

Bulletin Board

Contents

OCT. 10, 2025

(click on page numbers for links)

REGULATORY UPDATE

ASIA PACIFIC

Resources for employers to manage risks of silica dust in the workplace....	4
Australian study reveals extent of PFAS contamination in Sydney drinking water	4
What we heard about information requirements for designated fluorinated chemicals	5
Have your say about draft evaluations.....	6

AMERICA

Looming Government Shutdown Could Disrupt Chemical Regulation under TSCA	6
Import Alert 99-51	7
PFAS in Delaware: How the First State is Tackling Toxic Forever Chemicals..	8
Federal judge dismisses attempt to make EPA regulate PFAS in biosolids..	9
Wisconsin moves to bring PFAS limits in line with contested federal standards.....	10

EUROPE

Seize this 'crucial moment' for animal-free chemical testing reform, say experts	10
EU export of pesticides banned in bloc continues to increase despite commitment to end practice	11
HSE isocyanates awareness campaign and targeted inspections begin	12

REACH UPDATE

Topical science seminars available online	13
---	----

JANET'S CORNER

WHO AM I?	14
-----------------	----

HAZARD ALERT

Sodium Cyanide.....	15
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*** While Chemwatch has taken all efforts to ensure the accuracy of information in this publication, it is not intended to be comprehensive or to render advice. Websites rendered are subject to change.**

Bulletin Board

Contents

OCT. 10, 2025

GOSSIP

Microwave technique allows energy-efficient chemical reactions.....	21
Scientists Deliberately Add Defects to Graphene, Unlocking New Powers.....	23
ChatGPT Lab Assistant Predicts Material Properties in Seconds.....	25
Forged in disorder: High-entropy MXenes emerge as a new material	27
Have MOFs now made it?	31
Scientists transform 'forever chemicals' in water into fluoride with new process.....	32
Composite metal foam endures over 1 million load cycles at 400°C and 600°C	33
Biodegradable plastic made from bamboo is strong and easy to recycle	35
Direct signal analysis helps solve 50-year-old problem in molecular fluorescence analysis	36

CURIOSITIES

Tiny Sensors Rapidly Detect "Forever Chemicals" in Water	41
Century-Old Mystery Solved: Scientists Measure a Fraction of an Electron, Unlocking the Secret to Catalysis	44
Artificial Intelligence Helps Chemists Develop Tough New Polymers	46
Q&A: Exploring metal-organic frameworks (MOFs) with chemist.....	47
Tiny Sensors Rapidly Detect "Forever Chemicals" in Water	50
Explainer: why have metal-organic frameworks won the Nobel prize in chemistry?	53
Century-Old Mystery Solved: Scientists Measure a Fraction of an Electron, Unlocking the Secret to Catalysis	56
Splitting water: How order and disorder direct chemical reactivity.....	58
Bamboo-derived biodegradable plastic is as durable as the real thing.....	60
'Solids full of holes': Nobel-winning materials explained.....	61

TECHNICAL NOTES

(Note: Open your Web Browser and click on Heading to link to section) ..	64
CHEMICAL EFFECTS	64
ENVIRONMENTAL RESEARCH	64
PHARMACEUTICAL/TOXICOLOGY	64
OCCUPATIONAL.....	64

Bulletin Board

Regulatory Update

OCT. 10, 2025

ASIA PACIFIC

Resources for employers to manage risks of silica dust in the workplace

2025-09-30

To support the recently released model Code of Practice for managing the risks of respirable crystalline silica in the workplace, Safe Work Australia has published resources to assist employers working with silica-containing materials.

The resources include templates, a checklist and case studies:

- Assessing if the processing of silica is high risk – optional template
- Silica risk control plan – optional template
- Evaluating a respiratory protective equipment program for silica exposure – checklist
- Maintaining respiratory protective equipment used to minimise silica exposure, and
- Assessing if the processing of silica is high risk – case studies.

More silica resources, including fact sheets and infographics, are available on Safe Work Australia's website.

Learn how to comply with the model WHS Regulations to effectively manage risks associated with silica dust in the model Code of Practice: Managing risks of respirable crystalline silica in the workplace

Read More

Safe Work Australia, 30-09-25

<https://www.safeworkaustralia.gov.au/>

Australian study reveals extent of PFAS contamination in Sydney drinking water

2025-10-10

A recent study of drinking water across Greater Sydney, Australia's most populous city, by scientists at the University of NSW (UNSW) detected widespread contamination with toxic PFAS (per- and poly-fluoroalkyl substances).

Bulletin Board

Regulatory Update

OCT. 10, 2025

The scientists looked for 50 known PFAS compounds and found 31 in the drinking water samples, 21 of which were previously undocumented in Australia.

PFAS are called “forever chemicals” because they do not break down in the environment and accumulate in biological organisms. They are used in many everyday household items including non-stick cooking implements, make-up, greaseproof paper and waterproofing.

[Read More](#)

[WWS.org](https://www.wsws.org), 29-09-25

<https://www.wsws.org/en/articles/2025/09/29/miqq-s29.html>

What we heard about information requirements for designated fluorinated chemicals

2025-10-02

Overview

From February to April 2025, we asked for feedback on information that AICIS requires from assessment certificate applicants to assess introductions of designated fluorinated chemicals. We wanted your thoughts on whether the requirements for this type of introduction were clear before we formally added them to the assessment certificate online application form in AICIS Business Services.

We received a total of 8 submissions, which are summarised on this page along with our responses.

Outcome

We will implement the proposed information requirements without change. Below is the required information for certificate applications of designated fluorinated chemicals that we originally published earlier this year. An applicant will also need to provide the required information for a ‘health and environment focus’ application type.

Our information requirements are based on what we currently know about the potential hazards of designated fluorinated chemicals and the risks they pose if manufactured or imported into Australia. We may update these requirements as more information becomes available to us. We will

Bulletin Board

Regulatory Update

OCT. 10, 2025

seek feedback when appropriate and announce any changes before they take effect.

[Read More](#)

AICIS, 02-10-25

<https://www.industrialchemicals.gov.au/consultations/what-we-heard-about-information-requirements-designated-fluorinated-chemicals>

Have your say about draft evaluations

2025-10-02

We have published 8 draft evaluations and welcome your comments by 28 November 2025.

We have also updated our Rolling Action Plan of evaluations that are completed, in progress and under public consultation.

[Read More](#)

AICIS, 02-10-25

<https://www.industrialchemicals.gov.au/news-and-notice/have-your-say-draft-evaluations-open-public-comment-until-28-november-2025>

AMERICA

Looming Government Shutdown Could Disrupt Chemical Regulation under TSCA

2025-10-10

As Congress edges closer to another potential government shutdown, questions loom large about how federal agencies will manage critical regulatory responsibilities. For the U.S. Environmental Protection Agency (EPA), even a short lapse in appropriations and critical staffing could have significant consequences for the implementation of the Toxic Substances Control Act (TSCA).

TSCA is built around statutory deadlines. For example, there are strict timelines for new chemical reviews under Section 5 and for ongoing risk evaluations and risk management rules under Section 6. EPA is also subject to several court ordered deadlines as a result of settled lawsuits. A shutdown would likely halt or at the least slow many of these activities, creating ripple effects that extend well beyond the duration of the funding

Bulletin Board

Regulatory Update

OCT. 10, 2025

lapse. Unlike discretionary programs, many of EPA's core chemical safety functions cannot simply be paused without consequence.

Perhaps the most immediate impact would be on the processing of premanufacture notices (PMN) and other new chemical submissions under TSCA Section 5. EPA will stop reviewing all cases when it runs out of operating funds. While the Central Data Exchange (CDX) will remain open and cases can still be submitted, nothing will move forward until funding is restored and employees are back at their jobs. In prior shutdowns, EPA has issued Federal Register notices extending review periods, but even if review periods expire, it is highly unlikely fees would be refunded.

[Read More](#)

B&C, 01-10-25

<https://www.lawbc.com/looming-government-shutdown-could-disrupt-chemical-regulation-under-tsca/>

Import Alert 99-51

2025-10-18

Import Alert Name:

Detention Without Physical Examination of Human Food Products That Appear To Have Been Prepared, Packed Or Held Under Insanitary Conditions Resulting in Chemical Contamination

Reason for Alert:

The FDA oversees the safety of the U.S. food supply (domestic and imports) by monitoring for chemical contaminants in food and assessing the potential exposure and safety concerns posed by these chemicals.

For example, radionuclides such as Cesium-137 (Cs-137), a radioisotope of cesium, can be present in many places around the world as a result of contamination produced high in the atmosphere during nuclear testing. Cs-137 is created via nuclear reactions, such as occurring in nuclear power plants and is also commonly used in medical and other industrial applications. Elevated amounts of Cs-137 can be present at locations where contamination settled from accidents such as Chernobyl in 1986 and Fukushima in 2011.

Cs-137 emits beta particles and gamma radiation that are associated with adverse health effects. Potential for health concerns following Cs-137 exposure depends on the dose and the duration of exposure. High

Bulletin Board

Regulatory Update

OCT. 10, 2025

doses lead to acute radiation syndrome. However, exposure to low doses spread out over a period of time may not cause immediate apparent adverse effects but may still be harmful. The primary health effect of concern following longer term, repeated low dose exposure (e.g., through consumption of contaminated food or water over time) is cancer, resulting from damage to DNA within living cells of the body.

The FDA considers the totality of the circumstances, on a case-by-case basis, to determine whether a food appears to have been prepared, packed, or held under insanitary conditions whereby it has become contaminated with a chemical contaminant that may have rendered it injurious to health. Evidence may be obtained through analytical results and/or other information available to the Agency that demonstrates the environment associated with the food or the circumstances involved in producing the food may have caused the food to be contaminated with chemical contaminants. These findings and/or conditions may necessitate the need for documentation demonstrating corrective actions identifying and addressing the root cause of the contamination; the establishment of controls to ensure future shipments are not adulterated to overcome the appearance of adulteration; and verification that the controls are effective at preventing contamination.

This Import Alert covers specific firms and their food products that appear to have been prepared, packed, or held under insanitary conditions in which chemical contamination may have rendered the article of food injurious to health and that may be detained without physical examination in accordance with the guidance in FDA's Regulatory Procedures Manual (RPM) Chapter 9-8.

[Read More](#)

US FDA, 18-09-25

https://www.accessdata.fda.gov/cms_ia/importalert_1187.html

Bulletin Board

Regulatory Update

OCT. 10, 2025

PFAS in Delaware: How the First State is Tackling Toxic Forever Chemicals

2025-10-02

Significant progress has been made in combating forever chemicals in Delaware in recent years, and we continue to learn more about presence of these emerging contaminants in our land, water and bodies.

The chemicals, officially known as perfluoroalkyl and polyfluoroalkyl substances but more commonly referred to simply as PFAS, have been used in thousands of products, including cookware, clothing and firefighting foam, for decades following their creation in the mid-20th century. Extremely strong chemical bonds of carbon and fluorine atoms form molecules that are resistant to heat, grease, water and oil.

However, we now know these chemicals, which come in many thousands of forms, break down extremely slowly and thus exist in soil, water and tissue over extended periods of time. Almost every person on the planet has some quantity of PFAS in their bodies, whether from exposure at work, drinking water contaminated with PFAS, eating foods like fish that may contain PFAS, breathing PFAS molecules through the air or using products that were packaged with or have PFAS included.

[Read More](#)[Delaware.gov, 02-10-25](https://dnrec.delaware.gov/outdoor-delaware/pfas-in-delaware-how-the-first-state-is-tackling-toxic-forever-chemicals/)<https://dnrec.delaware.gov/outdoor-delaware/pfas-in-delaware-how-the-first-state-is-tackling-toxic-forever-chemicals/>

Federal judge dismisses attempt to make EPA regulate PFAS in biosolids

2025-10-02

A federal judge dismissed a lawsuit Monday that attempted to force the U.S. EPA to regulate contamination from per- and polyfluoroalkyl substances in sewage sludge. The suit, brought by farmers and public health groups last year, is one of several seeking to address growing concerns about contamination from the family of chemicals collectively called PFAS.

More than half of sewage sludge produced in the U.S. is applied on agricultural land as fertilizer, according to EPA data. The rest is composted

Bulletin Board

Regulatory Update

OCT. 10, 2025

with other organic material or sent to landfills and incinerators for disposal. The question of what to do with the material, which can be contaminated by upstream sources such as manufacturing plants and mills, has become more pressing as farmers fear that contaminated sludge can ruin their livestock or crops.

[Read More](#)[Waste Dive, 02-10-25](#)<https://www.yahoo.com/news/articles/federal-judge-dismisses-attempt-epa-121200941.html>

Wisconsin moves to bring PFAS limits in line with contested federal standards

2025-10-02

Environmental advocates are urging state regulators to bring Wisconsin's PFAS standards in line with federal drinking water standards despite an ongoing legal challenge to the federal rules.

The Wisconsin Department of Natural Resources held a public hearing Thursday on its proposed rule to mirror PFAS standards set by the Environmental Protection Agency last year.

The EPA issued a rule that set individual limits for two of the most commonly studied chemicals, PFOA and PFOS, at 4 parts per trillion. The agency also set standards at 10 parts per trillion for three other chemicals: PFNA, PFHxS and GenX chemicals. And it set a limit on a mix of four PFAS substances.

[Read More](#)[Wisconsin Public Radio, 02-10-25](#)<https://www.wpr.org/news/wisconsin-bring-pfas-limits-in-line-contested-federal-standards>

Bulletin Board

Regulatory Update

OCT. 10, 2025

EUROPE

Seize this 'crucial moment' for animal-free chemical testing reform, say experts

2025-09-30

The European Union is at a pivotal moment in its efforts to modernise chemical safety regulation, as policymakers, industry leaders and animal welfare advocates converge on the need to accelerate the transition away from animal testing under the REACH framework.

During a recent Euractiv Policy Triangle discussion in Brussels, experts emphasised the urgency of aligning regulatory frameworks with scientific innovation, particularly in the context of the European Commission's forthcoming roadmap to phase out animal testing.

Jay Ingram, Director of Chemicals at Humane World for Animals (HWA), described the current juncture as a once-in-a-generation opportunity.

"We are at a substantial and important moment in time right now. The regulation has been in force for nearly two decades, and this is the first time that we are seeing it opened up and ready for revision," he said.

"It's a crucial time for Europe. It's a crucial time for chemical safety, not just in Europe, but globally. People see Europe as a real leading light in the regulatory sphere. We also see it as a real turning point for science. Science has developed so much over the last two decades, and we really need to make sure that we make the most of it."

Read More

Euractiv, 30-09-25

<https://www.euractiv.com/news/seize-this-crucial-moment-for-animal-free-chemical-testing-reform-say-experts/>

EU export of pesticides banned in bloc continues to increase despite commitment to end practice

2025-10-02

Nearly 122,000 tonnes of pesticides banned in the EU were exported by companies in the bloc in 2024, up 50% from 2018, a new investigation has revealed. The European Commission, which committed to end this in 2020, is coming under increasing pressure to stop the practice.

Bulletin Board

Regulatory Update

OCT. 10, 2025

The investigation by Public Eye, a Swiss global justice group, and Unearthed, Greenpeace UK's journalism project, analysed export notifications obtained under freedom of information laws from regulatory authorities. Companies must list any exports of banned products under 'prior informed consent' rules.

Read More

Chemistry World, 02-10-25

<https://www.chemistryworld.com/news/eu-export-of-pesticides-banned-in-bloc-continues-to-increase-despite-commitment-to-end-practice/4022230.article>

HSE isocyanates awareness campaign and targeted inspections begin

2025-10-01

HSE inspectors will visit motor vehicle repair businesses from October to check protection measures against isocyanate exposure, the leading cause of occupational asthma in the UK.

Inspectors will focus on ensuring effective controls, procedures and health monitoring are in place. Many skilled vehicle paint sprayers develop this life-changing disease each year, forcing them to leave their profession permanently.

Employers must prevent or control worker exposure to isocyanates through effective control measures and arrange regular health surveillance and biological monitoring.

There are 3 critical control measures where motor vehicle repair businesses commonly fall down on compliance:

- proper spray booth ventilation with adequate extraction systems
- correct respiratory protection equipment - workers must use air-fed breathing apparatus
- safe clearance procedures with clearly displayed measurable clearance times

Read More

UK HSE, 01-10-25

<https://content.govdelivery.com/accounts/UKHSE/bulletins/3f53030>

Bulletin Board

REACH Update

OCT. 10, 2025

Topical science seminars available online

2025-09-28

Did you know that you can find topical science seminars focusing on chemical safety, regulatory science, and innovative research on our website? The science seminars are part of our new web pages on ECHA's scientific work.

Our latest science seminar explores how new approach methods can help distinguish adult and developmental neurotoxicity, supporting future regulatory decision-making and reducing animal testing.

Hear Dr Ellen Fritsche and Dr Jonathan Blum from the Swiss Centre for Applied Human Toxicology and Dr Tamara Tal from the Helmholtz Centre for Environmental Research present the latest developments under the Partnership for the Assessment of Risks from Chemicals (PARC).

[Read More](#)

ECHA, 29-09-25

<https://echa.europa.eu/news>

Bulletin Board

Janet's Corner

OCT. 10, 2025

WHO AM I?

2025-10-03

I am a common halogen used to disinfect pools and drinking water. I am a yellow-green gas.

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

**I am a common
halogen used to
disinfect pools and
drinking water.**

Bulletin Board

Hazard Alert

OCT. 10, 2025

Sodium Cyanide

2025-10-10

USES [2,3]

Sodium cyanide is used commercially for fumigation, electroplating, extracting gold and silver from ores, and chemical manufacturing.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

- Indoor Air: Sodium cyanide can be released into indoor air as fine droplets, liquid spray (aerosol), or fine particles.
- Water: Sodium cyanide can be used to contaminate water.
- Food: Sodium cyanide can be used to contaminate food.
- Outdoor Air: Sodium cyanide can be released into outdoor air as fine droplets, liquid spray (aerosol), or fine particles.
- Agricultural: If sodium cyanide is released as fine droplets, liquid spray (aerosol), or fine particles, it has the potential to contaminate agricultural products.

Routes of Exposure

Sodium cyanide can affect the body through ingestion, inhalation, skin contact, or eye contact.

HEALTH EFFECTS [4]

Acute Health Effects

EFFECTS OF SHORT-TERM (LESS THAN 8-HOURS) EXPOSURE

Early symptoms of cyanide poisoning include light-headedness, giddiness, rapid breathing, nausea, vomiting (emesis), feeling of neck constriction and suffocation, confusion, restlessness, and anxiety. Accumulation of fluid in the lungs (pulmonary oedema) may complicate severe intoxications. Rapid breathing is soon followed by respiratory depression/respiratory arrest (cessation of breathing). Severe cyanide poisonings progress to stupor, coma, muscle spasms (in which head, neck, and spine are arched backwards), convulsions (seizures), fixed and dilated pupils, and death. The CNS is the most sensitive target organ of cyanide poisoning. Cardiovascular effects require higher cyanide doses than those necessary

Sodium cyanide is an inorganic compound with the formula NaCN. It is a white, water-soluble solid. Sodium cyanide is a deliquescent crystal-line powder, which means that it has a strong affinity for moisture and will absorb relatively large amounts of water from the atmosphere if exposed to it, forming a liquid solution. [2] It often has a smell like bitter almonds, but not everyone can smell it due to a genetic trait. [3] It also has a high affinity for metals, which leads to the high toxicity of this salt. [1,2]

Bulletin Board

Hazard Alert

OCT. 10, 2025

for CNS effects. In serious poisonings, the skin is cold, clammy, and diaphoretic. Blue discoloration of the skin may be a late finding. Severe signs of oxygen deprivation in the absence of blue discoloration of the skin suggest cyanide poisoning.

EYE EXPOSURE:

- Redness, pain, and severe deep burns.
- Contact with the eyes can contribute to whole-body (systemic) toxicity.

INGESTION EXPOSURE:

- Nausea, vomiting (emesis), abdominal pain, and irritation or corrosion of the lining of the oesophagus and stomach.
- Whole-body (systemic) toxicity can occur.

INHALATION EXPOSURE:

- Mild to moderate: CNS effects: headache, confusion, anxiety, dizziness, weakness (malaise), and loss of consciousness. Cardiovascular effects: palpitations. Respiratory effects: respiratory tract irritation, difficulty breathing or shortness of breath (dyspnea), and transient increase in rate and depth of breathing (hyperpnea). GI effects: nausea and vomiting (emesis).
- Severe: CNS effects: coma, seizures, and dilated pupils (mydriasis). Cardiovascular effects: shock, abnormal or disordered heart rhythms (dysrhythmias), critically low blood pressure, and cardiac arrest. Respiratory effects: abnormally rapid, followed by abnormally slow respirations; accumulation of fluid in the lungs (pulmonary oedema); and respiratory arrest. Eye effects: dilated pupils, inflammation of the surface of the eye, and temporary blindness.

SKIN EXPOSURE:

- Irritation, tissue damage (ulceration), burning sensation, and pain.
- Absorption through the skin can contribute to whole-body (systemic) toxicity.

SAFETY

First Aid Measures [5]

GENERAL INFORMATION:

Careful observation, supplemental oxygen, and supportive care may be sufficient therapy for the patient/victim who does not exhibit physical

Bulletin Board

Hazard Alert

OCT. 10, 2025

findings of cyanide toxicity. For the patient/victim exhibiting physical findings of cyanide toxicity, initial treatment consists of administration of antidotes under a physician's direction, respiratory and circulatory support (oxygen and IV fluids), correction of chemical imbalances in the blood, and seizure control. Speed is critical. Avoid mouth-to-mouth resuscitation regardless of route of exposure. Avoid contact with vomitus, which may off-gas hydrogen cyanide.

ANTIDOTE:

Amyl nitrite, sodium nitrite, and sodium thiosulfate are antidotes for cyanide toxicity; however, amyl nitrite and sodium nitrite should not be administered to patient/victims suffering from smoke inhalation. In these cases, only administer sodium thiosulfate. The described administration of nitrites is based on a patient having normal haemoglobin levels. Below normal haemoglobin levels require titration of nitrites.

For mild to moderate physical findings such as nausea, vomiting, palpitations, confusion, anxiety, dizziness (vertigo), and/or abnormally fast or deep respiration (hyperventilation):

- **Child (less than 55 lb (25 kg)):** Observe the patient/victim and administer 0.75 mL per pound of a 25% solution (1.65 mL per kilogram of a 25% solution) of sodium thiosulfate intravenously over a period of 10 minutes.
- **Adult:** Observe the patient/victim and administer 12.5 g of a 25% solution (50 mL of a 25% solution) of sodium thiosulfate intravenously over a period of 10 minutes.

Personal Protective Equipment [5]

The following personal protective equipment is recommended when handling sodium cyanide:

- Splash goggles;
- Synthetic apron;
- Vapour and dust respirator (be sure to use an approved/certified respirator or equivalent);
- Gloves.

Personal Protection in Case of a Large Spill:

- Splash goggles;
- Full suit;
- Vapour and dust respirator;

Bulletin Board

Hazard Alert

OCT. 10, 2025

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

REGULATION

United States

OSHA: The Occupational Safety & Health Administration has set the following Permissible Exposure Limit (PEL) for sodium cyanide:
General Industry: 29 CFR 1910.1000 Z-1 Table -- 5 mg/m³ TWA; Skin

- Construction Industry: 29 CFR 1926.55 Appendix A -- 5 mg/m³ TWA; Skin
- Maritime: 29 CFR 1915.1000 Table Z-Shipyards -- 5 mg/m³ TWA

ACGIH: The American Conference of Governmental Industrial Hygienists has set a Threshold Limit Value (TLV) for sodium cyanide of 4.7 ppm, 5 mg/m³ Ceiling; Skin (TLV listed under Hydrogen Cyanide) -- 5 mg/m³ Ceiling; Skin (TLV listed under Cyanide Salts)

NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for sodium cyanide of 4.7 ppm, 5 mg/m³ STEL; Skin

REFERENCES

1. https://en.wikipedia.org/wiki/Sodium_cyanide
2. <http://www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/sodium-cyanide-factsheet>
3. http://adminopsnet.usc.edu/sites/default/files/all_departments/EHS/SodiumCyanide.pdf
4. http://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750036.html
5. <http://www.sciencelab.com/msds.php?msdsId=9927711>
6. https://www.osha.gov/dts/chemicalsampling/data/CH_230400.html
7. <http://www.safeworkaustralia.gov.au/sites/swa/about/Publications/Documents/772/Workplace-exposure-standards-for-airborne-contaminants.docx>

Bulletin Board

Gossip

OCT. 10, 2025

New Eco-Friendly Method Could Remove PFAS From Drinking Water

2025-10-08

Rice University researchers, in collaboration with international partners, have developed the first eco-friendly technology to rapidly capture and destroy toxic “forever chemicals” (PFAS) in water. The findings, recently published in *Advanced Materials*, mark a major step toward addressing one of the world’s most persistent environmental threats.

The study was led by Youngkun Chung, a postdoctoral fellow under the mentorship of Michael S. Wong, a professor at Rice’s George R. Brown School of Engineering and Computing, and conducted in collaboration with Seoktae Kang, professor at the Korea Advanced Institute of Science and Technology (KAIST), and Keon-Ham Kim, professor at Pukyung National University in South Korea.

What are PFAS?

PFAS, short for per- and polyfluoroalkyl substances, are synthetic chemicals first manufactured in the 1940s and used in products ranging from Teflon pans to waterproof clothing and food packaging. Their ability to resist heat, grease and water has made them valuable for industry and consumers. But that same resistance means they do not easily degrade, earning them the nickname “forever chemicals.”

Today, PFAS are found in water, soil and air around the globe. Studies link them to liver damage, reproductive disorders, immune system disruption and certain cancers. Efforts to clean up PFAS have struggled because the chemicals are difficult to remove and destroy once released into the environment.

Limitations of current technology

Traditional PFAS cleanup methods typically rely on adsorption, where molecules cling to materials like activated carbon or ion-exchange resins. While these methods are widely used, they come with major drawbacks: low efficiency, slow performance, limited capacity and the creation of additional waste that requires disposal.

“Current methods for PFAS removal are too slow, inefficient and create secondary waste,” said Wong, the Tina and Sunit Patel Professor in Molecular Nanotechnology and professor of chemical and biomolecular engineering, chemistry and civil and environmental engineering. “Our new approach offers a sustainable and highly effective alternative.”

Bulletin Board

Gossip

OCT. 10, 2025

A breakthrough material with real-world promise

The Rice-led team’s innovation centers on a layered double hydroxide (LDH) material made from copper and aluminum, first discovered by Kim as a graduate student at KAIST in 2021. While experimenting with these materials, Chung discovered that one formulation with nitrate could adsorb PFAS with record-breaking efficiency.

“To my astonishment, this LDH compound captured PFAS more than 1,000 times better than other materials,” said Chung, a lead author of the study and now a fellow at Rice’s WaTER (Water Technologies, Entrepreneurship and Research) Institute and Sustainability Institute. “It also worked incredibly fast, removing large amounts of PFAS within minutes, about 100 times faster than commercial carbon filters.”

The material’s effectiveness stems from its unique internal structure. Its organized copper-aluminum layers combined with slight charge imbalances create an ideal environment for PFAS molecules to bind with both speed and strength.

To test the technology’s practicality, the team evaluated the LDH material in river water, tap water and wastewater. In all cases, it proved highly effective, performing well in both static and continuous-flow systems. The results suggest strong potential for large-scale applications in municipal water treatment and industrial cleanup.

Closing the loop: Capture and destroy

Removing PFAS from water is only part of the challenge. Destroying them safely is equally important. Working with Rice professors Pedro Alvarez and James Tour, Chung developed a method to thermally decompose PFAS captured on the LDH material. By heating the saturated material with calcium carbonate, the team eliminated more than half of the trapped PFAS without releasing toxic by-products. Remarkably, the process also regenerated the LDH, allowing it to be reused multiple times.

Preliminary studies showed the material could complete at least six full cycles of capture, destruction and renewal, making it the first known eco-friendly, sustainable system for PFAS removal.

Global effort, global impact

“We are excited by the potential of this one-of-a-kind LDH-based technology to transform how PFAS-contaminated water sources are

Bulletin Board

Gossip

OCT. 10, 2025

treated in the near future," Wong said. "It's the result of an extraordinary international collaboration and the creativity of young researchers."

Technology Networks, 8 October 2025

<https://technologynetworks.com>

Microwave technique allows energy-efficient chemical reactions

2025-10-10

Some industrial processes used to create useful chemicals require heat, but heating methods are often inefficient, partly because they heat a greater volume of space than they really need to. Researchers, including those from the University of Tokyo, devised a way to limit heating to the specific areas required in such situations. Their technique uses microwaves, not unlike those used in home microwave ovens, to excite specific elements dispersed in the materials to be heated. Their system proved to be around 4.5 times more efficient than current methods.

While there's more to climate change than power generation and carbon dioxide (CO₂), reducing the need for the former and the output of the latter are critical matters that science and engineering strive to tackle. Under the broad banner of green transformation, Lecturer Fuminao Kishimoto from the Department of Chemical System Engineering at the University of Tokyo and his team explore ways to improve things like industrial processes. Their latest development could impact on some industries involved in chemical synthesis and may have some other positive offshoots. And their underlying idea is relatively straightforward.

"In most cases, chemical reactions occur only at very small, localized regions involving just a few atoms or molecules. This means that even within a large chemical reactor, only limited parts truly require energy input for the reaction," said Kishimoto.

"However, conventional heating methods, such as combustion or hot fluids, disperse thermal energy throughout the entire reactor. We started this research with the idea that microwaves could concentrate energy on a single atomic active site, a little like how a microwave oven heats food."

As Kishimoto mentions, the process is similar in concept to how a microwave oven works, only in this case, rather than having microwaves tuned to heat polar water molecules at around 2.45 gigahertz (which is also a common Wi-Fi frequency in case you've ever noticed that your

Bulletin Board

Gossip

OCT. 10, 2025

internet connection becomes unstable when you're heating leftovers), their microwaves are tuned to much lower frequencies around 900 megahertz. This is because those are ideal to excite the material they wished to heat up, zeolite.

"The most challenging aspect was proving that only a single atomic active site was being heated by the microwaves. To achieve this, we spent four years developing a specialized experimental environment at Japan's world-class large synchrotron radiation facility, SPring-8," said Kishimoto.

"This involved using spongelike zeolite, which is ideal because we can control the sizes of the sponge cavities, allowing us to balance different factors of the reactions. Inside the sponge cavities, indium ions act like antennas. These are excited by the microwaves which creates heat, which can then be transferred to reaction materials passing through the sponge."

By selectively delivering heat to specific materials, lower overall temperatures can be used to achieve reactions which are otherwise very demanding, such as water decomposition or methane conversion, both useful to create fuel products. They can further improve selectivity by varying the pore size of the zeolite sponge, with smaller pores yielding greater efficiency and larger pores enabling greater control over reactions.

And one key advantage is that this technique can even be used in carbon capture, recycling CO₂ as part of the methane conversion, and even recycle plastics more easily.

The challenge now will be how to scale this up to encourage industrial adoption—things that work in the lab don't directly translate into large industrial settings easily. And there are some limitations to the research that would also need to be addressed first. The material requirements are quite complex and aren't simple or cheap to produce; it's hard to precisely measure temperatures at the atomic scale, so current data rely on indirect evidence and more direct means would be preferred. And, despite the improvements in efficiency, there is still room for improvement here too, as there are heat and electrical losses along the way.

"We aim to expand this concept to other important chemical reactions beyond CO₂ conversion and to further optimize catalyst design to improve durability and scalability. The technology is still at the laboratory stage. Scaling up will require further development of catalysts, reactor design and integration with renewable power sources," said Kishimoto.

Bulletin Board

Gossip

OCT. 10, 2025

“While it is difficult to give an exact timeline, we expect pilot-scale demonstrations within the next decade, with broader industrial adoption depending on progress in both technology and energy infrastructure. To achieve this, we are seeking corporate partners to engage in joint development.”

Phys Org, 10 October 2025

<https://phys.org>

Scientists Deliberately Add Defects to Graphene, Unlocking New Powers

2025-10-05

Scientists grew defective graphene using Azupyrene, making it more useful for sensors and semiconductors. The defects alter how the material interacts with other substances.

Researchers have discovered a new approach to producing graphene that intentionally incorporates structural defects, enhancing the material's performance. This advancement could broaden its usefulness across fields such as sensors, batteries, and electronic devices.

A team from the University of Nottingham's School of Chemistry, the University of Warwick, and Diamond Light Source has created a one-step technique to grow graphene-like films. The method uses a molecule called Azupyrene, whose structure naturally mirrors the type of defect they wanted to introduce. Their findings were published in the journal Chemical Science.

David Duncan, Associate Professor from the University of Nottingham was one of the lead authors on the study, he says: “Our study explores a new way to make graphene, this super-thin, super-strong material is made of carbon atoms, and while perfect graphene is remarkable, it is sometimes too perfect. It interacts weakly with other materials and lacks crucial electronic properties required in the semiconductor industry.

How molecular design shapes graphene

“Usually, defects in material are seen as problems or mistakes that reduce performance; we have used them intentionally to add functionality. We found that the defects can make the graphene more “sticky” to other materials, making it more useful as a catalyst, as well as improving its capability of detecting different gases for use in sensors. The defects can

Bulletin Board

Gossip

OCT. 10, 2025

also alter the electronic and magnetic properties of the graphene, for potential applications in the semiconductor industry.”

Graphene consists of a flat arrangement of carbon atoms arranged in six-membered rings. The targeted defect introduces neighboring rings made up of five and seven carbon atoms. Because Azupyrene already has a geometry (or topology) that includes this irregular ring structure, it was used to grow graphene films containing a high proportion of these defects. By adjusting the temperature during growth, the researchers were also able to control how many defects appeared in the final material.

Scientists at the Graphene Institute in Manchester showed that the defective graphene films could be successfully moved onto a variety of surfaces while keeping the defects intact. This marks an important step forward in making the material suitable for integration into practical devices.

Collaboration and advanced techniques

This work used a wide range of advanced tools, bringing together a collaboration across the UK, Germany and Sweden using advanced microscopy and spectroscopy at Diamond Light Source in Oxfordshire and MAX IV in Sweden, as well as the UK national supercomputer ARCHER2, allowing the researchers to study the atomic structure of the defective graphene, demonstrating that the defects were present, and how the defects affected the chemical and electronic properties of the defective graphene.

Professor Reinhard Maurer, Department of Chemistry, University of Warwick, says: “By carefully choosing the starting molecule and the growth conditions, we’ve shown it’s possible to grow graphene in which imperfections can be introduced in a more controlled way. We characterize the signatures of these imperfections by bringing together atomic-scale imaging, spectroscopy, and computational simulation.”

“This study is a testament to what can be achieved through international collaboration and the integration of diverse scientific expertise,” said Dr. Tien-Lin Lee from Diamond Light Source. “By combining advanced microscopy, spectroscopy, and computational modelling across institutions in the UK, Germany, and Sweden, we were able to uncover

Bulletin Board

Gossip

OCT. 10, 2025

the atomic-scale mechanisms behind defect formation in graphene, something no single technique or team could have achieved alone.”

Sci Tech Daily, 5 October 2025

<https://scitechdaily.com>

ChatGPT Lab Assistant Predicts Material Properties in Seconds

2025-10-23

A custom GPT created by a materials scientist could help speed up the discovery of new advanced materials.

A Johns Hopkins University engineer has developed a specialized AI tool that could do for materials scientists what ChatGPT has done for coders and writers. The new system, called ChatGPT Materials Explorer, or CME, could speed the discovery of everything from advanced batteries to tougher alloys, according to findings appearing in Integrating Materials and Manufacturing Innovation.

“ChatGPT Materials Explorer is like having a specialized research assistant who is trained specifically to dig through huge databases, predict how a material or materials will behave without physical testing, sort through scientific papers to find studies relevant to your projects, and even analyze work and assist with scientific writing,” says CME inventor Kamal Choudhary, a professor of materials science and engineering at the university’s Whiting School of Engineering.

The tool’s key innovation is its access to real scientific data and physics-based models, enabling it to give accurate answers to questions posed by materials scientists. Choudhary’s experiences with ChatGPT inspired its creation.

“I work on a lot of superconductors, which are materials that conduct electricity without any resistance,” says Choudhary, who also holds a joint appointment in the Department of Electrical and Computer Engineering. “I would ask ChatGPT, ‘Can you design a superconductor with a particular composition and show me the crystal structure?’ It gave me a very generic response, which turned out to be the wrong answer.”

What Choudhary was experiencing are called hallucinations—when ChatGPT presents false information as factual, a not uncommon occurrence. Some experts estimate that ChatGPT has a hallucination rate of between 10% and 39%.

Bulletin Board

Gossip

OCT. 10, 2025

“Hallucinations happen because ChatGPT isn’t trained to understand facts,” Choudhary says. “If it can’t find the exact answer based on the data it’s pulling from, it will say something that sounds plausible. Data sources like Wikipedia or The New York Times don’t often include current facts and research about materials science and can lead to incorrect answers. CME pulls its information from materials science databases, so its answers can be trusted by materials scientists.”

Choudhary developed his specialized language model with the ChatGPT builder feature, which enables users to create custom GPTs tailored to their needs. He started by telling the AI broadly what he wanted it to do and setting parameters for its functions. Then he configured it, connecting the AI to the databases and instructing it on what kinds of answers it can give.

“These databases are how ChatGPT gets its information, so plugging in databases that are relevant to the field is crucial to getting the correct output from the chatbot,” Choudhary says. “Before, I would ask regular ChatGPT for the molecular structure notation of ibuprofen, and it would give an incorrect or generic response. With CME, I’ll get the right answer to this and many other materials science questions.”

The databases, including National Institute of Science and Technology-Joint Automated Repository for Various Integrated Simulations (NIST-JARVIS), the National Institutes of Health-Chemistry Agent Connecting Tool Usage to Science (NIH-CACTUS), and Materials Project, consistently update CME with the most recent materials science findings, he says.

“Materials Explorer is correct because these databases are automatically updated with new papers; it runs itself and pulls from the newest journals,” Choudhary says.

To test its resistance to hallucinations, Choudhary compared CME to ChatGPT 4 and ChemCrow, an AI agent geared to solve chemistry-related tasks. From asking the molecular formula for aspirin to interpreting phase diagrams, CME got all eight answers correct, whereas the other models gave only five accurate responses.

Choudhary is now working to develop the platform further by adding advanced materials modeling tools, automated literature reviews, and more. He is also developing an open-source platform which is available at AtomGPT.org. Contrary to the closed-source model of CME, which doesn’t enable users to edit the code that Choudhary established, Atom GPT allows select users to change the code and improve its ability to answer materials science questions.

Bulletin Board

Gossip

OCT. 10, 2025

“The ultimate goal is to make ChatGPT Materials Explorer the one-stop research assistant that can help materials scientists with computer simulations, data analysis, and other methods that advance the field,” Choudhary says. “What started as a fun project on the weekends has turned into something that could be a useful career resource for materials scientists.”

Technology Networks, 23 September 2025

<https://technologynetworks.com>

Forged in disorder: High-entropy MXenes emerge as a new material

2025-10-11

By breaking the rules of atomic order, scientists have created MXenes unlike any seen before. Nine metals now share a single atom-thin sheet, their once-neat layers dissolved into a patchwork of possibility. The result could redefine how we design materials for the harshest places on Earth and beyond.

History has shown that materials science has long prized symmetry and stability, celebrating crystals whose atoms lock into place like repeating tiles on an infinite floor. It is this type of order that gives rise to strength, conductivity, and control in a laboratory and real-world setting. But in one peculiar family of carbides, the script of symmetry and stability shifted. Here, what should have been chaos turned out to be strength, as if disorder and order were two faces of the same design.

That paradox emerged from work led by researchers at Purdue and Drexel Universities, who set out to see what would happen if they pushed a well-known family of layered carbides beyond its limits. The idea was both straightforward and bold: take a structure prized for its order and force it to host different layers of metals simultaneously to see how far it would go before collapsing into useless disorder.

Much to the scientists' surprise, that collapse never came. Instead, the material reached a tipping point. Once a specific threshold was crossed, order ceased, as predicted by the researchers. But instead of failure, entropy itself stepped in as the stabilizer, holding the structure together as a two-dimensional sheet. What looked like chaos instead uncovered a hidden strength. Out of that deliberate disorder came a new approach to designing materials.

Bulletin Board

Gossip

OCT. 10, 2025

MAX Phases: The Scaffolding Beneath

To understand what made this experiment possible, you must step back half a century into the 1970s, when scientists discovered a curious set of layered ceramics they called MAX phases. Their formula – written as M_nAX – hid a simple idea: sheets of transition metals bound to carbon or nitrogen, stacked with intervening layers of “A” elements like aluminum or silicon.

What made these materials unusual was their ability to combine qualities rarely found together. They had the toughness of ceramics, able to resist heat and wear, but also conducted electricity much like metals. That combination earned them attention, and their architecture proved especially interesting. The metal layers fell into distinct positions, some bonded outward to the A-layers and others inward to the carbon. It was a framework that seemed to invite both order and potentially, disruption.

For decades, these MAX phases were studied for their durability and conductivity. But their real importance emerged in 2011, when researchers realized MAX phases were more than simply layered ceramics. By carefully etching away their A-layers, they could peel the structure into ultrathin sheets just a few atoms thick. These sheets became known as MXenes.

From MAX to MXene

While MXenes inherited the toughness and conductivity of their parent phases, their real promise lay in the surfaces exposed when etched. Scientists discovered that these surfaces could be fine-tuned with oxygen, hydroxyl, or fluorine, giving them a way to adjust Mxene behavior for different tasks.

What emerged was a new class of two-dimensional materials, versatile in ways that graphene and other atom-thin sheets were not. MXenes could disperse in water, self-assemble into films, and be modified at the surface, almost like programmable matter. Within a few years they were being tested for energy storage, electromagnetic shielding, catalysis, and sensors.

The Breakthrough: Entropy Takes Over

Yet for all their promise, MXenes were still bound by their MAX origins. Most were made from ordered phases with only a few metals, and that very order, once their strength, became their limitation. To push those possibilities to their limit, the Purdue–Drexel team set out to force MAX phases to their breaking point.

Bulletin Board

Gossip

OCT. 10, 2025

They synthesized 40 different compositions, layering anywhere from two to nine transition metals into the same structure. Each new metal introduced competing preferences – some tending toward one atomic site, others toward another.

“Imagine making cheeseburgers with two to nine ingredients (layers),” said Babak Anasori of Purdue University. “However, if we add one or more ingredients ... then the metals do not follow any preference for order, and true disorder (high entropy) is achieved.”

With up to about six metals, the system behaved as expected: enthalpy, the energetic pull toward order, kept the structure biased. But once the count rose to seven or more, something shifted. Energetic preferences dissolved, and every configuration became equally likely. Entropy – enthalpy’s disordered doppelganger – stepped in and took over.

What should have collapsed turned instead into stability. Etching these high-entropy MAX phases into MXenes erased the neat divide between order and disorder, leaving a patchwork of possibilities spread across an atom-thin sheet. That patchwork carried into their chemistry: oxygen groups came to dominate their surfaces, while hydroxyl and fluorine fell away as more metals were introduced.

Properties of Entropy-Forged MXenes

Despite that disorder, the MXenes retained their parent metallic character. In fact, their electrical resistivity dropped dramatically as the number of metals increased, in some cases by nearly an order of magnitude. Infrared emissivity fell in parallel, pointing to materials that could endure the extreme environments of heat and radiation.

“This study indicates that short-range ordering – the arrangement of atoms over a short distance of a few atomic diameters – in high-entropy materials determines the impact of entropy versus enthalpy on their structures and properties,” said Brian Wyatt, a postdoctoral researcher at Purdue and first author of the study.

The result was not fragility, but resilience born of a platform strengthened by complexity. What began as a limit-test became a new way to engineer strength: designing within disorder itself.

Why It Matters: Tough Jobs, Real Applications

The implications go far beyond the laboratory. By showing that disorder can be engineered, these MXenes open a new frontier in materials design.

Bulletin Board

Gossip

OCT. 10, 2025

Metallic, conductive, and dispersible in water, these MXenes endure where most materials fail. That resilience makes them candidates for the toughest jobs imaginable; from the vacuum of space to the crushing pressures of the deep ocean and the corrosive grind of electrochemical systems.

“We want to continue pushing the boundaries of what materials can do, especially in extreme environments where current materials fall short,” said Anasori.

Their tunable surfaces add another layer of promise. MXenes show exceptional sensitivity to gases such as oxygen, ammonia, and nitrogen dioxide. Their two-dimensional structure gives them high surface area, while their adjustable terminations make them unusually selective and responsive. Unlike graphene or MoS₂, MXenes can be tuned both from the surface down and, through entropy, from the lattice up.

Bigger Picture

While MXenes’ story is only just beginning, history has shown that new materials often reframe the boundaries of possibility. Bronze enabled early tools and weapons. Steel reshaped cities and industry. And silicon gave rise to the digital world. MXenes may represent the next step in that lineage.

What makes this chapter different is the principle at its core. In trying to break order, scientists found a new way to build without it. Entropy became the architect.

“This is exactly where AI will become an enabling technology,” said Anasori. “Guidance from computational science, machine learning and AI will be crucial for navigating the infinite sea of new materials, guiding their development and helping to select the structures and compositions with required properties for specific technologies.”

What that future will look like depends on how far high-entropy MXenes can be scaled, purified, and tailored to real-world needs, such as batteries that can endure extreme environments, sensors that can detect volatile and toxic gases, or materials able to survive where others have historically failed. Even if we don’t yet know what the future of MXenes holds, the lesson here is that purpose can be found in disorder, and strength can emerge from what looks like, at first glance, chaos.

Bulletin Board

Gossip

OCT. 10, 2025

This study was published in the journal Science.

New Atlas, 11 October 2025

<https://newatlas.com>

Have MOFs now made it?

2025-10-10

The 2025 Nobel prize in chemistry was awarded to Susumu Kitagawa at Kyoto University in Japan, Richard Robson at the University of Melbourne in Australia, and Omar Yaghi at the University of California, Berkeley in the US, 'for the development of metal-organic frameworks' (MOFs).

This Nobel has been predicted for a while. Research on MOFs has exploded since the 2010s and it seems like hardly a day goes by when there isn't a paper about a new designer porous material or a new problem that they can solve. From water and carbon dioxide capture, to filtration and storage of hazardous materials, and applications in catalysis, MOFs' tunable porosity and chemistry have made them a playground for materials design.

And it's not just academic research. A cursory look at patent data shows over 125,000 patents on these materials being filed – by companies and universities alike – from the early 2000s onwards, with significant acceleration from 2013 to around 2022.

Perhaps part of the reason the Nobel committee has chosen to recognise MOFs now is that they are slowly beginning to deliver some of their promised benefits in more commercial environments. Since 2023, BASF has partnered with Svante to produce a MOF material for carbon capture at multi-tonne scale. Similarly Nuada (formerly MOF Technologies) has ongoing trials of its carbon-capturing MOF at an energy-from-waste facility in the UK. And Numat has established itself as a producer of specialist filtration and storage materials, such as gas mask filters that can capture and destroy chemical warfare agents. Other companies are scaling up MOFs for use in wide-ranging applications including energy storage.

Scale-up of MOF production remains a challenge – in part because of their individuality. While there are aspects of MOF synthesis that are common across families of materials, changes to metals or linkers inevitably lead to their own challenges. Maintaining control of structure, porosity and performance is much harder at industrial scale than in the laboratory.

Bulletin Board

Gossip

OCT. 10, 2025

Unsurprisingly, given the vast array of potential structures and synthesis methods that exist, computational predictions and artificial intelligence are increasingly being applied to MOF research and design, attracting attention from tech giants like Meta to develop new tools and algorithms.

It has felt like MOFs have been on the verge of commercial breakthroughs for a number of years – perhaps this Nobel prize will help provide the impetus to accelerate these elegant materials to real-world impact.

Chemistry World, 10 October 2025

<https://chemistryworld.com>

Scientists transform 'forever chemicals' in water into fluoride with new process

2025-08-17

Scientists have developed a new method to break down harmful "forever chemicals" by exposing them to a sunlight-activated material.

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are chemicals found in many household products, including cookware, cosmetics, dental floss and waterproof clothing. True to their nickname, the chemicals take thousands of years to break down, enabling them to accumulate in the environment and our bodies.

PFAS have been used since the 1940s. Initially, they were valued for their nonstick properties, but now they are linked to a number of health impacts, including increased risks of autoimmune disease, developmental disorders, reduced fertility and cancer in humans. This has led some PFAS to be banned. But with nearly 15,000 types having been produced, roughly 98% of the U.S. population has these chemicals in their blood.

Now, a team of researchers has found a way to break down the chemicals, reducing them to components that include fluoride, which is harmless at low doses. They published their findings July 25 in the journal Small.

"PFAS contamination continues to pose a global health risk, and this research represents a critical step toward safer communities and cleaner ecosystems," lead researcher Cameron Shearer, a materials scientist at the University of Adelaide in Australia, said in a statement.

PFAS owe their persistence to their strong chemical bonds; they consist of a head (often charged oxygen molecules) linked to a tail of carbon and

Bulletin Board

Gossip

OCT. 10, 2025

fluorine atoms. For PFAS to degrade, this bond must be broken — but this process is very difficult to achieve using traditional methods.

“Many water contaminants are degraded by adding a reactive chemical that binds to the carbon,” Shearer said. “However, in PFAS molecules, the carbon atoms are protected in such a way that makes this process nearly impossible.”

In recent years, researchers have been developing methods to break down PFAS using materials called photocatalysts, which absorb incident light to speed up chemical reactions. The scientists behind the new study turned to a photocatalytic material called cadmium indium sulfide, known for its ability to release reactive oxygen species — or free radicals — after being exposed to visible light.

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Live Science, 17 August 2025

<https://livescience.com>

Composite metal foam endures over 1 million load cycles at 400°C and 600°C

2025-10-07

New research shows that composite metal foam (CMF) is incredibly resilient at high temperatures, able to withstand repeated heavy loads even at temperatures of 400°C and 600°C. Coupled with the material's high strength-to-weight ratio, the finding suggests that CMF could be used in applications ranging from automobile engines to aerospace components to nuclear power technologies.

“CMF has many attractive properties, which make it appealing for a wide range of applications,” says Afsaneh Rabiei, corresponding author of a paper on the work and a professor of mechanical and aerospace

Bulletin Board

Gossip

OCT. 10, 2025

engineering at North Carolina State University. “But if you want to use a material in engines, airplane parts or any application involving repeated loading and high temperatures, you need to know how the material will perform.

“This is important for any application, but particularly when equipment failure could affect public health and safety—such as jet engine vanes, ducts, and exhaust flaps; turbine blades; hypersonic vehicle airframes and hot trailing edges of wings; gas and steam turbines; automobile brake system components and internal combustion engine parts; nuclear reactor fuel cladding and many more structures that go in service under extreme conditions of heat and load.”

CMFs are foams that consist of hollow spheres—made of materials such as stainless steel, nickel, or other metals and alloys—embedded in a metallic matrix. The resulting material is both lightweight and remarkably strong at absorbing compressive forces, with potential applications ranging from aircraft wings to vehicle armor and body armor.

In addition, CMF is better at insulating against high heat than conventional metals and alloys, such as steel. The combination of light weight, strength and thermal insulation means that CMF also holds promise for use in storing and transporting nuclear material, hazardous materials, explosives and other heat-sensitive materials.

To see how CMF would perform under repeated stress at high temperatures, the researchers worked with NC State's Constructed Facilities Laboratory, which is designed to test materials and structures under extreme circumstances.

For this study, the researchers worked with CMFs consisting of steel spheres in a steel matrix. The CMF samples were put through a repeated cycle of loading while exposed to temperatures of 23°C (73°F), 400°C (752°F), and 600°C (1,112°F).

At 400°C, the CMF withstood a cycle of loading that alternated between 6 and 60 megapascals (or between 870 and 8,702 units of pound-force per square inch) for more than 1.3 million cycles without failure before the researchers halted the test due to time constraints.

At 600°C, the CMF withstood a cycle of loading that alternated between 4.6 and 46 megapascals (or between 667 and 6,671 units of pound-force per square inch) for more than 1.2 million cycles without failure before the researchers halted the test due to time constraints.

Bulletin Board

Gossip

OCT. 10, 2025

"Knowing that in a compression-compression fatigue setting, the fatigue life of solid stainless-steel decreases significantly as temperature increases from room temperature to 400°C and 600°C, these results were remarkable," Rabiei says. "Our findings indicate the fatigue life of the steel-steel CMF is not diminished and that this lightweight material performs tremendously well in the extreme environment of high temperature cyclic loading.

"This discovery is exciting, and we're open to working with industry partners who would like to explore potential applications for CMF. This work was done with an eye toward developing a material that could be used to improve safety and efficiency related to the shipping of hazardous materials, so that's one potential application. But these findings are also relevant to any application where equipment may be exposed to high loads and high temperatures."

The paper, "Performance of Composite Metal Foams Under Cyclic Loading at Elevated Temperatures," is published open access in the Journal of Materials Science. First author of the paper is Zubin Chacko, a recent Ph.D. graduate from NC State. The paper was co-authored by Gregory Lucier, a research professor at NC State and manager of the Constructed Facilities Laboratory.

Phys Org, 7 October 2025

<https://phys.org>

Biodegradable plastic made from bamboo is strong and easy to recycle

2025-10-07

Hard plastic made from bamboo is as strong and durable as conventional plastics for uses such as household appliances and car interiors, but is also recyclable and biodegrades easily in soil.

Plastics derived from biological matter, or bioplastics, are increasingly popular, but they still only make up around half a per cent of the more than 400 million tonnes of plastics produced each year. This is, in part, because bioplastics lack the mechanical strength of many oil-based plastics and also can't be easily used in common manufacturing processes.

Now, Dawei Zhao at Shenyang University of Chemical Technology in China and his colleagues have developed a way to produce plastic from cellulose

Bulletin Board

Gossip

OCT. 10, 2025

derived from bamboo, which can replicate or surpass the properties of many widely used plastics.

"Bamboo's rapid growth makes it a highly renewable resource, providing a sustainable alternative to traditional timber sources, but its current applications are still largely limited to more traditional woven products," says Zhao.

Zhao and his team first treated the bamboo by adding zinc chloride and a simple acid, which breaks down the strong chemical bonds and produces a soup of smaller cellulose molecules. They then added ethanol, which makes the cellulose molecules rearrange into a strong, solidified plastic.

The plastic's toughness is comparable to commonly used engineering plastics – strong plastics used in vehicles, appliances and construction, says Andrew Dove at the University of Birmingham, UK, who wasn't involved in the study.

something that's going to challenge the use of the main plastics we use in packaging, like polyethylene and polypropylene," says Dove. "But while it's targeting a smaller set of engineering plastics, it could still help alleviate some of the sourcing concerns of the incumbent [plastics] in that area."

Although it isn't as cheap as some of the most commonly used plastics, Zhao and his team found that it can be completely recycled while keeping 90 per cent of its original strength, which could make it more economically attractive. They also report that it is biodegradable within 50 days, although this claim has failed to stand up to scrutiny for other biodegradable plastics.

New Scientist, 7 October 2025

<https://newscientist.com>

Direct signal analysis helps solve 50-year-old problem in molecular fluorescence analysis

2025-10-08

Last year, we celebrated 50 years since the first papers on fluorescence correlation spectroscopy (FCS) were published. It wasn't a wild celebration with masses on the streets, nor was it widely celebrated in universities, but rather a quiet admiration by people in the field for one of the cornerstone methods that has advanced our understanding of many processes at the molecular scale.

Bulletin Board

Gossip

OCT. 10, 2025

FCS began to shine with the availability of confocal microscopes in the 1990s and has since been actively used to study chemical reactions, formation of aggregates, molecular movements in cells, and attachment of molecules to membranes, to name a few applications.

By examining all these processes at the molecular scale, it becomes possible to study many aspects of physiology and material science at the single-molecule level. Through deep understanding of these processes, researchers can design drugs, discover new intracellular interactions, and advance materials in ways that would otherwise be impossible or very difficult.

New breakthrough from Estonian scientists

Recently, a team of Estonian scientists from the Laboratory of Systems Biology (Department of Cybernetics, TalTech) published a study that may revolutionize how we analyze FCS measurements and address one of the major weaknesses in this approach. They used powerful computational tools originally built for artificial intelligence, but instead of relying on AI's "black box" methods, they applied these tools to optimize transparent, physics-based models. Their study is published in the journal *Science Advances*.

To explain what has been accomplished and why it matters, we first need to cover the basics of FCS. At its core, FCS works by recording data from a very small volume—around a femtoliter (one quadrillionth of a liter, a smallest grain of sand in an Olympic swimming pool).

In its classical form, FCS uses a confocal microscope to make such a small measurement volume possible. In a confocal microscope, a laser is focused on the sample, whether it's a cell or other object, and the signal is collected only from the very small volume at the laser's focus. FCS is applied when we have very few molecules in this volume that can fluoresce—a property that allows certain molecules to emit light when excited by photons.

With so few molecules, the signal becomes very noisy. However, it's possible to associate increases in the signal with either molecules arriving in the volume, changing through chemical reactions, or sticking to surfaces. In principle, anything that changes the fluorescence in that volume can be associated with some physical process, like movement or reaction, can be studied.

Bulletin Board

Gossip

OCT. 10, 2025

How does FCS work?

To build intuition about FCS signal processing, imagine you want to learn whether one cashier in a shop works faster than another. One option is to let only one of them work and see how quickly they can process a long queue of customers. Unfortunately, while simple, this experiment would result in a rather large group of unhappy customers. The alternative is to have both cashiers work during quiet periods when there are few customers, and record when each customer arrives at the checkout point and leaves.

By focusing on just the small space around each cashier, you can determine the average time for processing a customer and whether these cashiers work at different speeds. This is essentially what FCS does with molecules: by tracking when fluorescence signals increase (molecules entering the observation volume) and decrease (molecules leaving), FCS can derive the corresponding molecular properties, such as how fast they move.

Autocorrelation and its statistical problem

While we can track customers fairly easily, working at the molecular level creates immediate problems due to poor signal quality. Molecules don't always emit photons, many photons get missed, and unwanted signals can interfere—making the data very noisy. To work around this, FCS measures rapidly (every microsecond) and repeatedly, collecting lots of data to analyze. It turns out that one very useful way to extract something analyzable from such a noisy signal is to calculate the signal's autocorrelation.

Essentially, autocorrelation tells you the chances of seeing an elevated signal after some time when you observe a spike in fluorescence. Indeed, if a large, slow-moving molecule enters the observation volume, the signal stays elevated until that molecule wanders away. By analyzing these autocorrelations, we can determine how fast molecules move.

Over the years, FCS development has taught us how to read autocorrelations like a fingerprint—they reveal whether we're seeing simple molecular movement, chemical reactions, particles of different sizes, or particles that interact with each other. However, there's a major problem with how we analyze these autocorrelations. The issue is statistical: since all the autocorrelation values come from the same single experiment, they're not truly independent measurements.

Bulletin Board

Gossip

OCT. 10, 2025

To understand this, imagine taking one day's temperature measurements every minute and asking: "How similar is the temperature now to what it was 1 hour ago? 2 hours ago? 4 hours ago?" Each comparison tells you something real about temperature patterns—the pattern would even reveal whether it was a sunny day or cloudy. But because all these similarity measurements come from the same temperature dataset, they're not statistically independent.

As a result, you can't properly assess the reliability of your conclusions—you might think you have strong evidence for a weather pattern, but you really just have one day's data analyzed in multiple ways. Similarly, in FCS, while each autocorrelation value at different time delays reveals genuine information about molecular behavior, they're all calculated from overlapping portions of the same fluorescence data.

Uncomfortable choices

To analyze these autocorrelations correctly, as demonstrated by several research groups, experiments would have to be much longer than is practical or even possible. Experimental time is ultimately limited by the amount of laser exposure your cell or other object can handle, and for living cells, this time is quite limited. This creates an uncomfortable choice: use FCS incorrectly or don't study the system at all.

About six years ago, a research group in the U.S. proposed an alternative approach: dropping autocorrelation from the analysis and using mathematical models that work directly with the noisy experimental data to extract the same information as from FCS. Their goal was to shorten experimental time by requiring less data. Like many others, the Estonian team was very interested in this approach and wanted to apply it to study molecular movement in heart muscle cells.

However, it turned out that the original implementation was very slow and, unexpectedly, was quite sensitive to initial guesses about key properties, such as a researcher's estimate of how bright the molecule is. This sensitivity could result in arriving at incorrect answers or failing to find any answer at all. So, while the idea of directly analyzing noisy FCS data was very attractive—particularly since it would also avoid the statistical data handling issues that plague traditional FCS—there were many practical issues with applying it.

Bulletin Board

Gossip

OCT. 10, 2025

FITSA required several times less data than FCS

In their recent study, the Estonian group published a new method based on the same idea as proposed earlier—directly analyzing the fluorescence signal—but overcoming many issues encountered in the earlier implementation. They demonstrated that the new method—fluorescence intensity trace statistical analysis (FITSA)—is very robust and doesn't require precise knowledge of molecular properties before the experiment.

Particularly interesting is the quantitative analysis of how much less data is needed to estimate molecular properties using FITSA versus classical FCS. Even when using FCS in its incorrect mode, FITSA required several times less data than FCS. When comparing with FCS as it should be properly applied, the differences become staggering: FITSA requires 300 to 21,000 times less data than FCS. Due to such huge differences, FITSA opens new opportunities to study these processes with scientific rigor not possible before.

The researchers envision that FITSA and methods based on similar approaches will replace classical FCS analysis pipelines in all their applications in life and materials science. Currently, there are still many practical problems to solve, but what FITSA has demonstrated is that there's a major advantage in direct analysis of experimental data. With further advances, it will allow us to study molecular environments and molecular interactions in a much more precise manner.

The implications could be transformative: imagine being able to follow how drugs interact with diseased cells with unprecedented precision, or rapidly screening thousands of potential new medicines by observing their molecular behavior in living cells. FITSA could enable researchers to study cellular processes that require prohibitively long experiments, potentially revolutionizing our understanding of everything from heart diseases to the development of advanced materials.

Phys Org, 8 October 2025

<https://phys.org>

Bulletin Board

Curiosities

OCT. 10, 2025

Tiny Sensors Rapidly Detect “Forever Chemicals” in Water

2025-09-26

The new portable test has the potential to distinguish different PFAS chemicals, including those on which the US Environmental Protection Agency recently put new limits.

They linger in our water, our blood, and the environment—“forever chemicals” that are notoriously difficult to detect.

But researchers at the UChicago Pritzker School of Molecular Engineering (UChicago PME) and Argonne National Laboratory have collaborated to develop a novel method to detect miniscule levels of per- and polyfluoroalkyl substances (PFAS) in water. The method, which they plan to share via a portable, handheld device, uses unique probes to quantify levels of PFAS “forever chemicals,” some of which are toxic to humans.

“Existing methods to measure levels of these contaminants can take weeks, and require state-of-the-art equipment and expertise,” said Junhong Chen, Crown Family Professor at the UChicago Pritzker School of Molecular Engineering and Lead Water Strategist at Argonne National Laboratory. “Our new sensor device can measure these contaminants in just minutes.”

The technology, described in the journal *Nature Water*, can detect PFAS present at 250 parts per quadrillion (ppq) – like one grain of sand in an Olympic-sized swimming pool. That gives the test utility in monitoring drinking water for two of the most toxic PFAS—perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS)—for which the U.S. Environmental Protection Agency (EPA) recently proposed limits of 4 parts per trillion.

“PFAS detection and elimination is a pressing environmental and public health challenge,” said Andrew Ferguson, Professor of Molecular Engineering at UChicago PME. “Computer simulations and machine learning have proven to be an incredibly powerful tool to understand how these molecules bind to molecular sensors and can guide experimental efforts to engineer more sensitive and selective molecular probes.”

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Bulletin Board

Curiosities

OCT. 10, 2025

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A detection challenge

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In recent years, studies have linked PFAS to health concerns, including cancers, thyroid problems and weakened immune systems. In light of some of these findings, the EPA proposed the new limits for PFOS and PFOA.

“The problem with enforcing these limits is that it’s very challenging and time-consuming to detect PFAS,” said Chen. “You currently can’t just take a sample of water and test it at home.”

The gold standard for measuring PFAS levels is an expensive laboratory test known as liquid chromatography/tandem mass spectrometry, which separates chemical compounds and provides information on each one.

Researchers attempting to make their own faster and cheaper PFAS tests face a few challenges: for one thing, PFAS chemicals are often present in water at much lower concentrations than dozens of other, more common contaminants. In addition, there are thousands of different PFAS chemicals with only slight variations between their chemical structures—but important differences in their health effects and regulations.

But Chen’s team has been developing highly sensitive, portable sensors on computer chips for the last fifteen years. Chen is already using the technology in a lead sensor for tap water, and his lab group suspected that the same method could be used in PFAS sensing. Their proposal to adapt the technology for PFAS became part of the National Science Foundation Water Innovation Engine in the Great Lakes.

Designed by AI

The gist of Chen’s sensor is that if a PFAS molecule attaches to his device, it changes the electrical conductivity that flows across the surface of the silicon chip. But he and his colleagues had to figure out how to make each sensor highly specific for just one PFAS chemical—such as PFOS.

Bulletin Board

Curiosities

OCT. 10, 2025

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“In this context, machine learning is a tool that can quickly sort through countless chemical probes and predict which ones are the top candidates for binding to each PFAS,” said Chen.

In the new paper, the team showed that one of these computationally-predicted probes does indeed selectively bind to PFOS—even when other chemicals common in tap water are present at much higher levels. When water containing PFOS flows through their device, the chemical binds to the new probe and changes the electrical conductivity of the chip. How much the conductivity changes depends on the level of PFOS.

To ensure that the readings from the new device were correct, the team collaborated with EPA and used EPA-approved liquid chromatography/tandem mass spectrometry methods to confirm concentrations and verified that the levels were in line with what the new device detected. The team further showed that the sensor could maintain its accuracy even after many cycles of detection and rinsing, suggesting the potential for real-time monitoring.

“Our next step is to predict and synthesize new probes for other, different PFAS chemicals and show how this can be scaled up,” says Chen. “From there, there are many possibilities about what else we can sense with this same approach— everything from chemicals in drinking water to antibiotics and viruses in wastewater.”

The end result may eventually be that consumers can test their own water and make better choices about their environment and what they consume.

Technology Networks, 26 September 2025

<https://technologynetworks.com>

Bulletin Board

Curiosities

OCT. 10, 2025

Century-Old Mystery Solved: Scientists Measure a Fraction of an Electron, Unlocking the Secret to Catalysis

2025-10-07

The discovery could significantly reduce the production costs of fuels, chemicals, and materials.

A research team from the University of Minnesota Twin Cities College of Science and Engineering and the University of Houston's Cullen College of Engineering has identified, and for the first time measured, the tiny fraction of an electron that enables catalytic manufacturing.

Details of the work appear in the open access journal ACS Central Science. The results clarify why precious metals such as gold, silver and platinum are so effective in catalysis and offer guidance for creating next-generation catalytic materials.

Catalysts are substances that lower the energy needed for chemical reactions. By doing so, they help manufacturers increase yield, speed, and efficiency when making other materials. These tools are central to processes used in pharmaceutical and battery production, and in petrochemical operations such as crude oil refining, helping supply keep pace with demand.

Finding catalysts that work faster and are easier to control is a primary objective across the fuels, chemicals, and materials sectors, which together represent economies worth multiple trillions of dollars. Around the world, researchers are racing to develop catalysts that can reduce costs and improve manufacturing efficiency across many industries.

Understanding How Molecules Interact with Catalysts

As molecules approach a catalyst surface, they share their electrons with the catalytic metal (in this case, gold, silver, or platinum), thus stabilizing the molecules in such a way that the desired reactions occur. This concept has been theorized for over a century, but direct measurements of these tiny, highly consequential percentages of an electron have never been directly observed.

Researchers at the Center for Programmable Energy Catalysis, headquartered at the University of Minnesota, have now shown that electron sharing can be directly measured by a technique of their own invention called Isopotential Electron Titration (IET).

Bulletin Board

Curiosities

OCT. 10, 2025

“Measuring fractions of an electron at these incredibly small scales provides the clearest view yet of the behavior of molecules on catalysts,” said Justin Hopkins, University of Minnesota chemical engineering Ph.D. student and lead author of the research study. “Historically, catalyst engineers relied on more indirect measurements at idealized conditions to understand molecules on surfaces. Instead, this new measurement method provides a tangible description of surface bonding at catalytically-relevant conditions.”

Determining the amount of electron transfer at a catalyst surface is key to understanding its performance. Molecules that are more prone to sharing their electrons bind stronger, with increasing reactivity, providing a directly measurable quantity for catalyst activity. Precious metals exhibit the precise extent of electron sharing with reacting molecules necessary to drive catalysis, even though this exchange has not been possible to directly measure until today.

The Power of Isopotential Electron Titration (IET)

IET can now serve as a tool for experimental description of new catalyst formulations, which will enable researchers to screen for and discover ideal catalytic substances more quickly going forward.

“IET allowed us to measure the fraction of an electron that is shared with a catalyst surface at levels even less than one percent, such as the case of a hydrogen atom on platinum,” said Omar Abdelrahman, corresponding author and an associate professor in University of Houston Cullen College of Engineering’s William A. Brookshire Department of Chemical and Biomolecular Engineering. “A hydrogen atom gives up only 0.2% of an electron when binding on platinum catalysts, but it’s that small percentage which makes it possible for hydrogen to react in industrial chemical manufacturing.”

With the emergence of nanotechnologies for synthesizing catalysts combined with new tools in machine learning to explore and utilize large datasets, engineers have identified large numbers of new catalytic materials. IET now enables a third method for directly characterizing new materials at a fundamental level.

“The foundation for new catalytic technologies for industry has always been fundamental basic research,” says Paul Dauenhauer, Distinguished Professor and director of the Center for Programmable Energy Catalysis at the University of Minnesota. “This new discovery of fractional electron distribution establishes an entirely new scientific foundation

Bulletin Board

Curiosities

OCT. 10, 2025

for understanding catalysts that we believe will drive new energy technologies over the next several decades.”

Sci Tech Daily, 7 October 2025

<https://scitechdaily.com>

Artificial Intelligence Helps Chemists Develop Tough New Polymers

3035-09-23

Everyday items like car tires, plastic bags and foam cushions come from materials called polymers that can take years to develop and test. Researchers at Carnegie Mellon University and the University of North Carolina at Chapel Hill have developed a new approach to create better rubber-like materials more quickly by combining artificial intelligence with human expertise.

Typically when researchers make a material stronger, it becomes less flexible, while flexible materials tend to be weaker. To fix this problem, the team created a machine learning model that works in tandem with human chemists. Machine learning — a subset of AI research — involves teaching an artificial intelligence to perform a specific task. In one experiment, the researchers collaborated with the AI tool to create a polymer that is both strong and flexible.

“There are so many applications for polymers: construction, car parts, footwear, moldings, coatings,” said Olexandr (Oles) Isayev, Carl and Amy Jones Professor in Interdisciplinary Science. “Whenever you make one for a specific application, it needs certain properties, and it can’t usually withstand force and expand at the same time. These new materials have excellent properties. They can do both.”

The group input the properties it wanted in a polymer into the design tool. Then, the model suggested a series of experiments that UNC-Chapel Hill chemists conducted using automated science tools. The researchers tested the produced materials and provided feedback to the model, so it could make adjustments.

“The AI system suggests an experiment, and after the experiment’s been made, we measure the properties, and we iterate,” Isayev said. “You can dynamically adjust and help the machine navigate to find materials with the desired properties.”

Bulletin Board

Curiosities

OCT. 10, 2025

Frank Leibfarth, professor of chemistry at UNC-Chapel Hill, said working in this new way was a breath of fresh air.

“In our human-augmented approach, we were interacting with the model, not just taking directions,” Leibfarth said. “This allowed us to combine the best aspects of human- and machine-guided processes to come to the optimal solution.”

Leibfarth also said he was excited for the potential applications for the polymer.

“Materials like this could be used in running shoes, medical devices like 3D printed dental implants, and durable parts for cars,” Leibfarth said.

“We’re at this really interesting time in chemistry and chemical engineering of finding out what’s the best strategy to go after the next great material,” said Dylan Anstine, a former postdoctoral fellow in Carnegie Mellon’s Department of Chemistry, who is now an assistant professor of chemical engineering and materials science at Michigan State University. “It’s clear that’s going to involve expert experimental chemists and expert computational chemists using the best data science tools we can. We were really teasing apart what that relationship looks like.”

The machine learning model also saved the researchers significant time and money by ruling out methods and chemicals that would not work. The researchers have made the program open source, so any lab can have access to this tool. If adopted in other labs, the tool could reduce the cost and time required for other discoveries.

This approach could accelerate the development of advanced materials for medical devices, footwear and electronics. By combining AI predictions with human expertise, the researchers hope they can solve complex materials challenges more effectively.

Technology Networks, 23 September 2025

<https://technologynetworks.com>

Q&A: Exploring metal-organic frameworks (MOFs) with chemist

2025-10-09

This year’s Nobel Prize in Chemistry was awarded to three researchers, including University at Albany alum Omar Yaghi, for their work on developing metal-organic frameworks (MOFs)—versatile molecular

Bulletin Board

Curiosities

OCT. 10, 2025

materials that can be used to harvest water from desert air, capture carbon dioxide, store toxic gases and even catalyze chemical reactions.

UAlbany’s Jeremy Feldblyum, associate professor of chemistry and director of graduate studies, is an expert in metal-organic frameworks, which he has been dedicated to studying for two decades.

While undertaking his Ph.D. at the University of Michigan, Feldblyum worked with Adam Matzger, who collaborated with Omar Yaghi and co-discovered methods to make metal-free framework materials that now show promise for applications in semiconductors and batteries, among other areas of science and technology.

Taking inspiration from his graduate and postdoctoral research, Feldblyum has explored ways to transform metal-organic frameworks into durable, high-performance materials for clean energy and sustainability. His team has looked at MOFs that can store electrical charge, conduct ions and selectively recover critical elements like lithium from battery waste. Uncovering how these materials function at the molecular level could lead to smarter, more sustainable solutions for energy storage, recycling and environmental protection.

We caught up with Feldblyum to learn about the importance of advancing research on metal-organic frameworks, his own work in this area, and the significance of this year’s Nobel nod to researchers working in this field.

What are metal-organic frameworks (MOFs)?

Metal-organic frameworks are solids whose chemical structures resemble the steel frameworks from which skyscrapers are built. Much like those frames, MOFs serve as “blank slate” materials that can be customized for myriad functions ranging from purifying water to mimicking the chemistry performed by enzymes in our bodies.

How did you become interested in working on metal-organic frameworks?

I stumbled upon this area by chance. When I was a graduate student at the University of Michigan, I had an interest in solar cells but to fulfill some administrative requirements, I also needed to work in an area related to polymers. It just so happened that there was space in the laboratory of Adam Matzger, a pioneering figure in MOFs who worked with Yaghi during the early years of the development of these materials. After joining the lab, I was hooked. There is an artistry to making MOFs that I adore, and they hold tremendous potential for benefiting humanity.

Bulletin Board

Curiosities

OCT. 10, 2025

What are the most promising applications for this technology?

Fundamentally, there isn't an area of science or technology where MOFs would be unable to play a role. The most promising directions are those where MOFs provide unparalleled advantages: energy-efficient separations and separations of rare and critical minerals, high-performance energy storage devices (for example, for those used in aeronautics and space), and medicine (drug delivery in particular).

What are you studying now?

Our lab examines many aspects of energy and materials security. Our work in MOFs focuses primarily on improving the battery supply chain and enabling fine chemical purification that has proven prohibitively difficult by other means. However, the interests in our research group are broad, and we are now exploring avenues ranging from food (for example, using these materials to alter food texture or deliver vitamins), to new phases of matter where MOFs can play a key role.

What does it mean to you for this research area to be recognized by a Nobel Prize?

When I began my graduate studies, I could not have conceived of just how ubiquitous MOFs would be in the scientific landscape. I am proud that I was able to make unique contributions in understanding MOF structure and behavior and am honored to be able to work in such an important field that has strong potential to impact our daily lives.

What excites you most about the future of this research area?

The future of MOFs is as limitless as the future of chemistry itself. I am constantly surprised by the new and innovative ways that scientists deploy these materials, and expect many more unexpected discoveries for using MOFs in ways that have yet to be demonstrated. These materials have the potential to improve the way we work with energy, materials and pharmaceuticals.

Thinking big picture, it is inspiring to consider the ways that science builds over time, including the scientific challenges that scientists had to overcome to get to where we are with metal-organic frameworks today. The awardees of this year's Nobel Prize in Chemistry—Susumu Kitagawa, Richard Robson and Omar Yaghi—pioneered many of the fundamental concepts chemists used to make and study MOFs.

Bulletin Board

Curiosities

OCT. 10, 2025

Robson was the first to recognize how coordination chemistry—the field of chemistry concerned with reactivity between metal- and carbon-based species—could be used to rationally design and form three-dimensional MOFs from deliberately selected chemical building blocks. Kitagawa was among the first to show that the space within MOFs could be emptied without destroying the material, paving the way for their use in applications ranging from batteries to pollutant removal. Yaghi developed straightforward and robust methods to make MOFs that enabled their use by scientists and engineers in other fields. With his contributions, discoveries have been made in areas ranging from conductive MOFs to MOFs that find use in quantum computing.

Together, this work is laying the foundation for transformational advances in technologies for climate resiliency, biomedical breakthroughs and new enhanced materials for public good.

Phys Org, 9 October 2025

<https://phys.org>

Tiny Sensors Rapidly Detect “Forever Chemicals” in Water

2025-09-26

The new portable test has the potential to distinguish different PFAS chemicals, including those on which the US Environmental Protection Agency recently put new limits.

They linger in our water, our blood, and the environment—“forever chemicals” that are notoriously difficult to detect.

But researchers at the UChicago Pritzker School of Molecular Engineering (UChicago PME) and Argonne National Laboratory have collaborated to develop a novel method to detect miniscule levels of per- and polyfluoroalkyl substances (PFAS) in water. The method, which they plan to share via a portable, handheld device, uses unique probes to quantify levels of PFAS “forever chemicals,” some of which are toxic to humans.

“Existing methods to measure levels of these contaminants can take weeks, and require state-of-the-art equipment and expertise,” said Junhong Chen, Crown Family Professor at the UChicago Pritzker School of Molecular Engineering and Lead Water Strategist at Argonne National Laboratory. “Our new sensor device can measure these contaminants in just minutes.”

Bulletin Board

Curiosities

OCT. 10, 2025

The technology, described in the journal *Nature Water*, can detect PFAS present at 250 parts per quadrillion (ppq) – like one grain of sand in an Olympic-sized swimming pool. That gives the test utility in monitoring drinking water for two of the most toxic PFAS—perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS)—for which the U.S. Environmental Protection Agency (EPA) recently proposed limits of 4 parts per trillion.

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“Even though they are typically present at miniscule concentrations, PFAS do have certain molecular characteristics that differentiate them from other things dissolved in water, and our probes are designed to recognize those features,” said Seth Darling, a Senior Scientist at both Argonne and UChicago.

A detection challenge

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In recent years, studies have linked PFAS to health concerns, including cancers, thyroid problems and weakened immune systems. In light of some of these findings, the EPA proposed the new limits for PFOS and PFOA.

“The problem with enforcing these limits is that it’s very challenging and time-consuming to detect PFAS,” said Chen. “You currently can’t just take a sample of water and test it at home.”

The gold standard for measuring PFAS levels is an expensive laboratory test known as liquid chromatography/tandem mass spectrometry, which separates chemical compounds and provides information on each one.

Researchers attempting to make their own faster and cheaper PFAS tests face a few challenges: for one thing, PFAS chemicals are often present in

Bulletin Board

Curiosities

OCT. 10, 2025

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To do this, Chen, Ferguson, Darling, and team turned to machine learning to help select unique probes that could sit on the sensing device and ideally bind only the PFAS of interest. In 2021, they won a Discovery Challenge Award from the UChicago Center for Data and Computing (CDAC) to support their use of artificial intelligence in designing PFAS probes.

“In this context, machine learning is a tool that can quickly sort through countless chemical probes and predict which ones are the top candidates for binding to each PFAS,” said Chen.

In the new paper, the team showed that one of these computationally-predicted probes does indeed selectively bind to PFOS—even when other chemicals common in tap water are present at much higher levels. When water containing PFOS flows through their device, the chemical binds to the new probe and changes the electrical conductivity of the chip. How much the conductivity changes depends on the level of PFOS.

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Bulletin Board

Curiosities

OCT. 10, 2025

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Technology Networks, 26 September 2025

<https://technologynetworks.com>

Explainer: why have metal–organic frameworks won the Nobel prize in chemistry?

2025-10-09

Infinite 3D polymers with precision porosity have opened up new horizons for chemistry. Here’s why this year’s Nobel prize looks at inner space

The 2025 Nobel prize in chemistry has been awarded to Susumu Kitagawa, at Kyoto University in Japan, Richard Robson, at the University of Melbourne in Australia, and Omar Yaghi, at the University of California, Berkeley in the US for their work on metal–organic frameworks (often called MOFs).

But what is a MOF? And what did the winners actually do? Here are the answers to some of the key questions about this year’s prize.

What is a metal–organic framework?

Metal–organic frameworks are materials in which metal ions are linked together by organic molecules in a regular repeating pattern to create a 3D network. Importantly, in the space between the metal nodes and the molecules that link them, there are large cavities that make the materials highly porous – speaking to Chemistry World back in 2017, Yaghi explained that just one gram of a MOF could have an internal surface area roughly equal to two American football fields.

This makes MOFs even more absorbent than other porous materials like zeolites and mesoporous silica. And it’s this feature that gives rise to the majority of MOFs’ most important applications.

Bulletin Board

Curiosities

OCT. 10, 2025

By using different metals and changing the type and length of the organic linkers, MOFs’ structures can be tuned to make the pores bigger or smaller, or to incorporate different functional groups, that will make the MOF better at binding specific guest molecules. This means that they can be optimised for use in things like gas storage, or various forms of filtration, or in carbon capture. The pores can also be designed to promote certain types of chemistry, meaning that MOFs have also found uses in catalysis, electrochemistry and fluorescence-based imaging.

Why are MOFs worthy of a Nobel prize?

During the Nobel announcement, the chair of the Nobel Committee for Chemistry, Heiner Linke, described MOFs’ ‘enormous potential’ that could unlock ‘previously unforeseen opportunities for custom-made materials with new functions’.

Robson’s first MOF was synthesised in 1989 (though he called them ‘coordination polymers’ or ‘infinite polymeric frameworks’), while Yaghi and Kitagawa’s work in the following years helped to define and develop the core concept. Since then, the field has exploded – in the early 2000s, just a few dozen research papers on MOFs were published each year; last year there were almost 10,000. And thousands of new MOF structures are reported each year, with over 100,000 reported to date. With this intensive research effort, numerous companies have been established seeking to commercialise MOFs for many different uses.

From a fundamental point of view, MOFs also represented a conceptual shift in terms of the way chemists design new materials. Rather than just tinkering with individual groups on a molecule, or linking them linearly to form polymers, MOFs offer the ability to controllably create a much larger extended and open 3D structure to optimise it for particular functions.

What did the laureates do?

In the 1980s, Robson decided to try to create a larger, synthetic variant of diamond’s famous network structure. Instead of tetrahedrally linked carbon atoms, Robson would use copper ions and an organic molecule with four ‘arms’. In an interview in 2019, he recalled that, at the time, most chemists would have thought that this mixture would have produced a ‘tangled bird’s nest’.

But Robson’s experiment worked, producing a regular, repeating crystalline structure – just as he’d predicted. When Robson and his collaborator Bernard Hoskins published their findings they described the

Bulletin Board

Curiosities

OCT. 10, 2025

material as 'the first example of a deliberately designed and constructed infinite framework'.

Robson realised that that many, many more variants could be made using this design principle.

In the years that followed, Yaghi and Kitagawa made key contributions that helped to define this new area of chemistry and explored how these materials could be of real practical use.

In 1995, Yaghi coined the term 'metal-organic framework' when reporting on a new MOF, based on cobalt and carboxylate linkers, that could selectively bind pyridine molecules. He showed that the material was highly stable and capable of adsorbing, releasing and recapturing the guest molecules over multiple cycles.

In 1999, Yaghi unveiled what is now one of the most famous materials in the field: MOF-5. The team estimated the internal surface area of this zinc-based MOF at an enormous 2900m² per gram of material. Key studies after this showed how families of MOFs could be rationally designed to fine-tune the size of their pores. Yaghi called this approach 'reticular chemistry'.

Kitagawa's major breakthroughs also came during the 1990s. In 1997 he designed MOF materials based on cobalt, nickel and zinc, that were intersected by open channels. These materials could absorb and release gases like methane, nitrogen and oxygen, without losing their structure.

Kitagawa also developed flexible MOFs, dynamic materials that could change their structures and offer new functionality in response to pressure, temperature and light.

What are MOFs used for?

Applications for MOFs have become apparent over the last two decades. For example, Yaghi's group has developed materials that selectively bind water molecules, enabling them to capture moisture from the desert air. Their ability to bind small gas molecules has also seen MOFs researched heavily for use in gas storage and carbon dioxide capture. Other groups have sought to use MOFs to capture per- and polyfluoralkyl substances from contaminated water.

They've also inspired other, more esoteric, projects including these incredible origami MOFs and beautiful designs that resemble mosaics from the Alhambra Palace.

Bulletin Board

Curiosities

OCT. 10, 2025

A number of companies are now commercialising MOFs. In 2016, a UK company called MOF Technologies, now called Nuada, unveiled a product designed to prolong the life of fruit and vegetables by storing and slowly releasing a compound that regulates plant growth. That same year, US start-up NuMat launched a line of gas cylinders that use MOFs to safely store toxic gases that are used in the electronics industry.

Perhaps one of the biggest success stories is the CALF-20 MOF, which has been commercialised by the Canadian firm Svante in its carbon capture technology. This MOF can strip carbon dioxide from the waste gases in flues of industrial facilities.

The US tech giant Meta recently trained an AI on 15,000 known MOF structures to try to develop new materials that could capture carbon even more efficiently. That's an approach that Yaghi also believes will make it easier to find the best MOFs for different applications, having recently told Nature that 'by using LLMs and AI tools, we can speed up discovery from years to weeks'.

Chemistry World, 9 October 2025

<https://chemistryworld.com>

Century-Old Mystery Solved: Scientists Measure a Fraction of an Electron, Unlocking the Secret to Catalysis

2025-10-07

The discovery could significantly reduce the production costs of fuels, chemicals, and materials.

A research team from the University of Minnesota Twin Cities College of Science and Engineering and the University of Houston's Cullen College of Engineering has identified, and for the first time measured, the tiny fraction of an electron that enables catalytic manufacturing.

Details of the work appear in the open access journal ACS Central Science. The results clarify why precious metals such as gold, silver and platinum are so effective in catalysis and offer guidance for creating next-generation catalytic materials.

Catalysts are substances that lower the energy needed for chemical reactions. By doing so, they help manufacturers increase yield, speed, and efficiency when making other materials. These tools are central

Bulletin Board

Curiosities

OCT. 10, 2025

to processes used in pharmaceutical and battery production, and in petrochemical operations such as crude oil refining, helping supply keep pace with demand.

Finding catalysts that work faster and are easier to control is a primary objective across the fuels, chemicals, and materials sectors, which together represent economies worth multiple trillions of dollars. Around the world, researchers are racing to develop catalysts that can reduce costs and improve manufacturing efficiency across many industries.

Understanding How Molecules Interact with Catalysts

As molecules approach a catalyst surface, they share their electrons with the catalytic metal (in this case, gold, silver, or platinum), thus stabilizing the molecules in such a way that the desired reactions occur. This concept has been theorized for over a century, but direct measurements of these tiny, highly consequential percentages of an electron have never been directly observed.

Researchers at the Center for Programmable Energy Catalysis, headquartered at the University of Minnesota, have now shown that electron sharing can be directly measured by a technique of their own invention called Isopotential Electron Titration (IET).

“Measuring fractions of an electron at these incredibly small scales provides the clearest view yet of the behavior of molecules on catalysts,” said Justin Hopkins, University of Minnesota chemical engineering Ph.D. student and lead author of the research study. “Historically, catalyst engineers relied on more indirect measurements at idealized conditions to understand molecules on surfaces. Instead, this new measurement method provides a tangible description of surface bonding at catalytically-relevant conditions.”

Determining the amount of electron transfer at a catalyst surface is key to understanding its performance. Molecules that are more prone to sharing their electrons bind stronger, with increasing reactivity, providing a directly measurable quantity for catalyst activity. Precious metals exhibit the precise extent of electron sharing with reacting molecules necessary to drive catalysis, even though this exchange has not been possible to directly measure until today.

Bulletin Board

Curiosities

OCT. 10, 2025

The Power of Isopotential Electron Titration (IET)

IET can now serve as a tool for experimental description of new catalyst formulations, which will enable researchers to screen for and discover ideal catalytic substances more quickly going forward.

“IET allowed us to measure the fraction of an electron that is shared with a catalyst surface at levels even less than one percent, such as the case of a hydrogen atom on platinum,” said Omar Abdelrahman, corresponding author and an associate professor in University of Houston Cullen College of Engineering’s William A. Brookshire Department of Chemical and Biomolecular Engineering. “A hydrogen atom gives up only 0.2% of an electron when binding on platinum catalysts, but it’s that small percentage which makes it possible for hydrogen to react in industrial chemical manufacturing.”

With the emergence of nanotechnologies for synthesizing catalysts combined with new tools in machine learning to explore and utilize large datasets, engineers have identified large numbers of new catalytic materials. IET now enables a third method for directly characterizing new materials at a fundamental level.

“The foundation for new catalytic technologies for industry has always been fundamental basic research,” says Paul Dauenhauer, Distinguished Professor and director of the Center for Programmable Energy Catalysis at the University of Minnesota. “This new discovery of fractional electron distribution establishes an entirely new scientific foundation for understanding catalysts that we believe will drive new energy technologies over the next several decades.”

Sci Tech Daily, 7 October 2025

<https://scitechdaily.com>

Splitting water: How order and disorder direct chemical reactivity

2025-10-07

In nature, the behavior of systems—whether large or small—is always governed by a few fundamental principles. For instance, objects fall downward because it minimizes their energy. At the same time, order and disorder are key variables that also shape physical processes. Systems—especially our homes—tend to become increasingly disordered over time.

Bulletin Board

Curiosities

OCT. 10, 2025

Even at the microscopic level, systems tend to favor increased disorder, a phenomenon known as an increase in so-called entropy.

These two variables—energy and entropy—play an important role in chemical processes. Processes occur automatically when energy can be reduced or entropy (disorder) increases.

Under standard conditions—such as in a glass of water—water autodissociation is hindered by both factors, making it a highly unlikely event. However, when strong electric fields are applied, the process can be dramatically accelerated.

Now, researchers at the Max Planck Institute for Polymer Research and the Yusuf Hamied Department of Chemistry at the University of Cambridge have uncovered a surprising mechanism that governs water autodissociation in such intense fields.

Their findings, published in the *Journal of the American Chemical Society*, challenge the traditional view that this reaction is mainly driven by energy considerations.

“Water autodissociation has been extensively studied in bulk conditions, where it’s understood to be energetically uphill and entropically hindered,” says Yair Litman, group leader at the Max Planck Institute. “But under the strong electric fields typical of electrochemical environments, the reaction behaves very differently.”

Using advanced molecular dynamics simulations, Litman and co-author Angelos Michaelides show that strong fields dramatically enhance water dissociation—not by making the reaction more energetically favorable, but by making it entropically favorable. The electric field initially orders water molecules into a highly structured network. When ions form, they disrupt this order, increasing the system’s entropy—or disorder—which ultimately drives the reaction forward.

“It’s a complete reversal of what happens at zero field,” explains Litman. “Instead of entropy resisting the reaction, it now promotes it.”

The study also shows that under strong electric fields, the pH of water can drop from neutral (7) to highly acidic levels (as low as 3), with implications for how we understand and design electrochemical systems.

“These results point to a new paradigm,” says Michaelides. “To understand and improve water-splitting devices, we need to consider not just energy,

Bulletin Board

Curiosities

OCT. 10, 2025

but entropy—and how electric fields reshape the molecular landscape of water.”

The research highlights the need to rethink how reactivity is modeled in aqueous environments under bias and opens up new possibilities for catalyst design, particularly in electrochemical and “on-water” reactions.

Phys Org, 7 October 2025

<https://phys.org>

Bamboo-derived biodegradable plastic is as durable as the real thing

2025-10-07

Bamboo plastic sounds like a compelling eco-friendly material for a variety of applications, but its questionable durability and recyclability leave a lot to be desired.

Researchers at Northeast Forestry University in Harbin, China have a solution: their new method for producing bamboo-based plastic results in a stronger material that can compete with traditional plastics, and can also degrade in soil in less than two months.

That’s a big step up over bamboo plastic composites used to make household items like serveware and cutlery that you might have seen in a local store.

These usually feature a bamboo fiber-based filler surrounded by an epoxy resin or similar polymer matrix. Those may look like more sustainable options over regular plastic, but the use of plastic matrices make them hard to recycle.

The scientists’ new solvent-mediated molecular engineering strategy uses a two-step process to create a better bamboo molecular plastic. First, bamboo cellulose is dissolved using a non-toxic alcohol solvent. Then it’s treated to trigger the cellulose chains to pack tightly together, producing a strong and stable plastic that can be shaped and formed in many different ways for use in automotive and infrastructure applications.

Indeed, the team’s study, which appeared in *Nature Communications* this week, notes the bamboo plastic displays a tensile strength and work of fracture (force required to fracture a material) higher than that of traditional plastics. Plus, it fully breaks down in soil, and can alternatively be recycled in a closed loop so you get a material with 90% of the strength

Bulletin Board

Curiosities

OCT. 10, 2025

of the original. How's that for a sustainable alternative to oil-based plastics?

New Atlas, 7 October 2025

<https://newatlas.com>

'Solids full of holes': Nobel-winning materials explained

2025-10-08

The chemistry Nobel was awarded on Wednesday to three scientists who discovered a revolutionary way of making materials full of tiny holes that can do everything from sucking water out of the desert air to capturing climate-warming carbon dioxide.

The particularly roomy molecular architecture, called metal-organic frameworks, has also allowed scientists to filter "forever chemicals" from water, smuggle drugs into bodies—and even slow the ripening of fruit.

After Japan's Susumu Kitagawa, UK-born Richard Robson and American-Jordanian Omar Yaghi won their long-anticipated Nobel Prize, here is what you need to know about their discoveries.

What are metal-organic frameworks?

Imagine you turn on the hot water for your morning shower, David Fairen-Jimenez, a professor who studies metal-organic frameworks (MOFs) at the University of Cambridge, told AFP.

The mirror in your bathroom fogs up as water molecules collect on its flat surface—but it can only absorb so much.

Now imagine this mirror was made of a material that was extremely porous—full of tiny holes—and these holes were "the size of a water molecule," Fairen-Jimenez said.

This material would be able to hold far more water—or other gases—than seems possible.

At the Nobel ceremony, this secret storage ability was compared to Hermione's magical handbag in Harry Potter.

The inside space of a couple of grams of a particular MOF "holds an area as big as a football field," the Nobels said in a statement.

Ross Forgan, a professor of materials chemistry at the University of Glasgow, told AFP to think of MOFs as "solids that are full of holes".

Bulletin Board

Curiosities

OCT. 10, 2025

They could look essentially like table salt, but "they have a ridiculously high storage capacity inside them because they are hollow—they can soak up other molecules like a sponge."

What did the Nobel-winners do?

In the 1980s, Robson taught his students at Australia's University of Melbourne about molecular structures using wooden balls that played the role of atoms, connected by rods representing chemical bonds.

One day this inspired him to try to link different kinds of molecules together. By 1989, he had drawn out a crystal structure similar to a diamond's—except that it was full of massive holes.

French researcher David Farrusseng compared the structure of MOFs to the Eiffel Tower. "By interlocking all the iron beams—horizontal, vertical, and diagonal—we see cavities appear," he told AFP.

However Robson's holey structures were unstable, and it took years before anyone could figure out what to do with them.

In 1997, Kitagawa finally managed to show that a MOF could absorb and release methane and other gases.

It was Yaghi who coined the term metal-organic frameworks and demonstrated to the world just how much room there was in materials made from them.

What can they do?

Because these frameworks can be assembled in different ways—somewhat like playing with Lego—companies and labs around the world have been testing out their capabilities.

"This is a field that's generating incredible enthusiasm and is moving extremely fast," Thierry Loiseau of French research center CNRS told AFP.

More than 100,000 different kinds have already been reported in scientific literature, according to a Cambridge University database.

"Every single month, there are 500 new MOFs," Fairen-Jimenez said.

He and Forgan agreed that likely the greatest impact MOFs will have on the world are in the areas of capturing carbon and delivering drugs.

Bulletin Board

Curiosities

OCT. 10, 2025

Though much hyped, efforts to capture carbon dioxide—the driver of human-caused global warming—have so far failed to live up to their promise.

Forgan said he was once “a bit skeptical about carbon capture, but now we’re finally refining (the MOFs) to the point where they are meeting all the industrial requirements”.

Canadian chemical producer BASF says it is the first company to produce hundreds of tons of MOFs a year, for carbon capture efforts.

The extra storage space also allows MOFs to smuggle molecules containing drugs into the body, with several currently undergoing clinical trials.

And Yaghi himself has demonstrated that a MOF material was able to harvest water vapor from the night air in the desert US state of Arizona.

Once the rising sun heated up the material, his team collected the drinkable water.

Phys Org, 8 October 2025

<https://phys.org>

Bulletin Board

Technical Notes

OCT. 10, 2025

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ENVIRONMENTAL RESEARCH

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