around minus 196 degrees Celsius.

"So, while we won't be seeing this type of data storage in our mobile phones for a while, it does make storing information in huge data centers more feasible."

The key to the new magnets' success is its unique structure, with the rare earth element dysprosium located between two nitrogen atoms. These three atoms are arranged almost in a straight line – a configuration predicted to boost magnetic performance but realized now for the first time.

Usually, when dysprosium is bonded to only two nitrogen atoms it tends to form molecules with more bent or irregular shapes. In the new

molecule, the researchers added a chemical group called an alkene that acts like a molecular pin, binding to dysprosium to hold the structure in place.

Simulating quantum spin behavior

"At ANU, we've developed a new theoretical approach to simulate the molecule's magnetic behavior, using only the fundamental equations of quantum mechanics, which has allowed us to explain why this particular molecular magnet performs so well compared to previous designs," Professor Chilton said.

"We were able to achieve this by leveraging the massive computational resources of the National Computational Infrastructure at ANU and the Pawsey Supercomputing Research Centre in Western Australia, including their large banks of GPU-accelerated compute nodes, to simulate the time-dependence of the electron spins in this molecular material.

"This has enabled us to explain why this new molecule, with its linear arrangement of atoms at its core, can show magnetic memory at such high temperatures. This molecule will now serve as a blueprint moving forward to guide the design of even better molecular magnets that can retain their data at even higher temperatures.

"In the more than 50 years since the release of The Dark Side of the Moon, technology has progressed leaps and bounds. It's exciting to think how technologies will continue to evolve in the next half a century."

Sci Tech Daily, 3 July 2025

https://scitechdaily.com

Average household dishwasher releases 33 million nano and microplastic particles per year, research finds

2025-07-02

A study has found household dishwashers could be sending millions of plastic particles into the wastewater system every year and researchers say the findings show the need for stronger policies.

The new research looked at the release of micro and nano-sized plastic particles from common plastic items during a dishwasher cycle.

Microplastics are defined as smaller than 5 millimetres while nanoplastics are defined as one micrometre or less — just one millionth of a metre.

The University of Queensland (UQ) study ran brand new plastic containers through a full cycle at 70 degrees Celsius and analysed the wastewater for plastic particles.

Researchers found a full load of plastic containers released roughly 920,000 particles.

Study co-author Elvis Okoffo estimates the average household with a dishwasher releases more than 33 million particles in one year.

That translates roughly to less than the weight of a grain of rice per person.

As of 2019, about 58 per cent of Australian households had a dishwasher, according to a Roy Morgan research.

The most common plastic types like polypropylene, polyethylene and polystyrene released the most and the largest particles, the UQ study found.

He said more research was needed to compare the difference between old and new materials and to see whether different temperatures and wash cycles made an impact.

Griffith University's Shima Ziajahromi co-authored a similar study that found 600,000 microplastic fibres can enter wastewater through a single washing machine cycle.

She said Dr Okoffo's findings align with what's been found in wastewater samples.

"We found plastics like polystyrene that we could not relate to any sources … but I can see that polystyrene is one of the major contributors to that dishwasher wastewater," Dr Ziajahromi said.

She would like to see more testing done on older containers.

"When you look at your old plastic containers there's a lot of scratches on them. It's very likely they release a lot more microplastics into the wastewater," Dr Ziajahromi said.

'We still don't know the risks'

Dr Ziajahromi said the findings highlight the need for better monitoring for microplastics in the wastewater system.

"There's a lot of sources that are releasing huge amounts of microplastics into our wastewater effluent every day," she said.

Much of that ends up in biosolids — a mix of water and organic materials that are a by-product of the wastewater system — which are then used to fertilise agricultural soil.

"They're all coming back to us," she said.

"It's not just the organisms that are exposed to microplastics, it's us."

Dr Ziajahromi said recent peer-reviewed research, which has not yet been released, found nanoplastics are being taken up by plants and "likely" ending up in the edible parts that we eat.

Studies are ongoing into the potential effects of microplastics on human health.

"By the time we know there is a risk it's too late and we have to spend a lot of money for remediation."

Changing washing machine standards could pave the way

The federal government's National Plastics Plan identified microplastics as "an issue of increasing concern".

One of the plan's goals is to phase in microfibre filters for new washing machines by 2030.

A spokesperson for Department of Climate Change, Energy, the Environment and Water said international work is underway to assess methods that measure microplastics in washing machines, with a standard to be ready by the end of 2026.

In January, France became the first country to require all new washing machines be equipped with microplastic filters.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

Dr Okoffo said he hopes to see a similar standard introduced for dishwashers.

"If you're going to have filters for washing machines by 2030, why not consider dishwashers in the grand scheme of things as well?"

ABC News, 2 July 2025

https://abc.net.au

Researchers Capture Nanoparticle Movements To Forge New Materials

2025-06-18

Researchers can now observe the phonon dynamics and wave propagation in self-assembly of nanomaterials with unusual properties that rarely exist in nature. This advance will enable researchers to incorporate desired mechanical properties into reconfigurable, solution-processible metamaterials, which have wide-ranging applications — from shock absorption to devices that guide acoustic and optical energy in high-powered computer applications.

Phonons are natural phenomena that can be thought of as discrete packets of energy waves that move through the building blocks of materials, whether they are atoms, particles or 3D-printed hinges, causing them to vibrate and transfer energy. This is a quantum mechanical description of common properties observed in various contexts, including the transfer of heat, the flow of sound and even seismic waves formed by earthquakes.

Some materials, both artificial and natural, are designed to move phonons along specific paths, imparting specific mechanical attributes. Two real-life examples of this include materials used in structures to resist seismic waves during earthquakes and the evolution of the rugged yet lightweight skeletons of deep-sea sponges, which enable them to withstand the extreme pressures of deep-water environments.

"Using the liquid-phase electron microscopy technique developed in our lab at Illinois, the new study marks the first time we've been able to observe phonon dynamics in nanoparticle self-assemblies, acting as a new type of mechanical metamaterials," said Qian Chen, a professor of material science and engineering at the University of Illinois Urbana-Champaign.

The multi-institutional, multi-discipline study is the result of a four-year collaboration between Chen, who led the materials science and

experimental portion; professor Xiaoming Mao at the University of Michigan, who led the mechanical metamaterials and theory portion of the study; and professor Wenxiao Pan, who led the simulation portion of the study at University of Wisconsin-Madison. Published in the journal Nature Materials, the study combines nanoparticle assembly with mechanical metamaterial principles, enabling the engineering of mechanical properties through structural design.

"Some refer to metamaterials development as mechano-logic," Chen said. "Metamaterials design is a very active field, and most research has focused on the macroscale realm, where it is easier to control the geometry and structure, as well as measure and model the phonon properties."

But Chen and her collaborators work in the nanoscale world, where both engineering and theoretical approaches to phonon control are tough. To address this problem, the team employed precise theoretical modeling in conjunction with experimental and observational techniques, as well as machine learning-accelerated simulations, to develop a new framework for metamaterials design.

In the lab, using liquid-phase electron microscopy, the team examined the vibrational trajectories of gold nanoparticles to determine the phonon band structures, and then matched these structures to a discrete mechanical model to extract nanoscale springs.

"We feel we are at a great intersection between disciplines, collaboration and the need for advancement in materials science," Chen said. "With nanoparticle assembly, we can design structures with very controlled geometry, and then with mechanical metamaterials, adapt the theoretical framework in material design."

"This opens a new research area where nanoscale building blocks — along with their intrinsic optical, electromagnetic, and chemical properties — can be incorporated into mechanical metamaterials," Mao said, "Enabling emerging technologies in multiple fields from robotics and mechanical engineering to information technology."

"This work also demonstrates the potential of machine learning to advance the study of complex particle systems, making it possible to observe their self-assembly pathways governed by complex dynamics," Pan said. "It opens new avenues for data-driven inverse design of

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

reconfigurable colloidal metamaterials using machine learning and artificial intelligence."

Technology Networks, 18 June 2025

https://technologynetworks.com

Eco-friendly plastic offers flexible electronic properties without 'forever chemicals'

2025-07-03

Researchers at Case Western Reserve University have developed an environmentally safer type of plastic that can be used for wearable electronics, sensors and other electrical applications. The material, a so-called ferroelectric polymer, is made without fluorine, considered a "forever" chemical that hurts the environment because compounds made with it don't break down quickly or at all.

Although the researchers are still working to improve the material's electric and elastic properties, the potential is vast for its flexibility of electronic uses and eco-friendly structure.

"How this material generates its electric properties is also fundamentally new," said lead researcher Lei Zhu, a professor of macromolecular science and engineering at the Case School of Engineering. "Unlike current ferroelectric materials, it doesn't have to crystallize to lock in the polarity that gives it electrical properties."

The research explaining the discovery was recently published in the journal Science. The new material is patent pending.

Electronic polymers

Polymers are large molecules comprised of long chains of smaller molecular units that can be man-made—such as plastics—or natural—like in a person's hair or DNA. By changing a polymer's molecular structure and length, it can vary its strength, flexibility, heat-resistance and ability to be recycled.

Ferroelectricity refers to certain materials with what is known as "spontaneous polarization" that can be reversed by applying an electric field—like an on-off switch. Ferroelectric materials allow for the development of smaller, more efficient electronic devices, reducing our reliance on traditional energy sources.

Flexible on-off switches

The new material Zhu and his research team have created is both flexible and has what is known as tunable electronic properties, which means they can be switched on and off.

They have wide applications in infrared detectors and sensors in wearable electronics, for which the materials need to be soft, pliable and elastic to be compatible with the human body. Conventional ceramic ferroelectric materials are rigid and brittle.

Polymers have the advantage of being flexible and lightweight, but the dominant ferroelectric polymer, poly(vinylidene fluoride), or PVDF, doesn't naturally degrade in the environment, making it a "forever chemical." The new material is made without fluorine.

Ferroelectric polymers also have applications in sensors for ultrasound diagnostic tools because they are acoustically compatible with biological tissues. They are also potentially useful in augmented and virtual reality (AR and VR) goggles.

"We're still in the development stage of synthesizing small quantities and investigating the properties," Zhu said. "But we're excited about the potential to replace environmentally harmful plastics in sensors and detectors."

Phys Org, 3 July 2025

https://phys.org

'Sugarbag' honey boasts remarkable antimicrobial properties

2025-06-29

Honey produced by some species of Australian stingless bees possesses impressive bacteria- and fungi-killing properties, according to new research. With problems of antimicrobial resistance, the golden syrup has the potential to be used alongside or in place of existing antibiotics.

Nature knows what it's doing, especially when it comes to producing medicinal compounds. Over millennia, native peoples have tried and tested these natural products the way nature intended. Sometimes, it takes Western medicine some time to catch up.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

In a new study led by the University of Sydney, researchers investigated the antimicrobial properties of honey produced by particular native stingless bee species. This honey has been used medicinally by Indigenous Australians for thousands of years, and may be helpful in the fight against antimicrobial resistance.

"Given the growing medical challenge of antimicrobial resistance, our findings suggest stingless bee honey could complement, or provide a valuable alternative to, synthetic antibiotics," said Dr Kenya Fernandes, from the university's School of Life and Environmental Sciences and the study's lead and corresponding author.

There are a few native Australian stingless bee species that produce a distinct honey, known locally as "sugarbag." While Indigenous Australians have used it for thousands of years as both a nutritious food source and a medicine to treat itchy skin and sores, there is limited research into the honey's antimicrobial properties. The word "microbe" covers a diverse range of organisms, including bacteria, viruses, and fungi. Honey's antimicrobial activity is attributed to either peroxide activity or non-peroxide activity.

Peroxide activity comes from hydrogen peroxide, a chemical known for its ability to kill microbes. An enzyme called glucose oxidase, which bees add to nectar, turns glucose into gluconic acid and hydrogen peroxide when the honey is diluted (for example, by wound moisture or saliva). Hydrogen peroxide works by damaging microbial proteins, DNA, and membranes and is effective against a wide variety of bacteria and fungi. Non-peroxide activity refers to antimicrobial effects not caused by hydrogen peroxide but due, instead, to other bioactive compounds such as phenolics and flavonoids. These compounds can disrupt cell membranes and interfere with cell metabolism, and are often more stable than peroxide activity.

While Manuka honey is a well-known example of non-peroxide activity, honey from some species of Australian stingless bees is known to have both peroxide and non-peroxide activity. In the present study, the researchers evaluated the antimicrobial activity of sugarbag honey produced by three species of stingless bees, Tetragonula carbonaria, Tetragonula hockingsi, and Austroplebeia australis. The honeys were tested against four disease-causing microbes: the bacteria Staphylococcus aureus ("golden staph") and E. coli, and the fungi Cryptococcus neoformans and Trichophyton interdigitale.

"Manuka honey from honeybees displays strong non-peroxide antimicrobial activity, which is one reason why its production has been a

commercial success," Fernandes said. "However, that is largely reliant on the source of its nectar from specific myrtle plants (Leptospermum). In contrast, the persistent antimicrobial activity of heat-treated, non-peroxide honey from stingless Australian bees across diverse locations and nectar sources suggests there is something special about these bees, rather than just nectar, that plays a critical role here."

All of the honeys showed antimicrobial activity. The fungus T. interdigitale was the easiest to kill, and C. neoformans was the hardest. Honey produced by T. carbonaria bees was the strongest overall, especially against fungi. A. australis honey was the weakest. When the honeys were heated to destroy hydrogen peroxide, many retained strong non-peroxide antimicrobial activity. This is important as it means they're more stable and useful in medical settings. The researchers found that, unlike regular honey, the stingless bee honeys they evaluated can slowly release hydrogen peroxide over several days, not just for a few hours. Astonishingly, some T. carbonaria honeys produced it for more than six days.

"We discovered the antimicrobial activity is consistent across all sugarbag samples tested, unlike honeybee honey, which can vary significantly based on seasonal changes and floral sources," said study co-author Professor Dee Carter, also from the University of Sydney's Life and Environmental Sciences School.

When the researchers looked at the makeup of the honeys, they found that they contained phenolics and flavonoids, plant compounds that've been shown to fight microbes and inflammation. They also found many different proteins in the honeys, including some potentially linked to immune defense. Indeed, each bee species' honey had a different protein "fingerprint." And, honey samples stored for 18 years still had antimicrobial power, even after the peroxide degraded, demonstrating the product's long-term stability.

"While we have yet to test the honeys against drug-resistant bacteria specifically, the presence of multiple antimicrobial factors significantly reduces the likelihood of resistance developing," said Fernandes.

The next step is to ensure that the sugarbag honey can be produced at the required scale, given that each stingless beehive only produces about half a liter (17 fl oz) a year.

"While the yield is small, these hives require less maintenance than traditional beehives, allowing beekeepers to manage larger numbers," said co-author Dr Ros Gloag. "With proper incentives, such as commercial value for the honey, it's feasible to cultivate more hives, providing a pathway for commercial scalability."

The study was published in the journal Applied and Environmental Microbiology.

New Atlas, 29 June 2025

https://newatlas.com

Owl's Silent Flight Inspires New Aerogels for Noise Reduction

2025-06-24

If you've seen an owl fly, you probably didn't hear a thing. That's because their skin and feathers dampen sound by absorbing high- and low-frequency flight noise. Inspired by this natural soundproofing, researchers publishing in ACS Applied Materials & Interfaces developed a two-layer aerogel that mimics the structures inside owl feathers and skin to mitigate sound pollution. This new material could be used in cars and manufacturing facilities to reduce traffic and industrial noise.

Noise pollution is more than a nuisance; excessive noise can cause hearing loss and can worsen health conditions such as cardiovascular disease and type 2 diabetes. When eliminating the source of noise pollution isn't feasible, soundproofing materials help dampen it. However, traditional materials absorb either high-frequency sounds, like squealing breaks, or low-frequency sounds, like the deep rumbling from a car engine. This means engineers often layer multiple types of soundproofing materials to achieve full-spectrum noise control, which adds weight and bulk. To overcome this, Dingding Zong and colleagues turned to an unlikely acoustic expert: the owl. The owl uses its soft feathers and porous skin to remain whisper-quiet during flight. The researchers' goal was to engineer a similarly versatile broadband sound absorber.

The researchers froze droplets of hexane into a layer of soft material, using a technique called emulsion-templated freeze-reconstruction. Removing the frozen hexane revealed a honeycomb-like pattern in the material. They added a second layer with silicon nanofibers instead of hexane droplets to create a fibrous pattern. The resulting light, porous two-layer aerogel mimics the structures in owl skin and feathers: The bottom porous layer resembles the bird's skin with microscopic cavities that cancel out

low-frequency noise; and the top feather-inspired layer, made of fluffy nanofibers, dampens high-frequency sounds.

Notably, the researchers found that their owl-inspired aerogels can:

- Absorb 58% of soundwaves that strike it, surpassing the threshold for effective noise control materials.
- Reduce 87.5 decibels of automobile engine noise to a safe level of 78.6 decibels, which is a better reduction than existing high-end noise absorbers.
- Maintain structural integrity through 100 compression cycles, with only 5% deformation.

The researchers believe this study paves the way for high-performance, lightweight and durable sound-absorbing materials that can significantly alleviate noise pollution from industrial equipment and traffic.

Technology Networks, 24 June 2025

https://technologynetworks.com

Loofah-like polymer can filter viruses while adapting flexibility with pH changes

2025-07-03

Porous materials have a wide range of applications due to their capacity to act as filters, or lightweight structural materials that use less material than a solid substance. Researchers, including those from the University of Tokyo, created a new material fine enough to filter things like viruses but is strong enough to be a rigid construction material for devices. The study is published in the journal Science.

What makes this material unique is that it can be flexible when wet and responds to changes in pH. This and the fact that it can be coated onto other substances gives rise to a new range of functional and safe materials which use a minimal amount of raw material to create, leading to more sustainable manufacturing possibilities.

You've probably seen a loofah sponge at some point, those coarse, tough, weblike things hanging in people's bathrooms. Given their rigid, fibrous nature, you would be forgiven for thinking they are made of some kind of plastic or synthetic material.

But believe it or not, the humble loofah sponge is actually the dried-out skeleton of a kind of melon often called an Egyptian cucumber. What

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

makes their desiccated husks so useful, though, is that they are strong when dry, flexible when wet, and dry quickly, which helps resist mold buildup. Some of these properties can be useful in materials made for very different purposes, such as in the manufacture of devices.

"We developed a lightweight yet mechanically robust porous polymer which resembles the fiber network of a natural loofah sponge. Though we did not set out to create something with such an appearance, it was a pleasant surprise," said Associate Professor Yoshimitsu Itoh from the Department of Chemistry and Biotechnology at the University of Tokyo.

"So-called polymer materials like this already exist in nature, but we wanted to create something synthetic as it affords us control over its properties such that we can give it various useful functions."

Itoh and his team created a polymer network which can be useful as a filter as the network is dense enough to allow fluids to pass but block objects, including bacteria and viruses (which are also killed). This is desirable as currently, filters for this are often made out of less-sustainable materials, but this synthetic loofah is made from a substance similar to lignin, which is a basic component of wood. Although the team has not yet investigated the safety of the material, it is safe for human contact.

"One drawback of lightweight polymers is their mechanical weakness—they tend to be very soft," said Itoh. "But ours is low density, only half a gram of material per cubic centimeter, but has a stiffness of 11 gigapascals—for reference this is perhaps four times stronger than that of an ordinary polymer.

"This means it could be used to create devices where strength is really key, without having to resort to denser, heavier and less-sustainable materials."

But there's scope for even greater functionality, as the team is also creating a thin porous carbon membrane by baking the membrane in an inert atmosphere. This could give engineers a material to make nanoscale, functional electronic components, such as microcapacitors, more efficiently and with greater structural characteristics.

Another possibility is for the polymer to have some dynamic properties, things that change with time due to the presence of something else. In this case, certain changes in pH, acidity or alkalinity, can make the polymer more or less rigid, essentially allowing a portion of material to become more or less porous.

"In principle, this material we created could find many uses, though we have many steps to take before contemplating industrial integration of any kind," said Itoh.

"But the production is very cheap and easy to perform, using only pure water with a voltage applied, and a mixture of deprotonated resorcinol and an aldehyde, which spontaneously combine to make an ultrathin membrane with a loofah-like appearance under an electron microscope.

"One big advantage of this membrane is that there is no need for post-processing. Usually, thin films are made by first synthesizing the bulk polymer and then processing it into a film. Our method can directly give the product the form of a thin film and is, in principle, applicable to roll-to-roll processing. This is a big advantage for the production."

Phys Org, 3 July 2025

https://phys.org

Path to carbon dioxide-based chemicals smoothed with a dash of acid

2025-06-27

The stability of the electrochemical reduction of carbon dioxide can be dramatically improved simply by adding a small amount of acid. This addresses a key stumbling block in the commercialisation of the reaction by dissolving the salts that block the reactor and rapidly lead to failure.

The electrochemical reduction of carbon dioxide is potentially a huge advance in green chemistry as it uses electricity to reduce carbon dioxide into important platform chemicals such as carbon monoxide and hydrocarbons. This could transform carbon-positive syntheses into carbon-negative ones.

An especially promising design for the electrolyser is the membrane electrode assembly. This incorporates two electrodes pressed against an anion exchange membrane. The cathode is a gas diffusion electrode continuously fed with carbon dioxide and water vapour. At the anode, oxygen evolution from water releases electrons that travel through the external circuit. However, these electrons can reduce either carbon dioxide or hydrogen, and owing to the stability of carbon dioxide, in the absence of other influences hydrogen reduction is strongly favoured.

Researchers, therefore, usually add alkali metal salts to the anode electrolyte. 'What people have shown in the literature – and this is kind

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

of an ongoing debate on the exact mechanism – is that the cations will have some electrostatic interactions … that would do this initial activation step [of carbon dioxide],' explains electrochemist Ahmad Elgazzar at Rice University in Texas. Unfortunately, at neutral pH the cations can also react with the carbon dioxide to form bicarbonates or carbonates, which have limited solubility in water and can clog the gas diffusion electrode, leading to pressure buildup and failure. Various solutions to this problem, such as membrane modification and pulsed electrolysis, have been investigated, but none have proved totally satisfactory.

In the new work, conducted with potassium salts, Elgazzar and colleagues in Haotian Wang's group at Rice University in Texas simply added hydrochloric acid to the water vapour. They found that, whereas membrane electrode assemblies run using pure water showed rapid degradation in activity and failed after less than 500 hours, assemblies supplied with a feed containing concentrations as low as 0.05M acid could work stably for up to 4500 hours. Moreover, although disassembly of the acid-humidified assemblies showed that some salt-deposition had occurred, the researchers do not believe that this was the cause of their eventual failure as they had not observed a sudden pressure drop in gas flow across the cell before it stopped working.

The researchers went on to demonstrate that the idea worked equally well with other, less corrosive acids. 'Potassium formate, potassium acetate – these salts all have much higher solubility than potassium bicarbonate,' says team member Shaoyun Hao. A technoeconomic analysis suggested that, owing to the tiny quantities of acid consumed, there was a clear cost benefit to implementing the scheme.

Chemical engineer Cao Thang Dinh at Queen's University, Canada, is impressed. 'Previously, we've tried to avoid this problem by minimising it,' he says. 'People have run [the reaction] at very low electrolyte concentration so they can avoid the salt formation. The downside of that is that when you run at very low salt concentrations you have a high cell resistance, so the overall energy conversion is low… Now they run at high salt concentrations but have similar or better stability.' He concludes: 'I'm surprised many people didn't try this before because it's so simple and yet it works. I think it will have a huge impact on practical applications.'

Chemistry World, 27 June 2025

https://chemistryworld.com

This breakthrough turns old tech into pure gold — No mercury, no cyanide, just light and salt

2025-06-27

An interdisciplinary team of experts in green chemistry, engineering and physics at Flinders University in Australia has developed a safer and more sustainable approach to extract and recover gold from ore and electronic waste.

Explained in the leading journal Nature Sustainability, the gold-extraction technique promises to reduce levels of toxic waste from mining and shows that high purity gold can be recovered from recycling valuable components in printed circuit boards in discarded computers.

The project team, led by Matthew Flinders Professor Justin Chalker, applied this integrated method for high-yield gold extraction from many sources - even recovering trace gold found in scientific waste streams.

The progress toward safer and more sustainable gold recovery was demonstrated for electronic waste, mixed-metal waste, and ore concentrates.

"The study featured many innovations including a new and recyclable leaching reagent derived from a compound used to disinfect water," says Professor of Chemistry Justin Chalker, who leads the Chalker Lab at Flinders University's College of Science and Engineering.

"The team also developed an entirely new way to make the polymer sorbent, or the material that binds the gold after extraction into water, using light to initiate the key reaction."

Extensive investigation into the mechanisms, scope and limitations of the methods are reported in the new study, and the team now plans to work with mining and e-waste recycling operations to trial the method on a larger scale.

"The aim is to provide effective gold recovery methods that support the many uses of gold, while lessening the impact on the environment and human health," says Professor Chalker.

The new process uses a low-cost and benign compound to extract the gold. This reagent (trichloroisocyanuric acid) is widely used in water sanitation and disinfection. When activated by salt water, the reagent can dissolve gold.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

Next, the gold can be selectively bound to a novel sulfur-rich polymer developed by the Flinders team. The selectivity of the polymer allows gold recovery even in highly complex mixtures.

The gold can then be recovered by triggering the polymer to "un-make" itself and convert back to monomer. This allows the gold to be recovered and the polymer to be recycled and re-used.

Global demand for gold is driven by its high economic and monetary value but is also a vital element in electronics, medicine, aerospace technologies and other products and industries. However, mining the previous metal can involve the use of highly toxic substances such as cyanide and mercury for gold extraction - and other negative environmental impacts on water, air and land including CO2 emissions and deforestation.

The aim of the Flinders-led project was to provide alternative methods that are safer than mercury or cyanide in gold extraction and recovery.

The team also collaborated with experts in the US and Peru to validate the method on ore, in an effort to support small-scale mines that otherwise rely on toxic mercury to amalgamate gold.

Gold mining typically uses highly toxic cyanide to extract gold from ore, with risks to the wildlife and the broader environment if it is not contained properly. Artisanal and small-scale gold mines still use mercury to amalgamate gold. Unfortunately, the use of mercury in gold mining is one of the largest sources of mercury pollution on Earth.

Professor Chalker says interdisciplinary research collaborations with industry and environmental groups will help to address highly complex problems that support the economy and the environment.

"We are especially grateful to our engineering, mining, and philanthropic partners for supporting translation of laboratory discoveries to larger scale demonstrations of the gold recovery techniques."

Lead authors of the major new study - Flinders University postdoctoral research associates Dr Max Mann, Dr Thomas Nicholls, Dr Harshal Patel and Dr Lynn Lisboa - extensively tested the new technique on piles of electronic waste, with the aim of finding more sustainable, circular economy solutions to make better use of ever-more-scarce resources in the world. Many components of electronic waste, such as CPU units and RAM cards, contain valuable metals such as gold and copper.

Dr Mann says: "This paper shows that interdisciplinary collaborations are needed to address the world's big problems managing the growing stockpiles of e-waste."

ARC DECRA Fellow Dr Nicholls, adds: "The newly developed gold sorbent is made using a sustainable approach in which UV light is used to make the sulfur-rich polymer. Then, recycling the polymer after the gold has been recovered further increases the green credentials of this method."

Dr Patel says: "We dived into a mound of e-waste and climbed out with a block of gold! I hope this research inspires impactful solutions to pressing global challenges."

"With the ever-growing technological and societal demand for gold, it is increasingly important to develop safe and versatile methods to purify gold from varying sources," Dr Lisboa concludes.

Fast Facts:

Electronic waste (e-waste) is one of the fastest growing solid waste streams in the world. In 2022, an estimated 62 million tonnes of e-waste was produced globally. Only 22.3% was documented as formally collected and recycled.

E-waste is considered hazardous waste as it contains toxic materials and can produce toxic chemicals when recycled inappropriately. Many of these toxic materials are known or suspected to cause harm to human health, and several are included in the 10 chemicals of public health concern, including dioxins, lead and mercury. Inferior recycling of e-waste is a threat to public health and safety.

Miners use mercury, which binds to gold particles in ores, to create what are known as amalgams. These are then heated to evaporate the mercury, leaving behind gold but releasing toxic vapours. Studies indicate that up to 33% of artisanal miners suffer from moderate metallic mercury vapor intoxication.

Between 10 million and 20 million miners in more than 70 countries work in artisanal and small-scale gold mining, including up to 5 million women and children. These operations, which are often unregulated and unsafe, generate 37% of global mercury pollution (838 tonnes a year) - more than any other sector.

Most informal sites lack the funding and training needed to transition towards mercury-free mining. Despite accounting for 20% of the global

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

gold supply and generating approximately US$30 billion annually, artisanal miners typically sell gold at around 70% of its global market value. Additionally, with many gold mines located in rural and remote areas, miners seeking loans are often restricted to predatory interest rates from illegal sources, pushing demand for mercury.

Science Daily, 26 June 2025

https://sciencedaily.com

Graphene Foam Advances Lab-Grown Cartilage for Osteoarthritis Treatment

2025-06-25

Researchers have produced some "electrifying" results in a new study examining how graphene foam can help to construct better lab-grown cartilage tissue for osteoarthritis treatment.

The study, published in ACS Applied Materials & Interfaces, used graphene foam as an electrically-conductive three-dimensional (3D) bioscaffold on which progenitor cells could be grown while receiving direct electrical stimulation. The researchers found that this stimulation increased the mechanical strength of the resultant graphene foam–cell constructs. The graphene foam bioscaffolds also enabled complete immersion of the construct in cell growth media, improving cell interconnectivity.

To learn more about this research, how these findings could shine a light on broader questions about cell signaling and what it could mean for osteoarthritis treatment, Technology Networks spoke with senior study author David Estrada, PhD, a professor of materials science and engineering at Boise State University.

Alexander Beadle (AB): Can you tell us a little more about osteoarthritis and the different treatment options that are currently available/being investigated for patients?

David Estrada, PhD (DE): Osteoarthritis is a degenerative joint disease where the articular cartilage of joints and the underlying bone degrade over time, for example, in your knees and hips. It can lead to increased pain, loss of mobility and disability.

Common treatments range from weight loss, prosthetic support devices, pain management with medication, site injection of stem cells and most commonly for severe cases, total joint replacement surgery.

AB: What are the major challenges relating to engineered cartilage materials?

DE: In my opinion, the biggest challenge related to engineered cartilage materials is developing patient-specific tissues that have the correct zonal architecture and can form osteochondral junctions, allowing the cartilage to be inserted into the human body and fully integrated with the surrounding tissue and joint.

Doing this in a minimally invasive manner would have a tremendous impact on the more than 75 million individuals that are expected to suffer from osteoarthritis by 2040.

AB: What is graphene foam and why is it such a promising bioscaffold material?

DE: Graphene foam is a carbon-based foam that is graphitic in nature, with an occasional region of true atomically thin graphene. It became popular in 2011 after a paper appeared in Nature Materials by Zongping Chen and Hui-Meng Cheng, who reported on its synthesis through chemical vapor deposition on nickel foam substrates and demonstrated its applications in flexible and stretchable sensors.

As a bioscaffold, graphene foam has several attractive features, including its carbon composition, biocompatibility and its 3D porous structure, which allows for nutrient delivery and waste removal. Of most interest to my team are its excellent mechanical and electrical properties, which can be tuned through the synthesis process. When it is seeded with cells, you now have an embedded electrode to directly apply voltage and/or current to the cells, allowing for fundamental investigations into the role of electrical stimulus and cell signaling pathways.

AB: In this new study, you investigated the effects of applying direct electrical stimulation to progenitor cells on a graphene foam scaffold. What did you observe?

DE: We observed several interesting things in this study, but, most importantly, we noticed that by creating custom bioreactors for electrical stimulus through graphene foam, we were able to overcome the hydrophobic nature of the foam – fully submerging the scaffold in the media during culture – which led to a 13-fold increase in cell-cell interconnectivity. This is extremely important for cell-cell communication during both the proliferation and differentiation processes.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

For one week, we applied electrical signals to the cells for five minutes a day and then passively cultured the cells for another week. We then measured the dynamic mechanical properties of the cell-graphene foam constructs and noticed that cells stimulated at 40 mV and 60 mV had increased proliferation and collagen type II production, which manifested in increased mechanical strength and energy dissipation as compared to our controls.

We are now digging deep into genomics and proteomics data to get a better understanding of the fundamental cell signaling pathways that were affected by direct electrical stimulus.

AB: Were there any notable challenges you came across in developing this technique, and if so, how did you overcome them?

DE: Global pandemics aside, there were many challenges that we faced. First and foremost was imaging the cells on the graphene foam using standard confocal fluorescence. Since graphene foam is opaque in the visible spectrum, getting light out of the scaffold from cells that were more than 50 µm deep into the foam proved problematic. This was overcome by using a new staining protocol that combined fluorophores with gold nanoparticles, allowing us to use X-ray imaging via micro-computed tomography to understand how cells were proliferating across – and within – the graphene foam branches. This resulted in a separate publication detailing that technique.

Secondly, was how to reliably apply the electrical signals in a manner that allowed for consistent delivery of the target voltages. We used 3D printing to design our own bioreactors that were compatible with our tissue culture protocols and enabled direct electrical connections to the graphene foam for electrical stimulus. After some modifications, our approach proved to be scalable and compatible with existing tissue cultureware and with electrical multiplexing forming the basis of a provisional patent for our e-stim chambers. Only after overcoming these challenges were we able to get to the fundamental study on the electrical stimulus and the impact on the mechanical performance of our cell-graphene foam constructs.

AB:What do you believe to be the future impact of this research?

DE: If we can understand the fundamental impact of electrical stimulus on cell signaling pathways, this not only opens the door to creating patient-specific cartilage implants, but will also broaden our knowledge of how cells communicate electrically to determine their fate in tissue formation.

The human body is incredibly complex, and while recent foci on the human microbiome have led to new insights on gut health, immune system development and more, comparatively very little attention has been given to the human electrobiome. If we can understand the molecular mechanisms of charge transport at the cellular level, then I think we will be well-positioned to further connect these findings with the electrical systems of the human body, which impact everything from signal transmission, cellular development, vision and even consciousness itself.

Technology Networks, 25 June 2025

https://technologynetworks.com

Water activates hidden aluminum sites to enhance zeolite catalysis

2025-07-03

Researchers from the Innovation Academy for Precision Measurement Science and Technology (APM) of the Chinese Academy of Sciences have found that water can activate previously "NMR-invisible" aluminum in ultra-stable Y (USY) zeolite, a critical material in catalysis.

This activation creates synergistic acid sites that markedly improve the catalyst's performance in converting diethyl ether to ethylene. The findings were published in the Journal of the American Chemical Society.

Zeolites are microporous materials with tunable acidity, widely used in petrochemical and fine chemical industries due to their shape selectivity, activity, and stability. Water, often present in catalytic processes, influences zeolite acidity and reaction dynamics by acting as solvent, reactant, product, and accelerator.

Key Lewis acid sites (LAS) include tri-coordinated framework and extra-framework aluminum species, many of which remain "NMR-invisible" and poorly understood, limiting knowledge of their catalytic roles.

To address this gap, the researchers conducted a comprehensive investigation into the dynamic interactions between "NMR-invisible" Al species and water in dehydrated USY zeolites by employing advanced solid-state NMR techniques combined with theoretical calculations.

The results demonstrate that water undergoes dissociative adsorption on "NMR-invisible" Al sites, leading to a substantial increase of over 60% in Brønsted acid sites (BAS), as well as the formation of Brønsted/

CHEMWATCH
Bulletin Board
Curiosities
JUL. 04, 2025

Lewis synergistic acid sites. This transformation dramatically enhances the catalytic activity of USY zeolite in the conversion of diethyl ether to ethylene.

The evolution of Al species induced by water adsorption was monitored using one-dimensional 27Al MAS NMR experiments. The water dissociation adsorption transforms "NMR-invisible" Al species into detectable forms, and facilitates the generation of BAS on tetra-, penta-, and hexa-coordinated Al. Furthermore, two-dimensional 1H–1H DQ–SQ NMR experiments were performed to investigate the spatial proximity of hydrogen species in the USY samples upon water adsorption.

These results confirm the formation of Brønsted/Lewis synergistic acid sites, where newly formed Brønsted acid protons are in close proximity to Al–OH groups. Based on these findings, the researchers elucidated the interaction mechanism between water and "NMR-invisible" Al species. They proposed a water-driven regulatory mechanism that modifies zeolite active sites, offering a deeper understanding of how moisture influences catalytic behavior.

Phys Org, 3 July 2025

https://phys.org

CHEMWATCH

Bulletin Board

Technical Notes

JUL. 04, 2025

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

CHEMICAL EFFECTS

Investigation of the Effect of Exposure to Liquid Chemicals on the Strength Performance of 3D-Printed Parts from Different Filament Types

Machine Learning and Large Language Models for Modeling Complex Toxicity Pathways and Predicting Steroidogenesis

Sustainable Closed-loop Recycling of Polyester Waste using Reconstructed Defective-Metal-Organic Frameworks

ENVIRONMENTAL RESEARCH

Assessment of vape shop built environment: airborne nicotine, particulate matter, ventilation, hazard identification, workplace practices, and safety perceptions

Estimates, temporal evolution, and drivers of the global burden of cardiovascular disease attributable to particulate matter air pollution, 1990-2021: A systematic analysis from the global burden of disease study 2021

Exploring the combined toxic effects of tri-n-butyl phosphate and polystyrene micro/nano-plastics on Daphnia magna under environmentally relevant concentrations

PHARMACEUTICAL/TOXICOLOGY

Cancer Care Affordability and the Healthcare Team: Expanding an Assessment of Clinical Perceptions and Attitudes in Nursing

A bedside-to-bench translational analysis of NF1 alterations and CDK4/6 inhibitor resistance in hormone receptor-positive metastatic breast cancer

OCCUPATIONAL

Artisanal Gold Mining in Mongolia: Silica Exposure and Silicosis Risk Factors-Field Survey

Factors associated with the clinical use of the International Classification of Functioning, Disability and Health by physical and occupational therapists: a national exploratory survey