CHEMWATCH

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CONTACT US

subscribers@chemwatch.net
tel +61 3 9572 4700
fax +61 3 9572 4777

1227 Glen Huntly Rd
Glen Huntly
Victoria 3163 Australia

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ASIA PACIFIC

Information requirements for assessment certificate applications of 'designated fluorinated chemicals'

2025-03-17

What's this about?

Designated fluorinated chemicals are a subset of per- and polyfluoroalkyl substances (PFAS) that capture the PFAS chemicals of highest concern to human health and the environment. This includes longer chain PFAS chemicals that are similar to PFOS, PFOA and PFHxS.

AICIS assesses the health and environmental risks of designated fluorinated chemicals that are not on the Australian Inventory of Industrial Chemicals (the Inventory), after an application for an assessment certificate is submitted through the form in AICIS Business Services. The chemical can only be manufactured or imported into Australia if AICIS issues an assessment certificate.

Our information requirements for these certificate applications are based on the latest scientific knowledge about PFAS chemicals. It includes requirements for toxicological studies on the chemical and information about impurities and degradation products.

We are seeking your feedback on the clarity of the information requirements that will be added to the form for an AICIS assessment certificate application for a chemical that is a 'designated fluorinated chemical' – will an applicant be able to clearly understand these requirements?

Why are we consulting?

The full set of information requirements for assessment certificate applications for designated fluorinated chemicals are not currently in the application form in AICIS Business Services. They are also not available on the AICIS website. Instead, the website directs potential applicants to contact us for guidance about the information needed for their application. This has led to requirements being communicated to an applicant as an information request after a certificate application has been submitted.

Before improving transparency by adding the requirements to the application form and publishing them, we would like your feedback about whether an applicant will be able to clearly understand them.

Read More

AICIS, 17-03-25

https://www.industrialchemicals.gov.au/consultations/information-requirements-assessment-certificate-applications-designated-fluorinated-chemicals

Update to APVMA Approved Labels

2025-03-18

What is changing

From 25 March 2025, the logo displayed on PubCRIS by the Australian Pesticides and Veterinary Medicines Authority (APVMA) on approved agricultural and veterinary chemical product label will change.

APVMA approved labels will now display the official logo of the APVMA as prescribed in Schedule 8 of the Agricultural and Veterinary Chemicals Code Regulations 1995.

Read More

APVMA, 18-03-25

https://www.apvma.gov.au/news-and-publications/news/update-apvma-approved-labels

Sixth Forum of Ministers and Environment Authorities of Asia Pacific

2025-03-21

The sixth Forum of Ministers and Environment Authorities of Asia Pacific (6th AP Forum) will take place from 26th to 29th August 2025 in Nadi, Fiji. The event is jointly organized by the Government of Fiji's Ministry of Environment and Climate Change and the United Nations Environment Programme.

The Forum provides a platform for governments, intergovernmental organizations, and other stakeholders to discuss and prioritize environmental issues in the Asia Pacific region. It aims to contribute to the outcome of the seventh session of the UN Environment Assembly (UNEA-

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7) taking place from 08 to 12 December 2025 in Nairobi, with the theme "Advancing sustainable solutions for a resilient planet".

The Forum offers Member States and other stakeholders an opportunity to present an Asia Pacific perspective on discussions at UNEA-7. Participants will review the progress of UNEA resolutions' implementation in the region, as well as the progress made in regional forums and platforms where UNEP is the secretariat. Such forums include the Asia Pacific Clean Air Partnership, Asia Pacific Adaptation Network, Acid Deposition Monitoring Network in East Asia, and the Asia-Pacific Regional Forum on Environment and Health.

Furthermore, the Forum will identify regional priorities and emerging issues, and address challenges and opportunities to strengthen the regional environmental agenda, delivering on environmental dimension of the SDGs, and regional commitments to multilateral environmental agreements. Participants will contribute to the draft UNEA-7 result documents, including ministerial statements and draft resolutions, and will share their insights and ideas to achieving the environmental dimension of the 2030 SDGs.

Read More

UNEP, 21-03-25

https://www.unep.org/events/conference/sixth-forum-ministers-and-environment-authorities-asia-pacific

AMERICA

Protecting Canadians' health and Canada's environment from "forever chemicals"

2025-03-05

The federal government is committed to protecting the health of Canadians, as well as safeguarding the environment. Today, the Government is taking additional steps to address the potential harm of per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals," commonly found in everyday products, including clothing, electronics, food packaging and cosmetics.

PFAS are a class of thousands of extremely persistent human-made substances. They are used in a wide range of products for their waterproofing, oil resistance or non-stick properties.

Today, the Government is publishing the State of Per- and Polyfluoroalkyl Substances (PFAS) Report. The report concludes that the class of PFAS, excluding fluoropolymers, is harmful to human health and the environment.

Exposure to PFAS can adversely affect multiple organs and systems including the liver, kidneys, thyroid, immune system, nervous system, metabolism and body weight, and reproduction and development. In the environment, PFAS are harmful to wildlife and can build up in living organisms. These substances do not break down easily and remain in the environment for long periods of time.

To address these risks, the Government of Canada is taking steps to propose the addition of the class of PFAS, excluding fluoropolymers, to Part 2 of Schedule 1 to the Canadian Environmental Protection Act, 1999 (CEPA). Through a step-by-step approach, the Government will prioritize the protection of health and the environment while considering factors such as the availability of alternatives. Phase 1, starting in 2025, will address PFAS in firefighting foams to better protect firefighters and the environment. Phase 2 will focus on limiting exposure to PFAS in products that are not needed for the protection of human health, safety, or the environment. This will include products like cosmetics, food packaging materials, and textiles.

Beginning in 2025, the Government of Canada will also require manufacturing and other facilities to report the use of PFAS to the National Pollutant Release Inventory. This data will improve understanding of how PFAS are used in Canada, help evaluate possible industrial PFAS contamination, and support efforts to reduce environmental and human exposure to harmful substances.

Read More

Government of Canada, 05-03-25

https://www.canada.ca/en/environment-climate-change/news/2025/03/protecting-canadians-health-and-canadas-environment-from-forever-chemicals.html

EPA kicks chemical regulations down the road

2025-03-19

Workers in chemical plants, along with communities near such facilities, will have to wait longer for regulations that aim to reduce cancer and other health risks associated with widely used solvents like trichloroethylene,

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perchloroethylene, and carbon tetrachloride, and common building block chemicals like formaldehyde and 1,3-butadiene.

While attention has focused on President Donald J. Trump's moves to gut the federal workforce and slash funding that doesn't align with his priorities, the US Environmental Protection Agency has been quietly delaying restrictions on many hazardous substances, from asbestos to air pollutants. Environmental groups fear the delays are a first step toward weakening or even eliminating the restrictions.

Many of the targeted chemicals fall under the jurisdiction of the Toxic Substances Control Act (TSCA). On March 10, the EPA announced that it will revisit how it conducts risk evaluations under that law, amid widespread disagreement over its current framework. The announcement is the first major indication that the agency plans to revise risk evaluations issued by the previous administration and roll back regulations based on those evaluations.

Since early February, the EPA has also requested delays in several court cases involving regulations that restrict industrial chemicals under TSCA and reduce air emissions from chemical plants under the Clean Air Act. In general, environmental and public health groups are seeking to strengthen the rules. Industry wants more time to comply with them and in some cases wants the EPA to eliminate them altogether.

Read More

c&en, 19-03-25

https://cen.acs.org/policy/chemical-regulation/EPA-kicks-chemical-regulations-down/103/web/2025/03

Adding PFAS to toxic substances list won't necessarily lead to stricter guidelines for drinking water

2025-03-21

A class of chemicals called per- and polyfluoroalkyl substances (PFAS) could be added to Canada's list of toxic substances, but it's unlikely to have an immediate effect on communities already contaminated with the "forever chemicals," such as North Bay, Ont.

In early March, Environment and Climate Change Canada announced it would move to add PFAS to the country's official toxic substances list.

Because they don't break down easily and are great at repelling water, PFAS are found in a number of everyday products including outdoor clothing, non-stick pans, cosmetics and even some food packaging.

Read More

CBC, 21-03-25

https://www.cbc.ca/news/canada/sudbury/pfas-toxic-substance-1.7486911

EPA Signals Potential Change of Position Regarding Key 2024 PFAS Rulemakings

2025-03-19

In February 2025, newly installed EPA leadership sought and obtained orders from the D.C. Circuit Court of Appeals staying pending legal challenges to two key rulemaking actions by the former administration: the setting of Maximum Contaminant Levels for six PFAS in drinking water under the Safe Drinking Water Act (SDWA), and the listing of PFOA and PFOS as hazardous substances under CERCLA. These legal challenges were previously discussed in the updates below, dated June 10, 2024 (SDWA case) and July 29, 2024 (CERCLA case).

EPA recently filed an unopposed motion in each case to hold the litigation in abeyance for 60 days (available here (February 7 request in SDWA case) and here (February 11 request in CERCLA case)). In the SDWA case, the motion stated that "a new administration took office on January 20, 2025. There is now new leadership at EPA. That new leadership is in the process of familiarizing itself with the issues presented in this case and related litigation." In the CERCLA case, the motion included a similar but not identical rationale: "With the change in administration on January 20, 2025, there is new EPA leadership. EPA needs time to brief new administration officials about this case and the underlying rule. To provide new leadership with time to familiarize themselves with these issues and determine how to proceed, [abeyance is being requested]."

Read More

JD Supra, 19-03-25

https://www.jdsupra.com/legalnews/epa-signals-potential-change-of-7238719/

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EUROPE

Updated health surveillance guidance: respirable crystalline silica (RCS)

2025-03-18

HSE has refreshed its guidance publication 'Health surveillance for those exposed to respirable crystalline silica'.

The publication:

- provides advice for employers on the health surveillance appropriate for those whose work may result in exposure to RCS
- sets out what you should expect from a health surveillance provider

Visit HSE's website to read the updated publication: Health surveillance for those exposed to respirable crystalline silica (G404).

Action required

Employers in industries such as construction, worktop manufacturing and installation, stone masonry, ceramics, and quarrying should review the updated guidance to ensure they comply with the Control of Substances Hazardous to Health Regulations (COSHH).

Where there is a risk of harm for those exposed to hazardous substances such as RCS, health surveillance is a legal requirement under COSHH.

Why RCS is harmful

Silica is a natural substance found in materials such as stone, concrete, brick and ceramics, and in other materials such as engineered stone. Harmful dusts such as RCS can be created when working these materials. Exposure to RCS can cause serious health issues, including silicosis, chronic obstructive pulmonary disease (COPD) and lung cancer.

Refreshed information

The guidance has been refreshed to clarify the following points:

- the RCS content in both natural and engineered stone dust is dependent on the level of crystalline silica in the stone or material being worked.
- our COSHH essentials sheet for managers of stone workers provides information on the approximate content of crystalline silica in common types of stone and other materials.

- worktop manufacturing and installation are stated as high-risk occupations andprovision of health surveillance must be considered. Where workers are regularly exposed to RCS dust and there is a reasonable likelihood that silicosis may develop, health surveillance must be provided
- occupational health professionals should be consulted to identifywhen additional health surveillance is necessary to detect ill-health, for example where over-exposure to RCS dust has already occurred

Read More

HSE, 18-03-25

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

France – Prohibits Clothing Textile Products, and Footwear Containing PFAS

2025-03-18

On February 28, 2025, the governor of France signed LAW No. 2025-188 of February 27, 2025 which aims at protecting the population from risks associated with perfluoroalkyl and polyfluoroalkyl substances (PFAS). Here are the key highlights of the Law:

1. Starting from January 1, 2026, it will prohibit the manufacturing, importing, exporting, and placing on the market the following products containing PFAS above a residual value defined by decree: Cosmetics products;
- Ski Waxes products;
- Clothing Textile products, footwear and waterproofing agents for clothing textile products and footwear intended for consumers, with the exception of clothing textile and footwear that are designed for the protection and safety of people, in particular in the performance of national defense or civil security missions, the list of which is specified by decree.

Read More

Intertek, 18-03-25

https://www.intertek.com/products-retail/insight-bulletins/2025/france-prohibits-clothing-and-footwear-containing-pfas/

Consumer protection: Second-hand platforms put to the test

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2025-03-07

In accordance with European law, online retailers must inform consumers about their rights and refrain from misleading advertising promises. The German Environment Agency (UBA) examined second-hand sales platforms as part of an EU-wide investigation by the European Consumer Protection Cooperation Network (CPC). The findings showed that almost half of the scrutinised platforms do not adequately inform consumers of their warranty rights.

UBA President Dirk Messner stated: "From a sustainability perspective, I welcome the second-hand trend as a counter-movement to fast-fashion. However, the CPC network's survey has shown that there is still action needed in order to improve consumer protection in the second-hand sector. What is most important is that the environmental benefits of second-hand shopping are presented in a realistic way and that consumers are informed about their rights."

Read More

UBA, 07-03-25

https://www.umweltbundesamt.de/en/press/pressinformation/consumer-protection-second-hand-platforms-put-to

EurEau reaction to legal challenges filed by the pharmaceutical and cosmetics sectors on the Urban Wastewater Treatment Directive

2025-03-12

EurEau notes the legal challenge from the two sectors that will have to contribute to the EPR under the recast to the Urban Wastewater Treatment Directive. We agree that all European legislation must comply with the principles of the EU Treaty, including article 191.2.

Under the revision that came into force in January this year, pharmaceutical and cosmetics producers will have to contribute to micropollutant removal costs (the so-called quaternary treatment) under Extended Producer Responsibility (EPR). The impact assessment that accompanied the Commission's proposal for the directive states that these two sectors are the greatest source of micropollutants found in urban wastewater and, therefore, EPR should apply to those two groups. The directive allows Member States to add to the EPR system other sectors producing micropollutants that can be found in urban wastewater.

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We urge national policy makers to ensure that the implementation of the EPR schemes continues as planned while the Court of Justice of the EU) assesses the case. Any delay in the implementation of EPR would lead to a similar delay in the launch of quaternary treatment.

Read More

EurEau, 12-03-25

https://www.eureau.org/news/974-eureau-reaction-to-legal-challenges-filed-by-the-pharmaceutical-and-cosmetics-sectors-on-the-urban-wastewater-treatment-directive

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REACH Update

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Consultations on harmonised classification and labelling

2025-03-19

We are looking for comments on the harmonised classification and labelling (CLH) proposals for:

• 5-methylhexan-2-one; isoamyl methyl ketone (EC 203-737-8, CAS 110-12-3); and

• 2-[(1R,6R)-3-methyl-6-prop-1-en-2-ylcyclohex-2-en-1-yl]-5-pentylbenzene-1,3-diol; cannabidiol (EC -, CAS 13956-29-1).

Have your say until 16 May 2025.

Due to the website and IT tools maintenance break during 21-24 March 2025, we have extended the commenting period for six CLH consultations until 24 March at 23:59 (Helsinki time). These were originally scheduled to close on 21 March at 23:59.

Read More

ECHA, 19-03-25

https://echa.europa.eu/harmonised-classification-and-labelling-consultation

Stakeholder survey on a new EU (network of) substitution centre(s) for hazardous chemicals

2025-03-19

The purpose of the new substitution centre(s) will be to support the identification and implementation of safer and more sustainable chemical alternatives and meet existing obligations.

As part of the project, we are reviewing existing initiatives and organisations that support companies with substitution of hazardous chemicals, with the aim to:

1. Draw inspiration for how a new network/centre could operate, based on the lessons learnt from existing initiatives in terms of success factors and challenges;
2. Identify existing initiatives that could be involved in a new network/centre; and

3. Consider how a new network/centre could complement existing initiatives.

The purpose of this stakeholder survey is two-fold:

A) to identify existing initiatives or organisations supporting substitution of hazardous chemical substances; and

B) to understand what activities a new EU (network of) substitution centre(s) should prioritise for the benefit of stakeholders.

Read More

European Commission, 19-03-25

https://ec.europa.eu/eusurvey/runner/EU_Network_of_Substitution_Centres_Task_2_Survey

Getting Dissolved can be Traumatizing

2025-03-28

Janet's Corner

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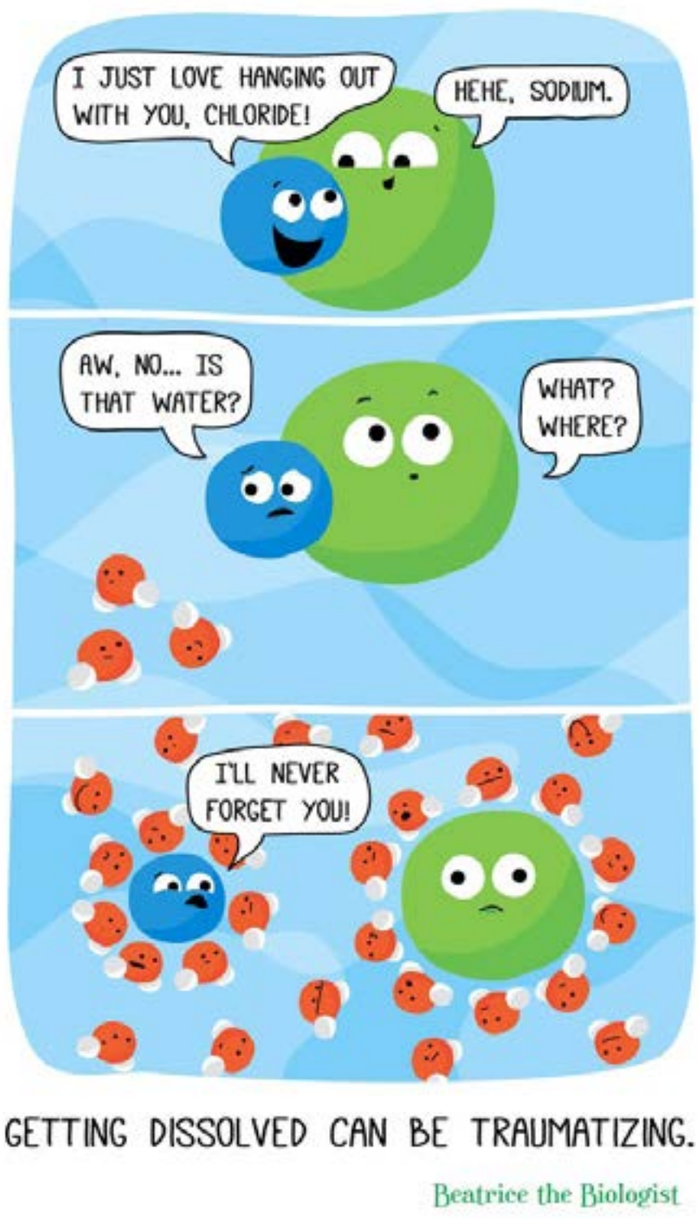

https://au.pinterest.com/pin/230457705909592081/

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Hazard Alert

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Sodium Hypochlorite

2025-03-28

Sodium hypochlorite is a chemical compound with the formula NaClO. It is a clear, slightly yellowish solution with a characteristic odour. Sodium hypochlorite is unstable. Chlorine evaporates from the solution and when heated, the sodium hypochlorite disintegrates. This also happens when sodium hypochlorite comes in contact with acids, sunlight, certain metals and poisonous and corrosive gasses, including chlorine gas. It is a strong oxidator and reacts with flammable compounds and reductors. Sodium hypochlorite solution is a weak base that is inflammable. [1,2]

USES [2,3]

Sodium hypochlorite is used on a large scale. For example in agriculture, chemical industries, paint- and lime industries, food industries, glass industries, paper industries, pharmaceutical industries, synthetics industries and waste disposal industries. In the textile industry sodium hypochlorite is used to bleach textile. It is sometimes added to industrial wastewater. This is done to reduce odours. Hypochlorite neutralises sulphur hydrogen gas (SH) and ammonia (NH3). It is also used to detoxify cyanide baths in metal industries. Hypochlorite can be used to prevent algae and shellfish growth in cooling towers. In water treatment, hypochlorite is used to disinfect water. In households, hypochlorite is used frequently for the purification and disinfection of the house.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

Exposure to PAH including phenanthrene can occur via fumes from vehicle exhaust, coal, coal tar, asphalt, wildfires, agricultural burning and hazardous waste sites. In addition, exposure also occurs by breathing cigarette and tobacco smoke, eating foods grown in contaminated soil or by eating meat or other food that have been grilled. Grilling and charring food actually increases the amount of PAHs in the food. Occupational exposure also occurs for people working in a plant that makes coal tar, asphalt and aluminium, or that burns trash. Furthermore, exposure may also occur for people working in a facility that uses petroleum or coal or where wood, corn and oil are burned.

Routes of Exposure

One of the most common ways phenanthrene can enter your body is through breathing contaminated air. It can get into your lungs when you breathe it. If you work in a hazardous waste site where PAHs are disposed, you are likely to breathe phenanthrene and other PAHs. If you eat or drink food and water that are contaminated with PAHs, you could be exposed. Exposure can also occur if your skin comes into contact with contaminated soil or products like heavy oils, coal tar, roofing tar or creosote where PAHs have been found. Creosote is an oily liquid found in coal tar and is used to preserve wood. Once in your body, the PAHs can spread and target fat tissues. Target organs include kidneys, liver and fat. However, in just a matter of days, the PAHs will leave your body through urine and faeces.

HEALTH EFFECTS [4]

Carcinogenicity

No data were available from studies in humans on the carcinogenicity of hypochlorite salts and there was inadequate evidence for the carcinogenicity of hypochlorite salts in experimental animals. Overall, the IARC assigned hypochlorite salts to Group 3, i.e. compounds that are not classifiable as to their carcinogenicity in humans.

SAFETY

First Aid Measures [5]

- Eye Contact: Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.
- Skin Contact: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.
- Serious Skin Contact: Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.
- Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

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- Ingestion: Do not induce vomiting. Examine the lips and mouth to ascertain whether the tissues are damaged, a possible indication that the toxic material was ingested; the absence of such signs, however, is not conclusive. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Workplace Controls & Practices [4]

- **Ingestion:** Rinse mouth with water immediately. If swallowed DO NOT induce vomiting. Give 1-3 glasses of water to drink. If vomiting occurs, place victim head lower then hips to prevent vomiting entering lungs. Seek immediate medical assistance or contact the Poisons Information Centre immediately.
- **Eye:** Hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by the Poisons Information Centre or a doctor, or for at least 15 minutes.
- **Skin:** If spilt on large areas of skin or hair, immediately drench with running water and remove clothing. Continue to wash skin and hair with plenty of water (and soap if material is insoluble) until advised to stop by the Poisons Information Centre or a doctor.
- **Inhaled:** Remove victim from further exposure. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. Seek medical attention if effects persist.
- **Advice to Doctor:** Treat symptomatically. Can cause corneal burns. Delayed pulmonary oedema may result.

Personal Protective Equipment [5]

- Wear overalls, face shield, elbow-length impervious gloves, splash apron and rubber boots.
- Always wash hands before smoking, eating, drinking or using the toilet.
- Wash contaminated clothing and other protective equipment before storage or re-use.
- If risk of inhalation exists, wear air supplied respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716.

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REGULATION

United States

- **NIOSH:** The National Institute for Occupational Safety and Health recommends an airborne recommended exposure limit (REL) of 0.5ppm for sodium hypochlorite for any 15 min work period.
- **AIHA:** The American Industrial Hygiene Association recommends a workplace environmental exposure level (WEEL) of 2mg/m3 for sodium hypochlorite for a 15 min work period.

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7. http://nj.gov/health/eoh/rtkweb/documents/fs/1707.pdf

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Gossip

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A cleaner future for tires: Scientists pioneer chemical process to repurpose rubber waste

2025-03-26

Every year, millions of tires end up in landfills, creating an environmental crisis with far-reaching consequences. In the United States alone, over 274 million tires were scrapped in 2021, with nearly 20% of them being discarded in landfills. The accumulation of these waste materials presents not only a space issue but also introduces environmental hazards, such as chemical leaching and spontaneous combustion.

While pyrolysis—a process that chemically recycles rubber through high-temperature decomposition—is widely used, it generates harmful byproducts like benzene and dioxins, posing health and environmental risks.

A study titled "Deconstruction of Rubber via C–H Amination and Aza-Cope Rearrangement," published in Nature, introduces a novel chemical method for breaking down rubber waste. This technique utilizes C–H amination and a polymer rearrangement strategy to transform discarded rubber into valuable precursors for epoxy resins, offering an innovative and sustainable alternative to traditional recycling methods.

The research was led by Dr. Aleksandr Zhukhovitskiy, William R. Kenan, Jr. Fellow and Assistant Professor in the Department of Chemistry at UNC-Chapel Hill.

Rubber, including the synthetic kind used in tires, is composed of polymers cross-linked together into a three-dimensional network that behaves as a tough, flexible material. Recycling these materials is difficult due to the extensive cross-linking within the polymer structure, which gives rubber its durability but also makes it resistant to degradation.

Traditional methods for breaking down rubber focus on two main approaches: devulcanization, which breaks sulfur cross-links but weakens the polymer's mechanical properties; and cleavage of the polymer backbones using oxidative or catalytic methods, which often results in complex, low-value byproducts. Neither approach provides an efficient, scalable solution for repurposing rubber waste.

"Our research seeks to overcome these challenges by developing a method that breaks down rubber into functional materials that possess value even as a mixture," said Dr. Zhukhovitskiy, who is the corresponding author of the study.

The researchers introduced a sulfur diimide reagent to enable the installation of amine groups at specific locations in the polymer chains. This step is crucial because it sets the stage for the subsequent backbone rearrangement. This chemical reaction reorganizes the polymer backbone, breaking down the rubber into soluble amine-functionalized materials that can be used to produce epoxy resins.

The researchers showed that their two-step process works very well. In a test with a model polymer, they broke it down significantly, reducing its molecular weight from 58,100 g/mol to about 400 g/mol. When they applied the method to used rubber, it broke down completely in just six hours, turning it into a soluble material with amine groups that could be used to manufacture broadly useful materials like epoxy resins.

The efficiency of this method is particularly striking when compared to traditional recycling techniques, which often require extreme temperatures or expensive catalysts. The researchers achieved their results under mild conditions (35–50°C, or 95–122°F) in aqueous media, making the process more environmentally friendly and cost-effective.

Epoxy resins are widely used in industries for adhesives, coatings, and composites. They are usually made from petroleum-based chemicals like bisphenol A and curing agents. This research shows that amine-modified poly-dienes, produced using the researchers' method, can create epoxy materials with strengths similar to commercial resins.

"In moments like this, I come to appreciate the power of organic synthesis," said Maxim Ratushnyy, a co-author of the paper and former postdoctoral scholar at UNC-Chapel Hill. "It is fascinating to see the ease with which the developed sequence of simple, yet powerful, organic transformations can take on a stubborn C–C bond and convert polybutadiene and polyisoprene-based rubbers into potentially valuable epoxy resins."

Beyond its practical applications, this study marks a significant step toward greener recycling technologies. The researchers evaluated the environmental impact of their process using the Environmental Impact Factor (E-factor), a measure of waste generated relative to the product yield.

"E-factor is a simple but powerful metric to compare the impact of a new process to incumbents, and also to highlight process steps that can be improved as we work to transition this process out of the lab and into practice," said Dr. Geoff Lewis, a research specialist at the University of Michigan's Center for Sustainable Systems.

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While the complete E-factor, which includes solvent use, was high, the simple E-factor, excluding solvents, was much lower, highlighting areas where the process could be further optimized for sustainability. The team is already exploring greener solvent systems and alternative reaction conditions to reduce waste generation.

"Our research represents a paradigm shift in how we approach the problem of rubber waste," said Sydney Towell, a co-author of the study and Ph.D. candidate at UNC-Chapel Hill.

"By harnessing the power of C–H amination and backbone rearrangement, this method provides a new pathway to transforming post-consumer rubber into high-value materials, reducing reliance on landfills and minimizing environmental harm."

Phys Org, 26 March 2025

https://phys.org

Spiral patterns can spontaneously form on metal surfaces

2025-03-23

A small mistake in a laboratory can sometimes lead to unexpected wonders. That is exactly what happened when a germanium wafer with evaporated metal films was left out overnight, and spiral patterns became etched into its surface.

The researchers who stumbled upon these strange patterns realized that chemical reactions, nudged by mechanical stress in the metal layer, could spontaneously carve stunning designs in the semiconductor.

The study was led by UCLA doctoral student Yilin Wong and Giovanni Zocchi, a professor of physics.

The resulting images have already sparked conversations among experts who are curious about how chemistry and force might work together in nature.

Self-forming metal patterns

In the early days of pattern formation research, scientists studied the Belousov-Zhabotinsky reaction to see how chemical reactions could arrange themselves in repeating waves.

That work inspired decades of experiments on reaction-diffusion systems, yet many setups still rely on older methods.

This new approach is the first significant addition to that research area since the 1950s, and it focuses on creating patterns not just through chemistry but also through mechanical deformations.

By harnessing a stressed metal film on a germanium wafer, patterns that include spirals, flower-like shapes, and other forms arise over the course of a day or two.

Why germanium matters

Semiconductor materials such as germanium have long been valued for electronics, thanks to their efficient pairing with thin films.

In the right environment, their surfaces can be carefully etched, making them useful for controlled studies.

In this case, the wafer was topped with chromium and gold, then exposed to a mild etching solution.

Over time, the stressed metal began to lift in certain spots, leading to wrinkles that guided the etching into spiral paths.

A surprising laboratory mistake

One night, a sample was accidentally left with a drop of water on it. People usually rinse away water droplets or dry them off, to avoid letting them sit on surfaces.

"I was trying to develop a measurement technique to categorize biomolecules on a surface through breaking and reforming of the chemical bonds," explained Wong.

The following day, that misstep revealed tiny dots that turned out to be chemical etch marks spiraling across the surface.

Mechanical strain and metal patterns

When a thin metal layer is under stress, it can buckle or separate from the surface below. This can shape the way chemical reactions proceed at the interface.

The research team found that mechanical strain drove local deformations which, in turn, altered how the solution etched the wafer. As the reaction advanced, wrinkles formed, guiding the spiral shapes and other patterns.

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Two processes united to create these designs. One was the straightforward etching reaction, and the other was the buildup of physical tension or compression in the metal coating.

The combination links chemical catalysis with mechanical force, a phenomenon also seen in living systems where enzymes and tissues interact. This experiment is special because it captures both aspects in a non-living setup.

Revisiting Turing's theory

Mathematician Alan Turing predicted that certain chemicals can spontaneously create stripes, spots, or other arrangements. His theory explained how basic processes could give rise to complex patterns without a guiding hand.

Turing's theory now supports the formation of these spiral etchings. Physical stress joins reaction-diffusion dynamics in this system.

Patterns that resemble biological structures

Living organisms rely on enzymes to kick-start growth, and that expansion distorts tissues. These deformations then loop back to affect how cells continue to develop.

This current experiment mirrors that interaction, though on a simpler, inanimate level. Some shapes on the wafer even resemble what we see in natural tissues, according to Professor Zocchi.

An electrified edge

The system forms what some describe as an electrolytic capacitor. This was highlighted by Professor Zocchi after observing how ions move and accumulate under the metal film.

It ensures the process is not just about dissolving the wafer. Charge also shifts between layers, affecting the overall reaction.

Steady formation of metal patterns

Typically, the patterns appear within a day or two once the chip is placed in a humid chamber with the solution. The reaction is mild but steady, leaving enough time for wrinkles to grow.

"The thickness of the metal layer, the initial state of mechanical stress of the sample, and the composition of the etching solution all play a role in determining the type of pattern that develops," said Professor Zocchi.

Exploring the metal patterns further

Some scientists see this method opening doors for advanced surface engineering. Others imagine it might shed light on how materials behave under stress or how nature sculpts itself.

For now, the lab mishap has sparked plenty of excitement. Every etched swirl is a reminder that major breakthroughs can come from unexpected moments.

Looking beyond the lab

Researchers hope to adapt these patterns for microfabrication, sensor design, or decorative coatings. The interplay between chemistry and mechanics could also inform new types of materials that self-organize.

"In the biological world, this kind of coupling is actually ubiquitous," said Professor Zocchi, adding that it is refreshing to see it in a synthetic setting.

These designs may help science close the gap between theory and real-world structures, bridging the concepts introduced by Turing with next-generation technologies.

The study is published in Physical Review Materials.

Earth, 23 March 2025

https://wearth.com

A new method to recycle fluoride from long-lived PFAS chemicals

2025-03-26

Oxford Chemistry researchers have developed a method to destroy fluorine-containing PFAS (sometimes labelled 'forever chemicals') while recovering their fluorine content for future use. The results have been published today (26 March 2025) in Nature.

PFAS -- which stands for poly- and perfluoroalkylated substances -- have been produced in large quantities for over 70 years. They are found in a wide variety of products including textiles, food packaging, non-stick cookware, and medical devices. Their unique properties come from multiple carbon-fluorine chemical bonds, a particularly strong chemical motif that also explains their resistance to degradation.

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This longevity has led to PFAS sometimes being referred to as "forever chemicals." Their persistence has resulted in widespread contamination around the world. Traces of PFAS have been found in drinking water and livestock, and have been associated with negative human health effects after chronic exposure.

This global problem urgently needs innovative technologies for the detection, recovery, and destruction of PFAS, as well as responsible pipelines to manage PFAS waste.

Now, a team of chemists at the University of Oxford and Colorado State University have shown it is possible to destroy a wide variety of these fluorine-containing PFAS chemicals while also recovering their fluorine content for reuse in industrial processes.

This operationally straightforward method works by reacting PFAS samples with potassium phosphate salts in the solid state. The reactants are ground together with ball bearings, which breaks down the long-lasting PFAS chemicals and allows the researchers to extract the fluorine content from the resulting product. In the study, the recovered fluoride was then used to generate common fluorinating reagents, which worked effectively in industrial reactions.

This recovery of fluoride, for re-entry into the fluorochemical industry, goes towards enabling a circular fluorine economy. This is particularly important given that fluorspar, the mineral from which essentially all fluorochemicals are manufactured, is categorised as critical for many industrial processes by nations around the world. Furthermore, the phosphate used as an activator in the PFAS destruction process was recovered and reused, implying no detrimental impact on the phosphorus cycle.

The team's method enables the mechanical destruction of all PFAS classes, including those commonly found in products such as non-stick coatings, electrical insulation, and industrial tubing. This means that the fluorine content from everyday waste such as Teflon tape could be recovered and used to generate important fluorine-containing chemicals, including precursors to pharmaceutical and agrochemicals such as cholesterol-lowering statin medications (Lipitor), anti-seizure agents (Rufinamide), and herbicides (Triaziflam).

A serendipitous observation made in the course of a previous study served as a starting point for the team's investigation. In an earlier set of experiments using a similar ball-milling method, they noticed that

the PFAS-containing sealing rings of the ball-milling jars were degraded during the reaction, resulting in higher fluoride yields than expected. They concluded that their process must be breaking down the PFAS in these sealing rings and liberating fluoride. They wondered if the method may be able to break down and upcycle other examples of PFAS, and have now demonstrated that the method does indeed have broad applicability across a wide range of PFAS.

Professor Véronique Gouverneur (University of Oxford), who led the study, said:

"Fluoride recovery is important because our reserves of Fluorspar, essential for the manufacturing of e.g. life-saving medicines, are rapidly depleting due to extensive mining. This method not only eliminates PFAS waste but also contributes to a circular fluorine chemistry by transforming persistent pollutants into valuable fluorochemicals."

Dr Long Yang (University of Oxford), one of the lead authors of the study, said:

"The mechanochemical destruction of PFAS with phosphate salts is an exciting innovation, offering a simple yet powerful solution to a long-standing environmental challenge. With this effective PFAS destruction method, we hope to shift away from the notion of PFAS as 'forever chemicals'."

Work at Colorado State University was led by Marshall Fixman and Branka Ladanyi Professor Robert Paton as part of the Department of Chemistry in the College of Natural Sciences.

Science Daily, 26 March 2025

https://sciencedaily.com

New water microcleaners self-disperse, capture microplastics and float up for removal

2025-03-26

In a new paper, researchers at North Carolina State University show proof of concept for a system that—in a single cycle—actively removes microplastics from water.

The findings, described in the journal Advanced Functional Materials, hold the potential for advances in cleansing oceans and other bodies of water of tiny plastics that may harm human health and the environment.

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"The idea behind this work is: Can we make the cleaning materials in the form of soft particles that self-disperse in water, capture microplastics as they sink, and then return to the surface with the captured microplastic contaminants?" said Orlin Velev, the S. Frank and Doris Culberson Distinguished Professor of Chemical and Biomolecular Engineering at NC State and corresponding author of the paper.

"We demonstrated how multiple principles can be integrated into a system that works in a single cycle."

The research starts with soft dendritic colloids—unique, hierarchically-branched soft particles with distinct properties such as the ability to stick to just about any surface—which can be created from a variety of polymers.

Velev and Ph.D. student Haeleen Hong, the paper's first author, say these particles' sticky nature can attract microplastics and grab them—even in wet and salty conditions, like ocean water.

"The cleansing particles in this research are made from chitosan, a biodegradable polymer originating from chitin, which comes from processed shellfish waste," Velev said. He adds that using environmentally safe materials that already come from the sea makes the process more sustainable.

Soft dendritic colloids take the shape of small pellets when dried in droplets suspended over a water-repellent surface. When dropped into water, particles in the pellets separate and spread out to hunt microplastics. But first the researchers infuse a bit of eugenol, a plant-based oil, on one section of the pellet as a dispersant.

"This oil makes the pellets move in the water by the so-called 'camphor boat effect,' decreasing the surface tension on one side of the pellet and driving it forward. This allows our microcleaners to spread out across a larger area, capturing microplastics as they move and descend," Hong said.

To make the return trip to the water's surface, the microcleaners also contain small particles of magnesium, which make them bubble up and rise to the surface when reacting with water.

To delay this return trip, the researchers coat the magnesium with an environmentally safe gelatin layer that blocks the magnesium's reaction with water. Essentially, thicker coats of the gelatin delay the particles from rising to the surface, allowing the microcleaners to pick up more microplastics as they swirl and descend in water.

"As the gelatin dissolves, the magnesium generates bubbles and the microcleaners rise, bringing the captured plastic particles to the surface in a dense, scummy mixture," Hong said.

The paper shows that the particles can "swim" and collect microplastics for up to 30 minutes. The microplastic-laden microcleaners that have floated up to the water surface can then be collected by skimming.

"Potentially, the collected scum can be bioprocessed into more chitosan, which can then be used to create more microcleaners in order to capture more microplastics," Velev said. Scaling up the process will take further investigations, the researchers say.

Former NC State Ph.D. student Rachel Bang co-authored the paper, along with current NC State Ph.D. student Lucille Verster.

Phys Org, 26 March 2025
https://phys.org

A cleaner future for tires: Scientists pioneer chemical process to repurpose rubber waste

2025-03-26

Every year, millions of tires end up in landfills, creating an environmental crisis with far-reaching consequences. In the United States alone, over 274 million tires were scrapped in 2021, with nearly a fifth of them being discarded into landfills. The accumulation of these waste materials presents not only a space issue but also introduces environmental hazards, such as chemical leaching and spontaneous combustion. While pyrolysis -- a process that chemically recycles rubber through high-temperature decomposition -- is widely used, it generates harmful byproducts like benzene and dioxins, posing health and environmental risks.

A U.S. Department of Energy-funded study, "Deconstruction of Rubber via C-H Amination and Aza-Cope Rearrangement," recently published in Nature and led by Dr. Aleksandr Zhukhovitskiy, William R. Kenan, Jr. Fellow and Assistant Professor in the Department of Chemistry at UNC-Chapel Hill, introduces a novel chemical method for breaking down rubber waste. This pioneering technique utilizes C-H amination and a polymer rearrangement strategy to transform discarded rubber into valuable precursors for epoxy resins, offering an innovative and sustainable alternative to traditional recycling methods.

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Rubber, including the synthetic kind used in tires, is composed of polymers cross-linked together into a three-dimensional network that behaves as a tough, flexible material. Recycling these materials is difficult due to the extensive cross-linking within the polymer structure, which gives rubber its durability but also makes it resistant to degradation. Traditional methods for breaking down rubber focus on two main approaches: de-vulcanization, which breaks sulfur cross-links but weakens the polymer's mechanical properties, and cleavage of the polymer backbones using oxidative or catalytic methods, which often result in complex, low-value byproducts. Neither approach provides an efficient, scalable solution for repurposing rubber waste.

"Our research seeks to overcome these challenges by developing a method that breaks down rubber into functional materials that possess value even as a mixture," said Dr. Zhukhovitskiy, who is the corresponding author of the study.

The researchers introduce a sulfur diimide reagent that enables the installation of amine groups at specific locations in the polymer chains. This step is crucial because it sets the stage for the subsequent backbone rearrangement. This chemical reaction reorganizes the polymer backbone, breaking down the rubber into soluble amine-functionalized materials that can be used to produce epoxy resins.

The researchers showed that their two-step process works very well. In a test with a model polymer, they broke it down significantly, reducing its molecular weight from 58,100 g/mol to about 400 g/mol. When they applied the method to used rubber, it broke down completely in just six hours, turning it into a soluble material with amine groups that could be used to manufacture broadly useful materials like epoxy resins.

The efficiency of this method is particularly striking when compared to traditional recycling techniques, which often require extreme temperatures or expensive catalysts. The researchers achieved their results under mild conditions (35-50°C, or 95-122°F) in aqueous media, making the process more environmentally friendly and cost-effective.

Epoxy resins are widely used in industries for adhesives, coatings, and composites. They are usually made from petroleum-based chemicals like bisphenol A and curing agents. This research shows that amine-modified poly-dienes, produced using the researchers' method, can create epoxy materials with strength similar to commercial resins.

"In moments like this I come to appreciate the power of organic synthesis," said Maxim Ratushnyy, a co-author of the paper and former postdoctoral scholar at UNC-Chapel Hill. "It is fascinating to see the ease with which the developed sequence of simple, yet powerful, organic transformations can take on a stubborn C -- C bond and convert polybutadiene and polyisoprene-based rubbers into potentially valuable epoxy resins."

Beyond its practical applications, this study marks a significant step toward greener recycling technologies. The researchers evaluated the environmental impact of their process using the Environmental Impact Factor (E-factor), a measure of waste generated relative to the product yield.

"E-factor is a simple but powerful metric to compare the impact of a new process to incumbents, but also to highlight process steps that can be improved as we work to transition this process out of the lab and into practice," said Dr. Geoff Lewis, a research specialist at the University of Michigan's Center for Sustainable Systems.

While the complete E-factor, which includes solvent use, was high, the simple E-factor, excluding solvents, was much lower, highlighting areas where the process could be further optimized for sustainability. The team is already exploring greener solvent systems and alternative reaction conditions to reduce waste generation.

"Our research represents a paradigm shift in how we approach the problem of rubber waste," said Sydney Towell, a co-author of the study and Ph.D. candidate at UNC-Chapel Hill. "By harnessing the power of C-H amination and backbone rearrangement, this method provides a new pathway to transforming post-consumer rubber into high-value materials, reducing reliance on landfills and minimizing environmental harm."

Science Daily, 26 March 2025

https://sciencedaily.com

A new method to recycle fluoride from long-lived PFAS chemicals

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Phys Org, 26 March 2025

https://phys.org

New materials for sustainable fabrics

2025-03-27

Textiles based on agricultural waste, algae and fungi are being developed to improve the environmental impact of the fashion industry

The fashion industry has a significant negative impact on the environment. Textiles made of synthetic polymers are popular due to their physical properties such as durability and flexibility, and the simplicity of manufacturing and using the fabric. However, most synthetic polymer materials are produced from petroleum and coal, and are not easily recycled. Furthermore, material processing and the dyeing of fabrics can result in excess water use and water pollution.

As environmental awareness and the demand for sustainable alternatives continues to grow, researchers and industrial manufacturers are exploring the use of agricultural residues and biotechnology applications to manufacture sustainable materials from organic materials such as algae, fungi and mycelium. However, bio-based materials face challenges to reach their full potential, such as cost-effectiveness and difficulties expanding to large-scale production. To overcome these obstacles, continuous collaboration between chemists, material scientists and industrial professionals is essential.

Several novel bio-based sustainable fibres are currently in use, often using locally available materials. Agricultural waste is a source of textile fibres in many countries; in Saudi Arabia they use date palm waste in textile production, in Egypt eco-awareness clothing has been made from pineapple and banana leaf fibres, and in Morocco, textiles have

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been developed from orange and olive waste. Using agricultural waste both reduces resource depletion and supports long-term economic sustainability by fostering jobs in sustainable textile productions for farmers and local business.

Among non-waste sources for new textiles, algae have been positioned as one of the most revolutionary microorganisms. Algae actively sequester carbon dioxide (around 1.8 kg of CO_2 per kilogram of biomass produced), hence reducing the carbon footprint of the textile industry.

Algae, fungi and crustaceans

Algiknit, based in the US, is a bio-based material company that has created kelp-based yarns and fibres as a biodegradable alternatives to synthetic fibres. To produce the textiles, a polysaccharide called alginate is extracted from the brown algae cell walls of kelp. This raw material is mixed with water to form a paste-like texture. The paste then undergoes both physical and chemical processing to transform it into filaments through extrusion.

Algae has potential as a sustainable textile because it can grow rapidly without the need for arable land or fresh water, making it a highly scalable option. Many researchers are also focusing on sustainable processing methods that use non-toxic materials, eco-friendly materials and green chemistry methods. In my opinion, however, for algae-based textiles to replace traditional materials they need further innovation, particularly to processing techniques, to improve their quality, durability, water resistance and performance.

Mycelium – a branched, thread-like network that forms a root-like structure of fungus – is another sustainable source. Mycelium-based materials are non-toxic, insulating and moisture absorbing and the final product is flexible and strong. MycoWorks and Bolt Threads in the US and other companies in Europe such as Fungi Mutarium in Italy and Mushlabs in Germany use mycelium-based materials in textiles. Mycelium can be grown rapidly using agricultural waste with minimal resource, but mycelium-based materials can be affected by moisture, which affects their usability in certain applications.

TômTex has also developed sustainable techniques to upcycle crustacean shell into fashion, bags, furniture and other applications. This innovative material is created from the biopolymer chitosan from two key natural waste products – mushrooms and seashells. The materials produced are petrochemical free, reducing dependence on fossil fuels, and can replicate the texture of fabrics like leather, suede and pleather. One of the main

challenges is to scale up the production and maintain the textile efficiency and durability with maintaining the cost.

Overcoming challenges

Bio-based materials derived from cellulose (often from wood pulp) reduce water consumption and use less energy than traditional polyester production. However, they produce other side effects and environmental challenges. Sodium hydroxide and carbon disulfide are produced during the process and production of common cellulose-based materials such as viscose and modal. These chemicals are toxic, placing both workers and the environment at risk if not managed properly. However, there are some cellulose-based materials, such as lyocell, that are produced using more environmentally friendly solvents (though lyocell production still uses some sodium hydroxide) that can be recycled. Nonetheless, all cellulose-based fabrics are treated with dyes and synthetic coatings that makes them difficult to biodegrade in landfills, hence causing end of life issues.

Other challenges that remain for bio-based materials and sustainable fabrics include maintaining the quality of the product, affordability and consumer acceptance. Chemists will play a crucial role in overcoming these challenges by developing eco-friendly innovative synthesis processes and by improving the biodegradability of textiles.

With global environmental awareness, manufacturers, scientists and policymakers need to collaborate to drive real change in the industry. The work done so far in this field demonstrates how scientific innovation can drive significant environmental progress.

Chemistry World, 2025-03-27

https://chemistryworld.com

New Microcleaners Capture and Remove Microplastics From Water

2025-03-27

In a new paper, researchers at North Carolina State University show proof of concept for a system that, in a single cycle, actively removes microplastics from water.

The findings, described in the journal Advanced Functional Materials, hold the potential for advances in cleansing oceans and other bodies of water of tiny plastics that may harm human health and the environment.

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"The idea behind this work is: Can we make the cleaning materials in the form of soft particles that self-disperse in water, capture microplastics as they sink, and then return to the surface with the captured microplastic contaminants?" said Orlin Velev, the S. Frank and Doris Culberson Distinguished Professor of Chemical and Biomolecular Engineering at NC State and corresponding author of the paper.

"We demonstrated how multiple principles can be integrated into a system that works in a single cycle."

The research starts with soft dendritic colloids – unique, hierarchically-branched soft particles with distinct properties such as the ability to stick to just about any surface – which can be created from a variety of polymers.

Velev and Ph.D. student Haeleen Hong, the paper's first author, say these particles' sticky nature can attract microplastics and grab them – even in wet and salty conditions, like ocean water.

"The cleansing particles in this research are made from chitosan, a biodegradable polymer originating from chitin, which comes from processed shellfish waste," Velev said. He adds that using environmentally safe materials that already come from the sea makes the process more sustainable.

Soft dendritic colloids take the shape of small pellets when dried in droplets suspended over a water-repellent surface. When dropped into water, particles in the pellets separate and spread out to hunt microplastics. But first the researchers infuse a bit of eugenol, a plant-based oil, on one section of the pellet as a dispersant.

"This oil makes the pellets move in the water by the so-called 'camphor boat effect,' decreasing the surface tension on one side of the pellet and driving it forward. This allows our microcleaners to spread out across a larger area, capturing microplastics as they move and descend," Hong said.

To make the return trip to the water's surface, the microcleaners also contain small particles of magnesium, which makes them bubble up and rise to the surface when reacting with water.

To delay this return trip, the researchers coat the magnesium with an environmentally safe gelatin layer that blocks the magnesium's reaction with water. Essentially, thicker coats of the gelatin delay the particles from rising to the surface, allowing the microcleaners to pick up more microplastics as they swirl and descend in water.

"As the gelatin dissolves, the magnesium generates bubbles and the microcleaners rise, bringing the captured plastics particles to the surface in a dense, scummy mixture," Hong said. The paper shows that the particles can "swim" and collect microplastics for up to 30 minutes. The microplastic-laden microcleaners that have floated up to the water surface can then be collected by skimming.

"Potentially, the collected scum can be bioprocessed into more chitosan, which can then be used to create more microcleaners in order to capture more microplastics," Velev said. Scaling up the process will take further investigations, the researchers say.

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Technology Networks, 27 March 2025

https://technologynetworks.com

Water Breaks the Rules: New Study Unravels Its Supercritical Secrets

2025-03-23

Researchers in Germany used terahertz spectroscopy and powerful simulations to finally debunk a key theory—that water molecules form hydrogen-bonded clusters in this state. Building a specialized high-pressure cell, the team showed that supercritical water behaves much like gas, lacking the long-lasting hydrogen bonds found in liquid water. Simulations confirmed that interactions between molecules are fleeting and disordered.

Shedding Light on Supercritical Water

Researchers at Ruhr University Bochum in Germany have gained new insights into the structure of supercritical water, a unique state in which water behaves like both a liquid and a gas. This state occurs only under extreme conditions: temperatures above 374°C and pressures above 221 bar.

One long-standing theory suggested that in this state, water molecules form clusters held together by hydrogen bonds. However, the Bochum team has now disproven this idea using a combination of terahertz spectroscopy and molecular dynamics simulations. Their findings were published on March 14, 2025, in the journal Science Advances.

Why Supercritical Water Matters

Supercritical water can be found in nature, such as around deep-sea hydrothermal vents known as black smokers, where extreme pressure and heat exist. Understanding its molecular structure could help scientists better explain the chemistry that occurs in these environments.

"Understanding the structure of supercritical water could help us to shed light on chemical processes in the vicinity of black smokers," says Dominik Marx, referring to a recent paper published by his research group on this topic.

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"Due to its unique properties, supercritical water is also of interest as a "green" solvent for chemical reactions; this is because it is environmentally friendly and, at the same time, highly reactive."

In order to improve the usability of supercritical water, it is necessary to understand the processes inside it in greater detail. Martina Havenith's team used terahertz spectroscopy for this purpose. While other spectroscopy methods can be employed to investigate H-bonds within a molecule, terahertz spectroscopy sensitively probes the hydrogen bonding between molecules – and thus would allow to detect the formation of clusters in supercritical water, if there are any.

Engineering a High-Pressure Breakthrough

"In experimental trials, applying this method to supercritical water was a huge challenge," explains Martina Havenith. "We need ten-fold larger diameters for our high-pressure cells for terahertz spectroscopy than in any other spectral range because we work with longer wavelengths." While working on her doctoral thesis, Katja Mauelshagen spent countless hours designing and building a new, suitable cell and optimizing it so that it could withstand the extreme pressure and temperature despite its size.

Rewriting the Molecular Picture

Eventually, the experimentalists managed to record data from water that was about to enter the supercritical state, as well as from the supercritical state itself. While the terahertz spectra of liquid and gaseous water differed considerably, the spectra of supercritical water and the gaseous state looked virtually identical. This proves that the water molecules form just as few hydrogen bonds in the supercritical state as they do in the gaseous state. "This means that there are no molecular clusters in supercritical water," concludes Gerhard Schwaab.

A member of Dominik Marx's team, Philipp Schienbein, who calculated the processes in supercritical water using complex ab initio molecular dynamics simulations as part of his doctoral thesis, came to the same conclusion. Just like in the experiment, several hurdles had to be overcome first, such as determining the precise position of the critical point of water in the virtual lab.

Ephemeral Bonds Define Supercritical Water

The ab initio simulations ultimately showed that two water molecules in the supercritical state remain close to each other only for a short time before separating. Unlike in a hydrogen bond, the bonds between

hydrogen and oxygen atoms don't have a preferred orientation, which is a key property of hydrogen bonds. The direction of the hydrogen-oxygen bond rotates permanently.

"The bonds that exist in this state are extremely short-lived: 100 times shorter than a hydrogen bond in liquid water," stresses Philipp Schienbein. The results of the simulations matched the experimental data perfectly, providing now a detailed molecular picture of the structural dynamics of water in the supercritical state.

Sci Tech Daily, 23 March 2025

https://scitechdaily.com

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Getting into the weeds of the glyphosate debate

2025-03-25

Assessments of the risk posed by the controversial herbicide depend on how the evidence is weighed

The herbicide glyphosate has polarised opinions for decades. And there are enough different ways to weigh the various evidence around its safety that make reaching any kind of unambiguous consensus hugely challenging. Those seeking to restrict use of herbicide tend to lean on the assessment from the World Health Organization's International Agency for Research on Cancer (IARC), which classifies glyphosate as 'probably carcinogenic to humans. Whereas parties seeking to retain commercial uses give more weight to decisions by national regulators and the European Chemicals Association (Echa) that suggest the available evidence does not support removing the products from the market.

Critics of IARC's assessment say that it focuses solely on the intrinsic hazards posed by glyphosate, rather than the overall assessment of the risk posed by that hazard under real-world exposure conditions. Conversely, Echa's decision, and those of various national regulators to renew approvals for glyphosate, are criticised as being biased by over-reliance on data from manufacturers (who have an enormous commercial interest in keeping the product on the market).

But while the lawyers battle back-and-forth over whether Bayer-Monsanto can be held responsible for thousands of US farmers' and horticulturalists' cancers, the body of knowledge around some more indirect effects of glyphosate continue to grow.

Beyond that, there are indications that the herbicide may affect the ability of bumblebees and other pollinators to withstand environmental stressors – they are less able to cope when food is scarce, for example. This kind of sublethal effect is difficult to pick up in conventional laboratory studies and field trials but can have significant detrimental effects on insect populations.

While some countries have begun to restrict glyphosate use – particularly in domestic settings – it seems unlikely that broader bans will be implemented anytime soon. And while there are alternative strategies farmers could use to deal with weeds, it is inexpensive and effective. However, there is recognition within the farming community that its over-reliance on a single herbicide is not an ideal situation. Resistant weed species are emerging and spreading, adding weight to arguments

for exploring alternative weed control strategies. But such strategies are almost inevitably more expensive. Hence, without restrictions on glyphosate, and/or support and incentives to investigate alternative approaches, it's difficult for farmers on narrow profit margins to justify the required investment.

Chemistry World, 25 March 2025

https://chemistryworld.com

New battery-free electricity source: Tiny plastic beads

2025-03-16

Harnessing a principle known as triboelectrification, researchers have worked out the optimal way to generate an electrical charge in a relatively simple way. The breakthrough could provide a battery-free way to power wearables and other devices.

In the world of clean power generation, triboelectrification is a relatively unknown player. It's basically the same thing as static electricity – the generation of energy through friction when two surfaces rub up against each other or are pulled apart. While the method will never replace wind, solar, geothermal and other green energy initiatives because of its inability to generate serious power, it could have a home in smaller applications such as medical devices and wearable tech.

In fact, triboelectrification has already been used to develop a sensor for detecting mercury in foods; a tree-mounted device that can detect carbon monoxide and temperature changes to monitor forest fire outbreaks; and a special yarn that can turn any fabric into a mini power plant. Researchers at the University of Alabama have even created an inexpensive triboelectric generator out of double-sided tape and plastic film.

Now, a team of researchers from Brussels, Australia, and Hong Kong has unlocked another secret to the effectiveness of the triboelectric effect. After experimenting with a range of materials, the scientists created nano-sized plastic beads made from melamine and formaldehyde. They then discovered that mixing the sizes of the beads was the key to the success of efficient triboelectric energy generation.

Specifically, they discovered that larger beads tended to acquire a negative charge while smaller ones tended to become positively charged. By designing a system known as a triboelectric nanogenerator (TENG) with the smaller beads on one side of a thin film and the larger ones on the other, they say it was able to output more electricity than would typically

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be possible by other triboelectric means. That includes methods that rely on rubbing two rough surfaces together to generate a charge. It should be noted that the current output measured during the experiments was only registered in nanoAmps, so let's not get too excited.

The fact that the beads aren't scraped against each other also means that they can last longer, with testing showing that they could survive 10,000 cycles. The researchers also say the beads can be produced without the use of solvents, making them cheaper to manufacture, and that they can be renewed with a simple coating of powder when they do wear out.

"Our research shows that small changes in material selection can lead to significant improvements in energy generation efficiency," said study lead author Ignaas Jimidar from Vrije Universiteit Brussels. "This opens up new possibilities for triboelectric nanogenerators in everyday life, without reliance on traditional energy sources."

The findings have been detailed in a paper published in the journal Small.

New Atlas, 16 March 2025

https://newatlas.com

Medical Infusion Bags Can Release Microplastics, Study Shows

2025-03-12

Microplastics have been found almost everywhere that scientists have looked for them. Now, according to research published in the ACS partner journal Environment & Health, these bits of plastic — from 1 to 62 micrometers long — are present in the filtered solutions used for medical intravenous (IV) infusions. The researchers estimate that thousands of plastic particles could be delivered directly to a person's bloodstream from a single 8.4-ounce (250-milliliter) bag of infusion fluid.

In clinical settings, IV infusions are packaged in individual plastic pouches and deliver water, electrolytes, nutrients or medicine to patients. The base of these infusions is a saline solution that contains filtered water and enough salt to match the content of human blood. Research from the 1970s suggests IV fluid bags can contain solid particles, but few scientists have followed up on what those particles are made of. Liwu Zhang, Ventsislav Kolev Valev and colleagues suspected that these particles could be microplastics that, upon infusion, would enter the recipient's

bloodstream and potentially cause negative health effects. So, they set out to analyze the types and amounts of particles in commercial IV fluid bags.

The team purchased two different brands of 8.4-ounce bags of IV saline solution. After the contents of each bag dripped into separate glass containers, the liquids were filtered to catch microscopic particles. Then the researchers counted a portion of the individual plastic fragments, using that amount to estimate the total number of microplastics in the entire pouch of IV liquid and to analyze the composition of the particles.

The researchers discovered that both brands of saline contained microplastic particles made from polypropylene — the same material as the bags — which suggests that the bags shed microplastics into the solutions. And they estimated that each bag of infusion fluid could deliver about 7,500 microplastics directly into the bloodstream. This figure rises to about 25,000 particles to treat dehydration or 52,500 for abdominal surgery, which can require multiple IV bags.

The researchers recommend keeping IV infusion bags away from ultraviolet light and heat to reduce microplastic shedding, and they say that micrometer-level filtration systems could be used to remove the particles during infusion.

While there are no clinical studies to date that have assessed the health risks of microplastics exposure, the researchers say their findings will help "provide a scientific basis for formulating appropriate policies and measures to mitigate the potential threats posed by microplastics to human health."

Technology Networks, 12 March 2025

https://technologynetworks.com

New study uncovers key pathways in hydronium and hydroxide ion neutralization

2025-03-25

A new study provides fresh insight into traditional acid-base chemistry by revealing that the mutual neutralization of isolated hydronium (H3O) and hydroxide (OH) ions is driven by electron transfer rather than the proton transfer that is expected in bulk liquid water.

Using deuterated water ions and advanced 3D coincidence imaging of the neutral products, researchers found two electron-transfer mechanisms that produce hydroxyl radicals (OH), which are crucial in atmospheric

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chemistry. These findings reshape our understanding of fundamental reaction dynamics and help explain the surprising finding of high OH and H2O2 concentrations at water microdroplet surfaces.

This discovery is significant because OH radicals play a key role in air quality, climate science, and even biochemical processes in the human body. By uncovering unexpected chemical reaction pathways, the study could influence future research on planetary and interstellar medium chemistry, as well as pollution control and medical applications.

The new study was led by Prof. Daniel Strasser from the Institute of Chemistry at Hebrew University in collaboration with Dr. Richard Thomas from Stockholm University and with Prof. Henning Schmidt, the director of the DESIREE facility, and was published in Nature Chemistry.

The study has unveiled critical insights into one of the most fundamental chemical reactions: the mutual neutralization of hydronium (H3O) and hydroxide (OH) ions. This reaction, essential to acid-base chemistry, is typically understood to yield two water molecules (H2O). However, the new experimental evidence demonstrates that electron-transfer mechanisms, rather than a proton-transfer pathway, dominate this reaction in the isolated system, leading to efficient formation of hydroxyl radicals (OH).

"The electron-transfer mechanisms we've uncovered suggest several pathways for spontaneous OH formation at low temperature conditions, without a catalyst or an external energy source," said Prof. Strasser. "Our work offers new insights not only into the quantum mechanism of the electron-transfer dynamics in acid-base chemistry, but also into broader processes like atmospheric chemistry, where OH radicals play an essential role."

A joint team of researchers from Hebrew University of Jerusalem and Stockholm University recorded the neutral products of individual neutralization reactions at the unique DESIREE facility at Stockholm University. The experimental breakthrough was made possible by detailed analysis of patterns of coincident products from a single reaction at a time, impinging on a time and position sensitive detector.

This study follows the team's previous research published in Science, where they first observed both the electron-transfer and proton-transfer products. In this latest work, they were able to record the distance at which an electron jumps from OH to H3O and correlate it to the outcome of the reaction. Electron transfer at a short ~4Å distance was

observed to result in OH + H2O + H products, while transfer across a larger ~9Å distance was observed to produce two OH radicals and a molecular H2 hydrogen.

"It is exciting to experimentally visualize the mechanisms that help explain the recently reported spontaneous formation of OH radicals (and subsequently hydrogen peroxide) on the surface of pure water microdroplets—an observation that may fundamentally change how we think about atmospheric chemistry," says Dr. Thomas, who led the Stockholm team.

Significance of non-adiabatic dynamics

Non-adiabatic processes are omnipresent in chemistry. They play a key role in photochemistry, ionization, and recombination reactions, where electronic states rapidly transition through mechanisms such as conical intersections or intersystem crossings. Nevertheless, the theoretical modeling and prediction of non-adiabatic reactions is still a challenge for quantum chemistry.

"Providing detailed experimental evidence will enhance our ability to validate and fine-tune theoretical modeling," says Prof. Henning Schmidt, the director of the DESIREE facility.

This study paves the way for further investigations into non-adiabatic reaction dynamics in other fundamental chemical systems. The findings have profound implications for our understanding of atmospheric chemistry, where OH radicals play a key role in oxidation processes, and for modeling chemical reactions in extreme environments such as interstellar space.

Additionally, the new insights into spontaneous H2O2 formation at water microdroplet surfaces could impact studies on atmospheric chemistry, environmental science, and even biomedical research.

Phys Org, 25 March 2024

https://phys.org

3D nanotech blankets offer new path to clean drinking water

2025-03-24

Researchers have developed a new material that, by harnessing the power of sunlight, can clear water of dangerous pollutants.

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Created through a combination of soft chemistry gels and electrospinning -- a technique where electrical force is applied to liquid to craft small fibers -- the team constructed thin fiber-like strips of titanium dioxide (TiO_2), a compound often utilized in solar cells, gas sensors and various self-cleaning technologies.

Despite being a great alternative energy source, solar fuel systems that utilize TiO_2 nanoparticles are often power-limited because they can only undergo photocatalysis, or create chemical reactions, by absorbing non-visible UV light. This can cause significant challenges to implementation, including low efficiency and the need for complex filtration systems.

Yet when researchers added copper to the material to improve this process, their new structures, called nanomats, were able to absorb enough light energy to break down harmful pollutants in air and water, said Pelagia-Iren Gouma, lead author of the study and a professor of materials science and engineering at The Ohio State University.

"There hasn't been an easy way to create something like a blanket that you can lay on water and start creating energy," she said. "But we are the only ones who have made these structures and the only ones to demonstrate that they actually work."

The study was recently published in the journal Advanced Science.

When titanium dioxide absorbs light, electrons are formed that oxidize water and attack pollutants, slowly destroying them until they become benign. When copper is added, that process is supercharged, making it even more effective.

To determine this, researchers worked to characterize the nanomat's updated properties to understand how it behaved and what made it different from other self-cleaning nanoparticles, said Gouma. Surprisingly, researchers found that compared to traditional solar cells, these nanomats can be more successful at power generation when placed under natural sunlight, she said.

"These nanomats can be used as a power generator, or as water remediation tools," she said. "In both ways, you have a catalyst with the highest efficiency reported to date."

These lightweight, easy-to-remove fiber mats can float and operate atop any body of water and are even reusable through multiple cleaning cycles. Because nanomats are so effective, researchers envision that they could be used to rid water of industrial pollutants in developing countries, turning

otherwise contaminated rivers and lakes into sources of clean drinking water.

Additionally, because this technology doesn't generate any toxic byproducts like some solar cell systems, nanomats are extremely environmentally friendly. "It's a safe material, it won't hurt anything, and it's as clean as it can be," said Gouma.

Still, although this team's technology is incredibly efficient, how long it will take to scale up commercially depends on how quickly industries take notice of the product. "We have the tools to make them in large quantities and translate them to various industries," said Gouma. "The only limitation is that it needs someone to take advantage of these abundant resources."

Overall, the study's findings suggest that nanomats could be a promising tool in many future photocatalytic applications, including long-term sustainability efforts like environmental remediation as well as solar-driven hydrogen production.

In the meantime, the team plans to examine ways to optimize the material further.

"This material is completely novel in terms of a new form of nanotechnology," said Gouma. "It's really impressive and something that we are very excited about."

Other Ohio State co-authors include Fateh Mikaeilia and Mohammad Mahafuzur Rahaman. This study was supported by the National Science Foundation.

Science Daily, 24 March 2025

https://sciencedaily.com

Electrochemical process that uses carbon dioxide to produce oxygen could be used in space

2025-03-24

To mitigate global climate change, emissions of the primary culprit, carbon dioxide, must be drastically reduced. A newly developed process helps solve this problem: CO2 is directly split electrochemically into carbon and oxygen.

As a Chinese research team reports in the journal Angewandte Chemie International Edition, oxygen could also be produced in this way

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underwater or in space—without requiring stringent conditions such as pressure and temperature.

Leafy plants are masters of the art of carbon neutrality: during photosynthesis, they convert CO2 into oxygen and glucose. Hydrogen atoms play an important role as "mediators." However, the process is not particularly efficient.

In addition, the oxygen produced does not come from the CO2 but from the absorbed water. True splitting of CO2 is not taking place in plants and also has not been achieved at moderate temperatures by technical means so far.

Ping He, Haoshen Zhou, and their team at Nanjing University, in collaboration with a researcher from Fudan University (Shanghai) have now achieved their goal to directly split CO2 into elemental carbon and oxygen. Instead of hydrogen, the "mediator" in their method is lithium.

The team developed an electrochemical device consisting of a gas cathode with a nanoscale cocatalyst made of ruthenium and cobalt (RuCo) as well as a metallic lithium anode. CO2 is fed into the cathode and undergoes a two-step electrochemical reduction with lithium. Initially, lithium carbonate Li2CO3 is formed, which reacts further to produce lithium oxide Li2O and elemental carbon.

In an electrocatalytic oxidation process, the Li2O is then converted to lithium ions and oxygen gas O2. Use of an optimized RuCo catalyst allows for a very high yield of O2, more than 98.6%, significantly exceeding the efficiency of natural photosynthesis.

As well as pure CO2, successful tests were also carried out with mixed gases containing varying fractions of CO2, including simulated flue gas, a CO2/O2 mixture, and simulated Mars gas. The atmosphere on Mars consists primarily of CO2, though the pressure is less than 1% of the pressure of Earth's atmosphere. The simulated Mars atmosphere thus contained a mixture of argon and 1% CO2.

If the required power comes from renewable energy, this method paves the way toward carbon neutrality. At the same time, it is a practical, controllable method for the production of O2 from CO2 with broad application potential—from the exploration of Mars and oxygen supply

for spacesuits to underwater life support, breathing masks, indoor air purification, and industrial waste treatment.

Phys Org, 24 March 2025

https://phys.org

Fluorescent caves could explain how life persists in extraterrestrial environments

2025-03-25

Deep below Earth's surface, rock and mineral formations lay hidden with a secret brilliance. Under a black light, the chemicals fossilized within shine in brilliant hues of pink, blue and green. Scientists are using these fluorescent features to understand how the caves formed and how life is supported in extreme environments, which may reveal how life could persist in faraway places, like Jupiter's icy moon Europa.

The researchers will present their results at the spring meeting of the American Chemical Society (ACS).

As it turns out, the chemistry in South Dakota's Wind Cave is likely similar to places like Europa -- and easier to reach. This is why astrobiologist Joshua Sebree, a professor at the University of Northern Iowa, ended up hundreds of feet underground investigating the minerals and lifeforms in these dark, cold conditions.

"The purpose of this project as a whole is to try to better understand the chemistry taking place underground that's telling us about how life can be supported," he explains.

As Sebree and his students began to venture into new areas of Wind Cave and other caves across the U.S., they mapped the rock formations, passages, streams and organisms they found. As they explored, they brought along their black lights (UV lights), too, to look at the minerals in the rocks.

Under the black light, certain areas of the caves seemed to transform into something otherworldly as portions of the surrounding rocks shone in different hues. Thanks to impurities lodged within the Earth millions of years ago -- chemistry fossils, almost -- the hues corresponded with different concentrations and types of organic or inorganic compounds. These shining stones often indicated where water once carried minerals down from the surface.

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"The walls just looked completely blank and devoid of anything interesting," says Sebree. "But then, when we turned on the black lights, what used to be just a plain brown wall turned into a bright layer of fluorescent mineral that indicated where a pool of water used to be 10,000 or 20,000 years ago."

Typically, to understand the chemical makeup of a cave feature, a rock sample is removed and taken back to the lab. But Sebree and his team collect the fluorescence spectra -- which is like a fingerprint of the chemical makeup -- of different surfaces using a portable spectrometer while on their expeditions. That way, they can take the information with them but leave the cave behind and intact.

Anna Van Der Weide, an undergraduate student at the university, has accompanied Sebree on some of these explorations. Using the information collected during that fieldwork, she is building a publicly accessible inventory of fluorescence fingerprints to help provide an additional layer of information to the traditional cave map and paint a more complete picture of its history and formation.

Additional undergraduate students have contributed to the study. Jacqueline Heggen is further exploring these caves as a simulated environment for astrobiological extremophiles; Jordan Holloway is developing an autonomous spectrometer to make measurement easier and even possible for future extraterrestrial missions; and Celia Langemo is studying biometrics to keep explorers of extreme environments safe. These three students are also presenting their findings at ACS Spring 2025.

Doing science in a cave is not without its challenges. For example, in the 48-degrees Fahrenheit (9-degrees Celsius) temperature of Minnesota's Mystery Cave, the team had to bury the spectrometer's batteries in handwarmers to keep them from dying. Other times, to reach an area of interest, the scientists had to squeeze through spaces less than a foot (30 centimeters) wide for hundreds of feet, sometimes losing a shoe (or pants) in the process. Or, they'd have to stand knee-deep in freezing cave water to take a measurement, and hope that their instruments didn't go for an accidental swim.

But despite these hurdles, the caves have revealed a wealth of information already. In Wind Cave, the team found that manganese-rich waters had carved out the cave and produced the striped zebra calcites within, which glowed pink under black light. The calcites grew underground, fed by the manganese-rich water. Sebree believes that when these rocks shattered, since calcite is weaker than the limestone also comprising the cave, the

calcite worked to expand the cave too. "It's a very different cave forming mechanism than has previously been looked at before," he says.

And the unique research conditions have provided a memorable experience to Van Der Weide. "It was really cool to see how you can apply science out in the field and to learn how you function in those environments," she concludes.

In the future, Sebree hopes to further confirm the accuracy of the fluorescence technique by comparing it to traditional, destructive techniques. He also wants to investigate the cave water that also fluoresces to understand how life on Earth's surface has affected life deep underground and, reconnecting to his astrobiological roots, understand how similar, mineral-rich water may support life in the far reaches of our solar system.

Science Daily, 25 March 2025

https://sciencedaily.com

Scientists Were Cleaning Dirty Water – Then They Accidentally Solved a Fusion Energy Problem

2025-03-22

Scientists have discovered a mercury-free method to isolate lithium-6, a vital ingredient in nuclear fusion fuel.

The breakthrough emerged by accident during water purification research and uses a material called zeta-vanadium oxide to selectively trap lithium-6 ions. The new method avoids the toxic COLEX process and has shown promising enrichment results in lab tests. Researchers now aim to scale the process to help power the future of clean energy.

Mercury-Free Method Unlocks Lithium-6 for Fusion Fuel

Lithium-6 is a key ingredient for producing fuel used in nuclear fusion but separating it from the far more abundant lithium-7 typically requires liquid mercury, a highly toxic substance. Now, scientists have developed a mercury-free method that can isolate lithium-6 just as effectively as the traditional approach. Their findings were published on March 20 in the journal Chem, published by Cell Press.

"This is a step towards addressing a major roadblock to nuclear energy," says chemist and senior author Sarbajit Banerjee of ETH Zürich and Texas A&M University. "Lithium-6 is a critical material for the renaissance of

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nuclear energy, and this method could represent a viable approach to isotope separation."

Toxic Legacy of COLEX and the Lithium-6 Shortage

The standard technique to isolate lithium-6, known as the COLEX process, uses liquid mercury and has been banned in the U.S. since 1963 due to environmental and health concerns. Since then, U.S. research has relied on a limited stockpile of lithium-6 maintained at Oak Ridge National Laboratory in Tennessee. Finding a safer, scalable method to isolate lithium-6 is essential for advancing nuclear fusion as a clean energy source.

Interestingly, the new method was discovered by accident. The researchers were developing filtration membranes to clean "produced water," a type of wastewater brought to the surface during oil and gas drilling, when they noticed the membranes were capturing unusually high amounts of lithium. That unexpected result led them to investigate further, ultimately uncovering a new way to separate lithium-6 without mercury.

A Hunch Leads to Isotope Selectivity Testing

"We saw that we could extract lithium quite selectively given that there was a lot more salt than lithium present in the water," says Banerjee. "That led us to wonder whether this material might also have some selectivity for the 6-lithium isotope."

The membrane's lithium-binding properties are due to a material called zeta-vanadium oxide (ζ-V2O5), a lab-synthesized inorganic compound that contains a framework of tunnels running in a single dimension.

"Zeta-V2O5 has some pretty incredible properties—it's an amazing battery material, and now we're finding that it can trap lithium very selectively, even with isotopic selectivity," says Banerjee.

Electrochemical Cell Confirms Lithium-6 Capture

To test whether the material could separate lithium-6 from lithium-7, the team set up an electrochemical cell with a zeta-V2O5 cathode. When they pumped an aqueous solution containing lithium ions through the cell while applying a voltage, the positively charged lithium ions were drawn towards the negatively charged zeta-V2O5 matrix and into its tunnels. Because lithium-6 and lithium-7 ions move differently, the zeta-V2O5 tunnels preferentially captured lithium-6 ions while the more mobile lithium-7 ions escaped capture.

"Lithium-6 ions stick a lot stronger to the tunnels, which is the mechanism of selectivity," says co-first author Andrew Ezazi of Texas A&M. "If you think of the bonds between V2O5 and lithium as a spring, you can imagine that lithium-7 is heavier and more likely to break that bond, whereas lithium-6, because it's lighter, reverberates less and makes a tighter bond."

As lithium ions are integrated into the zeta-V2O5, the compound gradually changes color from bright yellow to dark olive green, which enables the degree of lithium isolation to be easily monitored.

Reaching Fusion-Grade Lithium Without Mercury

The team shows that a single electrochemical cycle enriched lithium-6 by 5.7%. To obtain fusion-grade lithium, which requires a minimum of 30% lithium-6, the process needs to be repeated 25 times, and 90% lithium-6 can be obtained in about 45 sequential cycles.

"This level of enrichment is very competitive with the COLEX process, without the mercury," says Ezazi.

Toward Scalable, Cost-Effective Fusion Fuel

"Of course, we're not doing industrial production yet, and there are some engineering problems to overcome in terms of how to design the flow loop, but within a bunch of flow cycles, you can get fusion-grade lithium for quite cheap," says Banerjee.

The researchers say that their results suggest that materials like zeta-V2O5 could be used to isolate other substances, for example, to separate radioactive from non-radioactive isotopes.

Now, the team is taking steps to scale their method up to an industrial level.

"I think there's a lot of interest in nuclear fusion as the ultimate solution for clean energy," says Banerjee. "We're hoping to get some support to build this into a practicable solution."

Sci Tech Daily, 22 March 2025

https://scitechdaily.com

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Nuclear fusion fuel could be made greener with new chemical process

2025-03-20

Lithium-6 is a crucial material for nuclear fusion reactors, but isolating it is challenging – now researchers have found a way to do this without using toxic mercury

Limitless power from nuclear fusion may be a step closer following the accidental discovery of a new process to supply the isotope lithium-6, which is vital to providing fuel for a sustainable fusion reactor.

The least challenging fusion process involves combining two isotopes of hydrogen, deuterium and tritium, to yield helium, a neutron and a lot of energy. Tritium, a rare, radioactive isotope of hydrogen, is difficult and expensive to source. "Breeder" reactors seek to manufacture tritium by bombarding lithium with neutrons.

Lithium atoms exist as two stable isotopes: lithium-7 makes up 92.5 per cent of the element in nature and the rest is lithium-6. The rarer isotope reacts much more efficiently with neutrons to produce tritium in a fusion reaction.

However, the two lithium isotopes are extremely difficult to separate. Until now, this has only been achieved at a large scale using a highly toxic process reliant on mercury. Due to the environmental impact, this process has not been employed in Western countries since the 1960s and researchers are forced to rely on dwindling stockpiles of lithium-6 produced before the ban.

Sarbajit Banerjee at ETH Zurich in Switzerland and his colleagues have now discovered an alternative method serendipitously, while they were looking at ways to clean water contaminated by oil drilling.

The researchers noticed that the cement membranes they employed, containing a lab-made compound called zeta vanadium oxide, collected large quantities of lithium and seemed to disproportionately isolate lithium-6.

Zeta vanadium oxide contains tunnels surrounded by oxygen atoms, says Banerjee. "Lithium ions move through these tunnels, which happen to be just the right size [to bind lithium-6]," he says. "We found that lithium-6 ions are bound more strongly and are retained within the tunnels."

The researchers don't fully understand why lithium-6 is preferentially retained, but based on simulations, they believe it has to do with the interactions between the ions and the atoms at the edges of the tunnels, says Banerjee.

He says they have only isolated less than a gram of lithium-6 so far, but they hope to scale up the process so it can produce tens of kilograms of the isotope. A commercial fusion reactor is expected to need tonnes of the element every day.

"However, these challenges pale in comparison to the bigger challenges with plasma reactors and laser ignition for fusion," says Banerjee.

New Scientist, 20 March 2025

https://newscientist.com

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2025-03-22

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As lithium ions are integrated into the zeta-V2O5, the compound gradually changes color from bright yellow to dark olive green, which enables the degree of lithium isolation to be easily monitored.

Reaching Fusion-Grade Lithium Without Mercury

The team shows that a single electrochemical cycle enriched lithium-6 by 5.7%. To obtain fusion-grade lithium, which requires a minimum of 30% lithium-6, the process needs to be repeated 25 times, and 90% lithium-6 can be obtained in about 45 sequential cycles.

"This level of enrichment is very competitive with the COLEX process, without the mercury," says Ezazi.

Toward Scalable, Cost-Effective Fusion Fuel

"Of course, we're not doing industrial production yet, and there are some engineering problems to overcome in terms of how to design the flow loop, but within a bunch of flow cycles, you can get fusion-grade lithium for quite cheap," says Banerjee.

The researchers say that their results suggest that materials like zeta-V2O5 could be used to isolate other substances, for example, to separate radioactive from non-radioactive isotopes.

Now, the team is taking steps to scale their method up to an industrial level.

"I think there's a lot of interest in nuclear fusion as the ultimate solution for clean energy," says Banerjee. "We're hoping to get some support to build this into a practicable solution."

Sci Tech Daily, 22 March 2025

https://scitechdaily.com

CHEMWATCH
Bulletin Board

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Prediction of the exposure profile of bisphenol A in Chinese population by physiologically-based pharmacokinetics modeling