CHEMWATCH

Bulletin Board

Contents

JUL. 29, 2022

(click on page numbers for links)

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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.**

Contents

JUL. 29, 2022

HAZARD ALERT

GOSSIP

CURIOSITIES

CHEMWATCH
Bulletin Board
Contents
JUL. 29, 2022

TECHNICAL NOTES

ASIA PACIFIC

Variation of Inventory listing following revocation of CBI approval - 14 July 2022

2022-07-20

The Executive Director varied the terms of the Inventory listing for the following chemicals because approval had been revoked for the proper name of the industrial chemicals to be treated as confidential business information (CBI). The terms of the listings as varied are:

CAS number	1029874-65-4
Chemical name	Sulfonic acids, C15-18-sec-alkane hydroxy and C15-18-sec-alkene, sodium salts
Molecular formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	24 June 2022

CAS number	1084935-55-6
Chemical name	Sulfonic acids, C20-24-branched alkane hydroxy and C20-24-branched alkene, sodium salts
Molecular formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	29 June 2022

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

CAS number	2768937-93-3
Chemical name	1,3-Benzenedicarboxylic acid, polymer with 2,2-dimethyl-1,3-propanediol, 2-ethyl-2-(hydroxymethyl)-1,3-propanediol, hexanedioic acid, 3-hydroxy-2,2-dimethylpropyl 3-hydroxy-2,2-dimethylpropanoate and 1,3-isobenzofurandione, benzoate isononanoate
Molecular formula	(C10H20O4.C8H6O4.C8H4O3.C6H14O3.C6H10O4.C5H12O2)x.xC9H18O2.xC7H6O2
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	8 July 2022

CAS number	2768937-94-4
Chemical name	1,3-Benzenedicarboxylic acid, polymer with 2,2-dimethyl-1,3-propanediol, 2-ethyl-2-(hydroxymethyl)-1,3-propanediol, hexanedioic acid, 3-hydroxy-2,2-dimethylpropyl 3-hydroxy-2,2-dimethylpropanoate and 1,3-isobenzofurandione, benzoate
Molecular formula	(C10H20O4.C8H6O4.C8H4O3.C6H14O3.C6H10O4.C5H12O2)x.xC7H6O2
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	8 July 2022

CAS number	1312349-72-6
Chemical name	2-Propenoic acid, 2-methyl-, (1R,2R,4R)-1,7,7-trimethylbicyclo[2.2.1]hept-2-yl ester, rel-, polymer with 1,4-butanediol, butyl 2-propenoate, dimethyl carbonate, 1,6-hexanediol, 3-hydroxy-2-(hydroxymethyl)-2-methylpropanoic acid, 5-isocyanato-1-(isocyanatomethyl)-1,3,3-trimethylcyclohexane and 1,5-pentanediol, diethanolamine-blocked, compds. with 2-(dimethylamino)ethanol
Molecular formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	8 July 2022

CAS number	1312350-88-1
Chemical name	2-Propenoic acid, 2-methyl-, (1R,2R,4R)-1,7,7-trimethylbicyclo[2.2.1]hept-2-yl ester, rel-, polymer with 1,4-butanediol, butyl 2-propenoate, 1,3-dioxolan-2-one, 1,6-hexanediol, 3-hydroxy-2-(hydroxymethyl)-2-methylpropanoic acid, 5-isocyanato-1-(isocyanatomethyl)-1,3,3-trimethylcyclohexane and 1,5-pentanediol, diethanolamine-blocked, compds. with 2-(dimethylamino)ethanol
Molecular formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	8 July 2022

Published date

14 July 2022

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

Read More

AICIS, 14-07-22

https://www.industrialchemicals.gov.au/news-and-notices/variation-inventory-listing-following-revocation-cbi-approval-14-july-2022

China | NIFDC released public consultation on "Testing methods for 40 kinds of raw materials such as ethyl acrylate in cosmetics" and other two standards

2022-07-20

On 8th Jul, 2022, NIFDC released 3 testing method standards of raw materials in cosmetics for public consultation.

These standards are:

- Detection method of 40 kinds of raw materials such as ethyl acrylate in cosmetics
- Detection method of 24 kinds of raw materials such as CI59040 in cosmetics
- Detection method of 8 kinds of raw materials such as thioglycolic acid in cosmetics

Public consultation period: 8th Jul, 2022 – 31st Jul, 2022.

Read More

Chemycal, 20-07-22

https://chemycal.com/news/a5cbca58-8c84-450b-a715-8efac5932fcc/China__NIFDC_released_public_consultation_on_Testing_methods_for_40_kinds_of_raw_materials_such_as_ethyl_acrylate_in_cosmetics_and_other_two_standards

On 8th Jul, 2022, NIFDC released 3 testing method standards of raw materials in cosmetics for public consultation.

Thailand notified draft notification of the committee on labels

2022-07-20

This Regulation requires the labelling of label controlled products produced in Thailand or imported for sale in Thailand to contain information such as:

- Name or type of product
- Manufacturer and importer's name or registered trademark

- Name of the manufacturing country-Dimensional information of goods
- Usage and storage instruction-Warnings, Contraindications, or cautions
- Manufacturing date and expiring date
- Price

The content on the product label must be clearly visible and legible.

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Chemycal, 20-07-22

https://chemycal.com/news/1aa4587c-1069-420f-929c-7d47f9cc1e45/Thailand_notified_draft_notification_of_the_committee_on_labels

India's Air Pollution Challenge: Translating Policies into Effective Action

2022-07-21

Air pollution remains one of the biggest threats to India's environment and is a serious impediment to economic development. A Lancet study estimated that air pollution in India accounted for 1.7 million premature deaths in 2019, which is nothing less than 17.8 percent of the total deaths recorded in the country that year. Both ambient particulate matter (PM) pollution and household air pollution contributed significantly to these deaths. The same study estimated that economic losses from premature deaths and morbidity amount to US$ 37 billion annually or 1.36 percent of India's GDP.

Air pollution is a cross-sectoral problem with emissions originating from diverse sources.

Air pollution is a cross-sectoral problem with emissions originating from diverse sources. Particulate matter poses the biggest challenge, with emission levels continuously exceeding standards, particularly in urban areas. Industrial activities (36 percent) and residential combustion (39 percent) account for the bulk of PM2.5 emissions. The transport sector, concentrated largely in urban centres, adds another 4 percent although, being an on-ground source, its real impact on air quality is higher.

Other pollutants, such as the oxides of nitrogen (NOx) and of sulphur (SOx), and ozone, are still within prescribed limits in India but are rising. Emissions of NOx come mainly from the transport sector (35 percent), thermal power plants (22 percent), and the agricultural sector (15 percent). Emissions of SOx are primarily from the industrial sector (49 percent) and power (43 percent). The patterns of emissions in urban areas are different from the overall national picture: road dust, construction activities, and

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

transport are the main contributors to both PM2.5 and PM10 emissions. The contribution of different sectors also changes with the seasons: for example, emissions from dust and construction in cities are higher in the winter, particularly in the north. Trans-boundary sources of emission also contribute sizeably to city pollution.

In recent years, policymakers have paid more attention to the worsening air pollution. The National Air Quality Standards were established in 1982 and have been updated periodically to indicate appropriate air quality levels and provide a uniform basis for assessing them at the national level. The National Air Quality Monitoring Programme (NAMP) is being implemented to determine the status of ambient air quality and monitors compliance with prescribed standards. Perhaps the most significant step has been the announcement of the National Clean Air Programme (NCAP) for Indian cities in 2019. The plan mandates 122 cities with high pollution levels to devise city-specific action plans with the overall aim of reducing PM2.5 emissions by 20-30 percent by 2024 compared to 2017 levels.

Read More

ORF, 21-07-22

https://www.orfonline.org/research/indias-air-pollution-challenge/

AMERICA

Colombia is first in Western Hemisphere to protect 30% of ocean

2022-07-03

Colombia's outgoing President Iván Duque has announced that the country became the first in the Western Hemisphere to make 30% of its ocean territory a protected area, banning fishing and oil exploration.

Colombia's outgoing President Iván Duque has announced that the country became the first in the Western Hemisphere to make 30% of its ocean territory a protected area, banning fishing and oil exploration.

Why it matters: Ocean degradation caused by overfishing, coral reef bleaching, pollution and other factors, along with rising sea levels and temperatures caused by climate change, increases the likelihood of death, flooding and a loss of food sources, scientists say.

- It also destroys the ocean's biodiversity.
- Oceans produce half of all the world's oxygen and absorb 31% of human-produced carbon dioxide.

Background: Over 100 countries have joined a pact to protect 30% of the oceans by 2030.

- Less than 8% of the world's oceans are protected areas, according to the Marine Conservation Institute, a nonprofit organization based in Seattle.

Details: Duque made the announcement during the United Nations Ocean Conference in Portugal on Monday.

- It includes the creation of four new protected marine areas at the UN conference. Almost a third of its oceans will now have preservation measures, and extractive activities will be forbidden in many areas.

The big picture: Nine countries with Pacific coasts — the U.S., Mexico, Chile, Peru, Ecuador, Canada, Panama, Costa Rica and Colombia — signed a declaration at the Summit of the Americas this month promising to work faster toward protecting ocean areas and to collaborate more.

Read More

AXIOS, 3-07-22

https://www.axios.com/2022/07/03/colombia-protected-ocean

EPA OIG Finds EPA Was Not Transparent about Changes Made to LCPFAC SNUR after Administrator Signature

2022-07-13

On July 7, 2022, the U.S. Environmental Protection Agency (EPA) Office of Inspector General (OIG) released a report entitled "The EPA Was Not Transparent About Changes Made to a Long-Chain PFAS Rule After Administrator Signature." OIG evaluated the extent to which EPA followed applicable policies, procedures, and guidance for the changes made to the long-chain perfluoroalkyl carboxylate and perfluoroalkyl sulfonate chemical substances (LCPFAC) significant new use rule (SNUR) between the EPA Administrator's signing of the final rule on June 22, 2020, and the publication of the final rule in the Federal Register on July 27, 2020. OIG states that it initiated the evaluation based on a Congressional request. OIG notes that the substances in question are types of per- and polyfluoroalkyl substances (PFAS), which are manufactured chemicals widely used in industry and consumer products. SNURs require that EPA be notified before regulated chemical substances are used in new ways that might cause environmental or human health concerns.

OIG states that by not following all docketing procedures, EPA did not meet transparency expectations and risked compromising the public's trust in the rulemaking process.

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

According to OIG, EPA did not follow all applicable policies, procedures, and guidance when making changes to the LCPFAC SNUR after the Administrator signed it and before it was published in the Federal Register. Specifically:

- Although EPA identified changes made to the SNUR in a post-signature change memorandum, which was signed by the Administrator, as required by EPA's Changes to Rule Documents Prepared for the Administrator's Signature procedures, EPA did not docket that memorandum, as stipulated in EPA's Creating and Managing Dockets: Frequently Asked Questions for EPA Action Developers guidance.
- OIG states that because the request for changes was communicated via telephone, it could not identify the origin of the requested changes and could not determine whether EPA complied with the transparency provisions of Executive Order 12866, Regulatory Planning and Review.

OIG states that by not following all docketing procedures, EPA did not meet transparency expectations and risked compromising the public's trust in the rulemaking process. OIG notes that EPA followed the Office of the Federal Register's Document Drafting Handbook guidance for requesting changes to the final rule, however.

Read More

TSCAblog, 13-07-22

https://www.tscablog.com/entry/epa-oig-finds-epa-was-not-transparent-about-changes-made-to-lcpfac-snur-aft

EPA knocks Colorado's system for issuing air quality permits to minor polluters like drilling sites, gold mines

2022-07-18

The Environmental Protection Agency found "important concerns" with the way Colorado regulators review and issue permits to minor polluters such as mines, asphalt plants and oil and gas drilling rigs, and those problems risked further damage to the state's already poor air quality, according to a 309-page report released last week.

The report — in response to a whistleblower complaint filed in 2021 by employees at the state's Air Pollution Control Division — determined those charged with regulating how much pollution spews into the state's air were lax in how they assessed the potential for emissions and that they failed to properly document how they made their decisions.

The Environmental Protection Agency found "important concerns" with the way Colorado regulators review and issue permits to minor polluters

The Air Pollution Control Division issued air permits even when analyses indicated emissions would violate air quality standards and were not compliant with a state plan to improve air quality, the EPA found.

In one of the four air permits reviewed by the federal agency, the investigation found that the division divided one permit into two smaller projects, which meant a Teller County gold mine could meet a lower threshold for pollution and avoid more strict regulation.

The EPA's report listed six recommendations for improvement while acknowledging that the Air Pollution Control Division already has started making some changes. The EPA wants the Air Pollution Control Division, which falls under the Colorado Department of Public Health and Environment, to keep more complete records and better document how it makes decisions on its permitting standards.

It also wants the agency to go back and review 11 permits that were flagged by the whistleblowers to see if they were properly issued and make necessary changes, the EPA report said. The state has until Oct. 21 to respond to the EPA's findings.

Kevin Bell, a lawyer for the Public Employees for Environmental Responsibility, which filed the complaint on behalf of the whistleblowers, said the permitting problems were irresponsible and put the state further behind in its efforts to improve air quality.

Foul air continues to cause health problems, especially for people with asthma and other respiratory problems. Already this year, the EPA announced plans to downgrade Denver and the northern Front Range to "severe" violators of federal ozone standards, which would mean higher gas prices and more permitting for industries such as oil and gas, trucking and mining.

Read More

The Denver Post, 18-07-22

https://www.starbeacon.com/region/epa-knocks-colorado-s-system-for-issuing-air-quality-permits-to-minor-polluters-like-drilling/article_a64d6a36-172c-5c0a-970b-415981ce7235.html

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

Tesla Gigafactory Nevada Needs Special Permit To Pollute More

2022-07-17

Tesla's Reno Gigiafactory will gain approval from Nevada to change classifications. The new classifications will allow Tesla to increase the amount of emissions it is allowed to release annually. Nevada's Division of Environmental Protection has decided that Tesla's application for the bump in emissions standards satisfied the requirements set by both Nevada and the federal government.

However, the Nevada Division of Environmental Protection (NDEP) notes that the change in class and the increase in emissions allowed does not mean the standards that Tesla has to follow are less strict. This fits if, for example, Tesla needs the bump in emissions to be able to produce more Tesla Model 3 sedans.

Reno Gazette Journal reached out to NDEP for elaboration on the permit, receiving the following response: "The proposed permit still requires Tesla, Inc. to maintain compliance with state and federal regulations and ambient air quality standards, and also requires the facility to conduct regular monitoring and reporting. While overall emissions at the facility are expected to increase, the permit sets emission limits to ensure that public health is protected."

Per NDEP, Tesla currently runs this particular Gigafactory under a Class II air quality permit. That designation fits facilities like the Gigafactory that emit less than 100 tons of any single regulated pollutant annually. In addition, less than 25 tons of hazardous air pollutants can be produced yearly. That includes carcinogens and those that can cause serious environmental damage as well.

The step up to a Class I permit means the plant will now be able to emit more than 100 tons of regulated pollutants and more than 25 tons of hazardous air pollutants yearly.

Read More

Car Buzz, 17-07-22

https://carbuzz.com/news/tesla-gigafactory-nevada-needs-special-permit-to-pollute-more

The step up to a Class I permit means the plant will now be able to emit more than 100 tons of regulated pollutants and more than 25 tons of hazardous air pollutants yearly.

Revealed: US cities refusing to replace toxic lead water pipes unless residents pay

2022-07-20

Elena Bautista didn't pay much attention to the work crews that rolled down her street last year. They planned to remove water pipes made of lead, a toxin that can permanently damage children's brains.

But they skipped the tenement building where Bautista and her two kids lived.

They dug up pipes only at the homes of those who paid or took out loans for thousands of dollars, as well as under the public streets. Worse, the removal work risked causing a significant spike of toxic water for weeks, maybe months, in the homes of those unable to pay for it.

Bautista lives in Providence, Rhode Island, a city with a history of severe lead problems, yet this practice is happening all over the US. Pipes made of lead, a material not safe in any amount, supply tap water to millions of homes such as Bautista's. To completely halt contamination, there is no other option but to rip the lead pipes out of the ground and change them for a different material.

But according to a Guardian investigation, some US cities are now essentially telling residents: pay up for the replacement or get more poison in your water.

America's massive lead problem came into focus in 2015, when thousands of mostly Black residents in the city of Flint, Michigan, were found to have been poisoned by lead in their drinking water. Since then it has become clear that this problem is systemic and widespread, and that many other Americans lack access to a fundamental right: water that is reliably safe and clean.

Read More

The Guardian, 20-07-22

https://www.theguardian.com/us-news/2022/jul/20/us-cities-force-residents-pay-thousands-replace-lead-pipes-risk-drinking-toxic-water

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CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

INTERNATIONAL

New moves to update fracking regulations alarm environmental activists

2022-07-17

As the world faces an energy crisis and a scramble for oil and gas, the South African government is tightening its grip on the highly controversial hydraulic fracturing process and has opened up the subject for public discussion.

Hydraulic fracturing or fracking is the process of injecting chemicals at high pressure into oil and gas-carrying rocks beneath the Earth's surface. This extraction process can lead to methane leaks, contamination of groundwater and air pollution.

South Africa's Department of Forestry, Fisheries and the Environment (DFFE) has said it is inviting public participation in setting up regulations to "prescribe minimum requirements for the submission of applications for an authorisation, right, permit or licence for the onshore exploration of oil and gas intending to utilise hydraulic fracturing".

According to the DFFE, the regulations will identify areas and activities prohibited from fracking, such as preventing drinking water from being used and municipal facilities being banned from the disposal of fracking operations waste.

Authorisation

Environmental authorisation would be required for each phase of the fracking process, including seismic surveying, fracking itself and the production phase, said the DFFE. The department added: "This step-wise approach allows for information to be generated to support each phase of the process and will facilitate the consideration of cumulative impacts of the operation."

The regulations will be supported by two minimum information requirements: environmental requirements for exploration prior to fracking and environmental requirements for exploration and production that uses fracking.

"These documents are to provide guidance to developers on the authorisation requirements for all decision-making and will facilitate a one-stop authorisation process," the department said.

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"These documents are to provide guidance to developers on the authorisation requirements for all decision-making and will facilitate a one-stop authorisation process," the department said.

Read More

Daily Maverick, 17-07-22

https://www.dailymaverick.co.za/article/2022-07-17-new-moves-to-update-fracking-regulations-alarm-environmental-activists/

OECD Publishes Project Report on Chemical Accidents Involving Nanomaterials

2022-07-11

This document presents the outcome from a project of the OECD Working Party on Chemical Accidents (WPCA) that aimed to investigate safety issues related to the prevention of, preparedness for, and response to accidents involving manufactured nanomaterials. Initiated during the 2009-2012 Programme of Work, the project was managed by a Steering Group comprised of Switzerland as the lead, France, Germany, Japan, the United Kingdom, and Business at OECD (BIAC). A first draft report entitled "Risk of Major Accidents involving Nanomaterials" prepared by Daniel Bonomi, Federal Office for the Environment, Switzerland, and supported by Steve Hankin, Institute of Occupational Medicine (IOM), United Kingdom, was issued in 2014. However, because of the complexity of the

Initiated during the 2009-2012 Programme of Work, the project was managed by a Steering Group comprised of Switzerland as the lead, France, Germany, Japan, the United Kingdom, and Business at OECD (BIAC).

CHEMWATCH
Bulletin Board
Regulatory Update
JUL. 29, 2022

issue and the range of comments received requiring further consideration, the publication had to be postponed. In 2020, the WPCA decided to revive the project and finalise the report with the purpose of changing the target audience from 'chemical accident inspectors' to 'chemical safety policymakers'. The work plan included taking into account information published by the OECD Working Party on Manufactured Nanomaterials (WPMN) and cooperating with it during the revision process. A new Steering Group was established with participants from both Working Parties, from Costa Rica (Melissa Camacho Elizondo, Andrea Araya Sibaja), Germany (Arne Krietsch, Doris Völker) and Switzerland (Daniel Bonomi), with the support of Kyeong Wha Chung from the OECD Secretariat. This project was financially supported by the Federal Office for the Environment, Switzerland.

Read More

OECD, 11-07-22

https://www.lexology.com/library/detail.aspx?g=f5266e37-66db-4e1f-be32-d8f09be311ee

REACH Update

JUL. 29, 2022

Consultations following ECHA's Executive Director Requests to the Committees

2022-07-06

Following a request from ECHA's Executive Director under Article 77(3)(c) of REACH, ECHA may hold a consultation to support the Committees in adopting an opinion on the safety of substances on their own, in mixtures or in articles. The consultations listed below are ongoing.

- Only the comments addressing the topic of the specific consultation will be taken into account
- Further information on each consultation, including practical instructions for submission, are provided in an information note as well as the comments form itself, which is accessed by clicking on the link 'give comments' in the substance details.

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ECHA, 06-07-22

https://echa.europa.eu/echas-executive-director-requests-to-the-committees

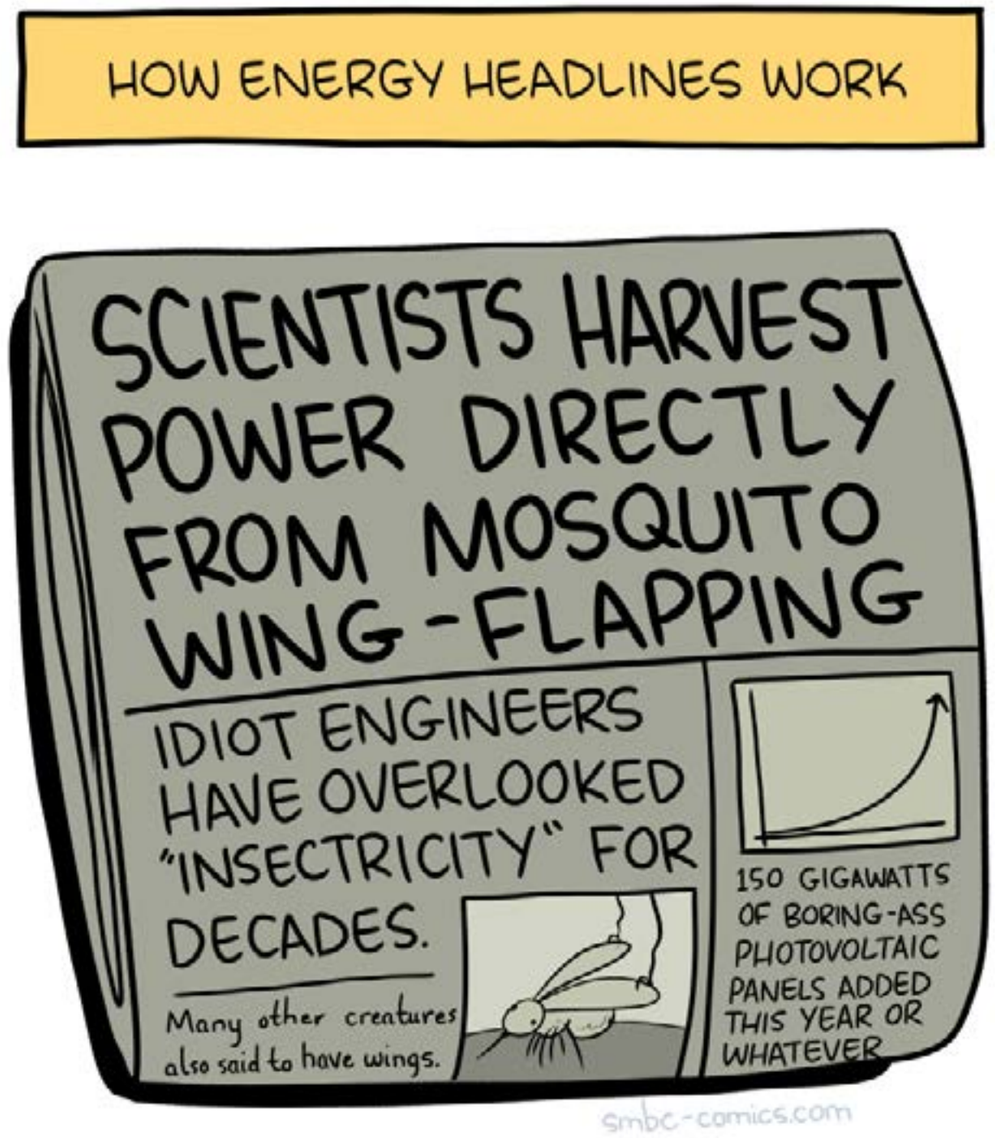
CHEMWATCH
Bulletin Board

Janet's Corner

JUL. 29, 2022

How Energy Headlines Work

2022-07-29



https://www.smbc-comics.com/comic/energy

Beryllium

2022-07-29

Beryllium is a toxic bivalent element, steel grey, strong, lightweight, primarily used as hardening agent in alloys. Beryllium has one of the highest melting points of the light metals. It has excellent thermal conductivity, is nonmagnetic, it resists attack by concentrated nitric acid and at standard temperature and pressures beryllium resist oxidation when exposed to air. [1]

Beryllium is a naturally occurring element that is present in rocks, coal, oil, soil, and volcanic dust. Some beryllium compounds are soluble in water. Two kinds of minerals, bertrandite and beryl, are commercially mined for the recovery of beryllium. The majority of beryllium that is mined is converted into alloys. [2]

USES [3]

Industrial grade beryl is used as a feedstock for beryllium metal, alloys and oxide, all of which have many high-tech applications particularly in the nuclear, electronic and ceramic industries. Beryllium is a structural material in space technology, inertial guidance systems, additive in rocket fuels, moderator and reflector of neutrons in nuclear reactors (e.g. at ANSTO, Lucas Heights). Pure beryllium metal is used to make aircraft disc brakes, nuclear weapons and reactors, aircraft-satellite-space vehicle structures and instruments, X-ray transmission windows, missile parts, fuel containers, precision instruments, rocket propellants, navigational systems, heat shields, and mirrors. Beryllium alloys such as beryllium-copper are used in electrical connectors and relays, springs, precision instruments, aircraft engine parts, non-sparking tools, submarine cable housings and pivots, wheels, and pinions. More specifically, beryllium oxide is used in the manufacture of specialty electrical and high-technology ceramics, special glass, electronic heat sinks, electron tubes, electrical insulators, electronics components, microwave oven components, nuclear fuels and nuclear moderators, gyroscopes, military vehicle armour, rocket nozzles, and laser structural components. Beryllium chloride is used in refining beryllium ores and as a chemical reagent. Beryllium fluoride is used in refining beryllium and manufacturing beryllium alloys, and as a chemical reagent. Beryllium nitrate is used as a chemical reagent, a gas mantle hardener and in refining beryllium ores.

Beryllium is a toxic bivalent element, steel grey, strong, lightweight, primarily used as hardening agent in alloys.

CHEMWATCH
Bulletin Board
Hazard Alert
JUL. 29, 2022

SOURCES & ROUTES OF EXPOSURE

Sources of Emission [3]

- Industry sources: Mining of ores containing beryllium can contribute to higher levels in air, soil and water, i.e. small quantities of beryl are produced as a by-product of feldspar mining at Broken Hill (NSW). Emissions to air can result from combustion of coal and oil in power plants.
- Diffuse sources: Some hazardous waste sites and tobacco smoke.
- Natural sources: Pure beryllium is not found in nature. Beryllium compounds can be found in mineral rocks, soil, coal, oil, and volcanic dust.
- Transport sources: Beryllium emissions are normally not associated with mobile sources.
- Consumer products: Small quantities can be found in products such as personal computers, televisions, calculators, and microwave ovens.

Routes of Exposure [4]

- Inhalation – Predominant route of exposure for the general and occupational populations.
- Oral – Major route of exposure for the general populations.
- Dermal – Minor route of exposure for general and occupational populations.

HEALTH EFFECTS [5]

Acute Effects

Acute inhalation exposure to high levels of beryllium has been observed to cause inflammation of the lungs and acute pneumonitis (reddening and swelling of the lungs) in humans; after exposure ends, these symptoms may be reversible. Acute animal tests have demonstrated beryllium compounds to vary in acute toxicity, ranging from high to extreme acute toxicity from oral exposure.

Chronic Effects

Chronic occupational exposure of humans to beryllium by inhalation has been reported to cause chronic beryllium disease (berylliosis), in which granulomatous lesions (noncancerous) develop in the lung. The onset of these effects may be delayed by 3 months to more than 20 years. Symptoms of chronic beryllium disease include irritation of the

mucous membranes, reduced lung capacity, shortness of breath, fatigue, anorexia, dyspnea, malaise, and weight loss. In addition, chronic inhalation exposure has been observed to cause immunological effects in humans and animals. A skin allergy may result from dermal exposure to beryllium. Eye contact with beryllium dust has been observed to cause acute conjunctivitis in humans. Animal studies have also reported effects on the lung, such as chronic pneumonitis, from chronic inhalation exposure. The Reference Concentration (RfC) for beryllium is 0.00002 milligrams per cubic metre (mg/m3) based on respiratory effects in humans. The Reference Dose (RfD) for beryllium is 0.002 milligrams per kilogram body weight per day (mg/kg/d) based on small intestinal lesions in dogs.

Reproductive/Developmental Effects

The potential for beryllium to induce developmental or reproductive effects has not been adequately assessed. Limited information is available on the reproductive or developmental effects of beryllium in humans following inhalation exposure. A case control study found no association between paternal occupational exposure and the risk of stillbirth, pre-term delivery, or small-for-gestational-age infants, although this study has limited sensitivity. No data are available on reproductive or developmental effects in animals following inhalation.

Cancer Risk

Several human epidemiological studies have investigated the relationship between beryllium exposure in workers and lung cancer deaths. Although there are shortcomings in all the studies, the results are suggestive of a causal relationship between beryllium exposure and an increased risk of lung cancer. Beryllium compounds have been shown to cause lung cancer from inhalation exposure in rats and monkeys. EPA has classified beryllium as a Group B1, probable human carcinogen.

SAFETY [6]

First Aid Measures

- Inhalation: Breathing difficulty caused by inhalation of particulate requires immediate removal to fresh air. If breathing has stopped, perform artificial respiration and obtain medical help.
- Ingestion: Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.

CHEMWATCH
Bulletin Board
Hazard Alert
JUL. 29, 2022

- Skin: Thoroughly wash skin cuts or wounds to remove all particulate debris from the wound. Seek medical attention for wounds that cannot be thoroughly cleansed. Treat skin cuts and wounds with standard first air practices such as cleansing, disinfecting and covering to prevent wound infection and contamination before continuing work. Obtain medical help for persistent irritation. Material accidentally implanted or lodged under the skin must be removed.
- Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Treatment of Chronic Beryllium Disease: There is no known treatment that will cure chronic beryllium disease. Prednisone or other corticosteroids are the most specific treatment current available. They are directed at suppressing the immunological reaction and can be effective in diminishing signs and symptoms of chronic beryllium disease. In cases where steroid therapy has had only partial or minimal effectiveness, other immunosuppressive agents, such as cyclophosphamide, cyclosporine, or methotrexate, have been used. These latter agents remain investigational. Further, in view of the potential side effects of all the immunosuppressive medications, including steroids such as prednisone, they should be used only under the direct care of a physician. In general, these medications should be reserved for cases with significant symptoms and/or significant loss of lung function. Other symptomatic treatment, such as oxygen, inhaled steroids, or bronchodilators, may be prescribed by some physicians and can be effective in selected cases.

Exposure Controls & Personal Protection

Exposure Controls

- Whenever possible, the use of local exhaust ventilation or other engineering controls is the preferred method of controlling exposure to airborne particulate. Where utilised, exhaust inlets to the ventilation system must be positioned as close as possible to the source of airborne generation. Avoid disruption of the airflow in the area of a local exhaust inlet by equipment such as a man-cooling fan. Check ventilation equipment regularly to ensure it is functioning properly. Provide training on the use and operation of ventilation to all users. Use qualified professionals to design and install ventilation systems.
- Machining operations conducted under a flow of liquid coolant require compete hooded containment and local exhaust ventilation. Openings into the hood must be baffled to prevent release of fast moving

particulate. The cycling through a machine of liquid lubricant/coolant containing finely divided beryllium particulate in suspension can result in the concentration building to a point where the particulate may become airborne during use. Prevent coolant from splashing onto floor areas, external structures or operators' clothing. Utilise a coolant filtering system to remove particulate from the coolant.

Personal Protective Equipment

Respiratory Protection

- When airborne exposures exceed or have the potential to exceed the occupational limits, approved respirators must be used as specified by an Industrial Hygienist or other qualified professional.
- Exposure to unknown concentrations of particulate requires the wearing of a pressure-demand airline respirator or pressure-demand self-contained breathing apparatus (SCBA). Use pressure-demand airline respirators when performing jobs with high potential exposures such as changing filters in a baghouse air cleaning device.

Other Protective Equipment

- Protective overgarments or work clothing must be worn by persons who may become contaminated with particulate during activities such as machining, furnace rebuilding, air cleaning equipment filter changes maintenance, furnace tending, etc.
- Contaminated work clothing and overgarments must be managed in a controlled manner to prevent secondary exposure to workers of third parties, to prevent the spread of particulate to other areas, and to prevent particulate from being taken home by workers.
- Wear gloves to prevent contact with particulate or solutions and to prevent metal cuts and skin abrasions during handling.
- Wear safety glasses, goggles, face shield, or welder's helmet when risk of eye injury is present, particularly during melting, casting, machining, grinding, welding, powder handling, etc.

REGULATION [2,7]

Exposure Limits

United States:

Exposure Limits and Health Effects (Updated September 6, 2012)

CHEMWATCH
Bulletin Board
Hazard Alert
JUL. 29, 2022

Standard Set By	Exposure Limit	Health Effect Codes -- Health Effects and Target Organs
OSHA PEL - General Industry See 29 CFR 1910.1000 Table Z-1 (See also ANSI Z37.29-1970)	0.002 mg/m³ TWA 0.005 mg/m³ Ceiling 0.025 mg/m³ Peak (30 minutes)	HE10 -- chronic beryllium disease (berylliosis‡) HE11 -- pneumonitis HE14 -- beryllium granuloma†, contact dermatitis
OSHA PEL - Construction Industry See 29 CFR 1926.55 Appendix A	0.002 mg/m³ TWA	HE10 -- chronic beryllium disease (berylliosis‡) HE11 -- pneumonitis HE14 -- beryllium granuloma†, contact dermatitis
OSHA PEL - Shipyard Employment See 29 CFR 1915.1000 Table Z-Shipyards	0.002 mg/m³ TWA	HE10 -- chronic beryllium disease (berylliosis‡) HE11 -- pneumonitis HE14 -- beryllium granuloma†, contact dermatitis
NIOSH REL	0.0005 mg/m³Ceiling Ca See Appendix A	HE2 -- lung cancer HE3 -- kidney stones; enlargement of the liver, spleen, and heart; multiple granulomas of the lung, spleen, liver, and lymph nodes HE4 -- heart failure leading to death HE10 -- tracheobronchitis, pneumonitis HE11 -- pulmonary oedema leading to death HE14 -- eye, upper respiratory, and skin irritation; contact dermatitis

Standard Set By	Exposure Limit	Health Effect Codes -- Health Effects and Target Organs
ACGIH TLV® (2008)	0.00005 mg/m³ TWA (inhalable particulate matter) A1 Skin; dermal sensitizer (DSEN); respiratory sensitizer (RSEN)	HE9 -- beryllium sensitization
		HE10 -- chronic beryllium disease (berylliosis‡)
CAL/OSHA PELs	0.0002 mg/m³ TWA 0.025 mg/m³ Ceiling	HE9 -- beryllium sensitization
		HE10 -- granulomas of the lung

Australia:

Safe Work Australia has set an eight-hour time weighted average (TWA) exposure limit for beryllium of 0.002 mg/m3.

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CHEMWATCH
Bulletin Board

Chemists change the bonds between atoms in a single molecule for the first time

2022-07-15

A team of researchers from IBM Research Europe, Universidade de Santiago de Compostela and the University of Regensburg has changed the bonds between the atoms in a single molecule for the first time. In their paper published in the journal Science, the group describes their method and possible uses for it. Igor Alabugin and Chaowei Hu, have published a Perspective piece in the same journal issue outlining the work done by the team.

The current method for creating complex molecules or molecular devices, as Alagugin and Chaowei note, is generally quite challenging—they liken it to dumping a box of Legos in a washing machine and hoping that some useful connections are made. In this new effort, the research team has made such work considerably easier by using a scanning tunneling microscope (STM) to break the bonds in a molecule and then to customize the molecule by creating new bonds—a chemistry first.

The work by the team involved placing a sample material into a scanning tunneling microscope and then using a very tiny amount of electricity to break specific bonds. More specifically, they began by pulling four chlorine atoms from the core of a tetracyclic to use as their starting molecule. They then moved the tip of the STM to a C-Cl bond and then broke the bond with a jolt of electricity. Doing so to the other C-Cl and C-C pairs resulted in the formation of a diradical, which left six electrons free for use in forming other bonds. In one test of creating a new molecule, the team then used the free electrons (and a dose of high voltage) to form diagonal C-C bonds, resulting in the creation of a bent alkyne. In another example, they applied a dose of low voltage to create a cyclobutadiene ring.

The researchers note that their work was made possible by the development of ultrahigh precision tunneling technology developed by a team headed by Gerd Binnig and Heinrich Rohrer, both with IBM's laboratory in Zurich. They suggest their technique could be used to better understand redox chemistry and to create new kinds of molecules.

Phys Org, 15 July 2022

https://phys.org

Selectively and reversibly the molecular structure in the center can be transformed to the structure on the right or on the left, by voltage pulses applied form the tip of a scanning probe microscope.

Stress hormone awakens our brain 100 times a night to shape our memory

2022-07-14

Scientists probing the mysterious machinations of the brain during sleep have made a fascinating discovery around how its chemistry changes throughout the night. The research centers on the levels of a stress hormone called noradrenaline, which fluctuates wildly and awakens our brain without us even realizing it and may have implications for the way we retain memories.

"You may think that sleep is a constant state that you are in, and then you wake up. But there is a lot more to sleep than meets the eye," explains Assistant Professor Celia Kjærby from the University of Copenhagen. "We have learned that noradrenaline causes you to wake up more than 100 times a night. And that is during perfectly normal sleep."

Kjærby and her colleagues made this discovery through experiments on mice. Optical fibers attached to LEDs and genetically-engineered light receptors were inserted into the brains of the rodents, which enabled levels of noradrenaline to be tracked as they slept. This neurotransmitter is associated with stress, adrenaline and our ability to focus. Previous research has implicated the noradrenaline system in the relationship between breathing-based meditation and cognitive function and raised the prospect of leveraging it in next-generation treatments for ADHD

Prior studies have also suggested that noradrenaline is inactive during sleep. But by monitoring its levels in sleeping mice, the scientists have found that to be far from the case. And because the study focused on the same biological mechanisms shared by all mammals, the scientists say the observations translate to humans "in all probability."

Prior studies have also suggested that noradrenaline is inactive during sleep. But by monitoring its levels in sleeping mice, the scientists have found that to be far from the case.

Noradrenaline concentrations were seen increasing and decreasing in waves during sleep. The scientists observed a clear relationship between noradrenaline levels and the degree of wakefulness, which is constantly shifting throughout the night. Low levels corresponded with a sleeping state, and when levels peaked, the brain would briefly awaken.

"Neurologically, you do wake up, because your brain activity during these very brief moments is the same as when you are awake," said second author of the study, Mie Andersen. "But the moment is so brief that the sleeper will not notice."

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

In further experiments, the scientists used implants to actually manipulate the amplitude of the noradrenaline waves. In doing so, they were able to show that mice with the highest number of deep noradrenaline valleys performed best in memory tests. These involved having the mice sniff objects, go to sleep, and then return to them to see what they remembered.

"The mice developed 'super memory,' said Kjærby. "They had less trouble remembering things they had learned the previous day. Of course, this suggests that the noradrenaline dynamic strengthens the sleep processes which affect our memory."

Some antidepressants will actually increase levels of noradrenaline, which the scientists point out could impact on our memory in light of these new findings. This suggests the development of alternative drugs could be a healthier path forward in treating depression. More broadly, the study sheds important new light on the benefits of sleep when it comes to memory.

"We have found the essence for the part of sleep that makes us wake up rested and which enables us to remember what we learned the day before," said Maiken Nedergaard, who led the study. 'We have found that the refreshing part of sleep is driven by waves of noradrenaline. The very short awakenings are created by waves of norepinephrine, which are also so important for memory. You could say that the short awakenings reset the brain so that it is ready to store memory when you dive back into sleep."

The research was published in the journal Nature Neuroscience.

New Atlas, 14 July 2022

https://newatlas.com

Alcohol consumption carries significant health risks and no benefits for young people, study finds

2022-07-16

The new analysis from the Global Burden of Disease estimates that 1.34 billion people consumed harmful amounts of alcohol (1.03 billion males and 0.312 billion females) in 2020.

The analysis suggests that for young adults ages 15-39, there are no health benefits to drinking alcohol, only health risks, with 59.1% of people who

New analysis suggests that recommendations for how much one can drink should be based on age and local disease rates.

consumed unsafe amounts of alcohol in 2020 between ages 15-39 years and 76.7% male.

The authors note that given the complex relationship between alcohol and diseases and different background rates of diseases across the world, the risks of alcohol consumption differ by age and by geographic location.

For adults over age 40, health risks from alcohol consumption vary by age and region. Consuming a small amount of alcohol (for example, drinking between one and two 3.4-ounce glasses of red wine) for people in this age group can provide some health benefits, such as reducing the risk of cardiovascular disease, stroke, and diabetes.

Authors call for alcohol consumption guidelines to be revised to emphasise consumption levels by age, stressing that the level of alcohol consumption recommended by many existing guidelines is too high for young people in all regions.

They also call for policies targeting males under age 40, who are most likely to use alcohol harmfully.

Young people face higher health risks from alcohol consumption than older adults, according to a new analysis published in The Lancet. This is the first study to report alcohol risk by geographical region, age, sex, and year. It suggests that global alcohol consumption recommendations should be based on age and location, with the strictest guidelines targeted toward males between ages 15-39, who are at the greatest risk of harmful alcohol consumption worldwide.

The research also indicates that adults aged 40 and older without underlying health conditions may see some benefits from small alcohol consumption (between one and two standard drinks per day), including a reduced risk in cardiovascular disease, stroke, and diabetes.

Using estimates of alcohol use in 204 countries, researchers calculated that 1.34 billion people consumed harmful amounts in 2020. In every region, the largest segment of the population drinking unsafe amounts of alcohol were males aged 15-39 and for this age group, drinking alcohol does not provide any health benefits and presents many health risks, with 60% of alcohol-related injuries occurring among people in this age group, including motor vehicle accidents, suicides, and homicides.

"Our message is simple: young people should not drink, but older people may benefit from drinking small amounts. While it may not be realistic to think young adults will abstain from drinking, we do think it's important

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

to communicate the latest evidence so that everyone can make informed decisions about their health," says senior author Dr Emmanuela Gakidou, Professor of Health Metrics Sciences at the Institute for Health Metrics and Evaluation (IHME) at the University of Washington's School of Medicine.

Age and region should drive alcohol consumption policies

The researchers looked at the risk of alcohol consumption on 22 health outcomes, including injuries, cardiovascular diseases, and cancers using 2020 Global Burden of Disease data for males and females aged 15-95 years and older between 1990 and 2020, in 204 countries and territories. From this, the researchers were able to estimate the average daily intake of alcohol that minimises risk to a population. The study also estimates another critical quantity—how much alcohol a person can drink before taking on excess risk to their health compared to someone who does not drink any alcohol.

The recommended amount of alcohol for people aged 15-39 before risking health loss was 0.136 standard drinks per day (a little more than one-tenth of a standard drink). That amount was slightly higher for females aged 15-39 years at 0.273 drinks (about a quarter of a standard drink per day). One standard drink is defined as 10 grams of pure alcohol, which is equivalent to a small glass of red wine (100ml or 3.4 fluid ounces) at 13% alcohol by volume, a can or bottle of beer (375 ml or 12 fluid ounces) at 3.5% alcohol by volume, or a shot of whiskey or other spirits (30 ml or 1.0 fluid ounces) at 40% alcohol by volume.

The analysis also suggests that for adults aged 40 and older without any underlying health conditions, drinking a small amount of alcohol may provide some benefits, such as reducing the risk of ischemic heart disease, stroke, and diabetes. In general, for individuals aged 40-64 years in 2020, safe alcohol consumption levels ranged from about half a standard drink per day (0.527 drinks for males and 0.562 standard drinks per day for females) to almost two standard drinks (1.69 standard drinks per day for males and 1.82 for females).

For individuals over 65 years in 2020, the risks of health loss from alcohol consumption were reached after consuming a little more than three standard drinks per day (3.19 drinks for males and 3.51 for females). The estimates suggest that small amounts of alcohol consumption in populations over 40 without underlying conditions may be associated with improved health outcomes, particularly in populations that predominantly face a higher burden of cardiovascular diseases.

The distribution of disease burden for a given age group varied substantially across regions, resulting in variations in risks from alcohol consumption, particularly in individuals aged 40 years and older.

For example, among individuals aged 55–59 years in north Africa and the Middle East, 30.7% of alcohol-related health risks were due to cardiovascular disease, 12.6% were due to cancers, and less than 1% were due to tuberculosis. By contrast, in this same age group in central sub-Saharan Africa, 20% of alcohol-related health risks were due to cardiovascular disease, 9.8% cancers, and 10.1% were due to tuberculosis.

As a result, consumption levels for this age group before risking health loss were 0.876 drinks (or almost one standard drink per day) in north Africa and the Middle East and 0.596 drinks (about half a standard drink per day) in central sub-Saharan Africa.

Overall, the recommended alcohol intake for adults remained low at between 0 – 1.87 standard drinks per day, regardless of geography, age, sex, or year.

"Even if a conservative approach is taken and the lowest level of safe consumption is used to set policy recommendations, this implies that the recommended level of alcohol consumption is still too high for younger populations. Our estimates, based on currently available evidence, support guidelines that differ by age and region.

Understanding the variation in the level of alcohol consumption that minimises the risk of health loss for populations can aid in setting effective consumption guidelines, supporting alcohol control policies, monitoring progress in reducing harmful alcohol use, and designing public health risk messaging," says lead author Dana Bryazka, researcher at IHME.

Young men are at greatest risk of harmful alcohol consumption.

Using these estimates, the proportion of the population consuming alcohol in amounts exceeding these thresholds by location, age, sex, and year, was also calculated, serving as a guide for targeting alcohol control efforts.

Among individuals consuming harmful amounts of alcohol in 2020, 59.1% were age 15-39 years, and 76.7% were male, with 1.03 billion males and 0.312 billion females drinking harmful amounts of alcohol. Harmful use of alcohol was particularly concentrated in young males in Australasia, western Europe, and central Europe.

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

"Although the risks associated with alcohol consumption are similar for males and females, young males stood out as the group with the highest level of harmful alcohol consumption. This is because a larger proportion of males compared to females consume alcohol and their average level of consumption is also significantly higher," says Dr Gakidou.

The authors acknowledge some limitations with this paper, including that patterns of drinking were not examined. Therefore, this study did not distinguish between individuals who infrequently engage in heavy episodic drinking and those who consume the same amount of alcohol over several days. Alcohol consumption was also self-reported, which could have introduced bias, and the study could not include data on consumption during the COVID-19 pandemic due to pandemic-related delays with routine data collection, which could also have affected these estimates.

Writing in a linked Comment, Robyn Burton and Nick Sheron of King's College London (who were not involved in the study) say, "These findings seemingly contradict a previous GBD estimate published in The Lancet, which emphasised that any alcohol use, regardless of amount, leads to health loss across populations.

There are three main differences between the two GBD publications. First, the most recent study uses data from 2020 instead of 2016. Second, the relative risk curves for five alcohol-related outcomes have been updated. However, neither of these changes is driving the differences in results. Instead, the differences are due to the novel method of weighting relative risk curves according to levels of underlying disease, alongside the calculation of more disaggregated estimates by sex, age, and geographical region.

The causes that contribute to all-cause mortality vary across groups, and this changes the proportional risk of alcohol on mortality. Across most geographical regions in this latest analysis, injuries accounted for most alcohol-related harm in younger age groups. This led to a minimum risk level of zero, or very close to zero, among individuals aged 15–39 years across all geographical regions. This is lower than the level estimated for older adults, due to a shift in alcohol-related disease burden towards cardiovascular disease and cancers. This highlights the need to consider existing rates of disease in a population when trying to determine the total harm posed by alcohol."

This study was funded by the Bill and Melinda Gates Foundation. A full list of GBD 2020 Alcohol Collaborators is available in the paper.

The Brighter Side of News, 16 July 2022

https://www.thebrighterside.news

"Self-boosting vaccines" load multiple drug doses into a single shot

2022-07-17

Researchers at MIT have developed microparticles that can release doses of drugs at specific times over days, weeks or months. The platform could be useful for creating what the team calls "self-boosting vaccines."

Vaccines and other drugs often require multiple doses, but getting them at the optimal time can be tricky for many people who don't have easy access to medical services. To help remove that pressure, the MIT team developed a drug delivery system that can be given just once, and release extra doses at the required time.

The system consists of microparticles that the team describes as being like tiny coffee cups, which are made of a biocompatible polymer called PLGA. Drug particles are loaded into the cup, then a lid is fused to the top using a gentle heat. As the polymer degrades over time, it releases the drug payload.

The general design has been tested over a few years, but for the new study, the researchers investigated exactly how it works, and created new techniques to scale up production. The team was surprised to find that particle size didn't affect the timing of the drug release – instead, it all came down to the type of polymer used.

The PLGA is slowly cleaved by water, the team observed, until the lid eventually breaks open and spills the drug into the body. Different compositions of polymers break down at different rates, which could allow scientists to tweak the design to release drugs after a few days, weeks, or months as needed.

"If you want the particle to release after six months for a certain application, we use the corresponding polymer, or if we want it to release after two days, we use another polymer," said Morteza Sarmadi, lead author of the study. "A broad range of applications can benefit from this observation."

"If you want the particle to release after six months for a certain application, we use the corresponding polymer."

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

The team says the technique could be applied to a range of vaccine types, including those based on DNA, RNA or recombinant proteins. The first example in development is a self-boosting polio vaccine currently being tested in animals, which normally requires up to four injections.

The research was published in the journal Science Advances.

New Atlas, 17 July 2022

https://newatlas.com

'Black hole police' discover a dormant black hole outside the Milky Way galaxy

2022-07-18

A team of international experts who are known for debunking black hole discoveries have found a dormant stellar-mass black hole in the Large Magellanic Cloud, a galaxy that neighbors the Milky Way. The team includes Kareem El-Badry—nicknamed by fellow astronomers as the "black hole destroyer"—of the Center for Astrophysics | Harvard & Smithsonian (CfA).

"For the first time, our team got together to report on a black hole discovery, instead of rejecting one," says study lead Tomer Shenar, a Marie-Curie Fellow at Amsterdam University in the Netherlands.

The team found that the star that gave rise to the black hole vanished without any sign of a powerful explosion.

"We identified a needle in a haystack," says Shenar. Though other similar black hole candidates have been proposed, the team claims this is the first "dormant" stellar-mass black hole to be unambiguously detected outside of the Milky Way galaxy. The work was published today in the journal Nature Astronomy.

Stellar-mass black holes form when massive stars reach the end of their lives and collapse under their own gravity. In a binary, a system of two stars revolving around each other, this process leaves behind a black hole in orbit with a luminous companion star. The black hole is "dormant" if it does not emit high levels of X-ray radiation, which is how such black holes are typically detected.

The discovery was made thanks to six years of observations obtained with the European Southern Observatory's (ESO's) Very Large Telescope (VLT).

The black hole is "dormant" if it does not emit high levels of X-ray radiation, which is how such black holes are typically detected.

"It is incredible that we hardly know of any dormant black holes, given how common astronomers believe them to be," explains co-author Pablo Marchant of KU Leuven. The newly found black hole is at least nine times the mass of the Sun, and orbits a hot, blue star weighing 25 times the Sun's mass.

Dormant black holes are particularly hard to spot since they do not interact much with their surroundings.

"For more than two years now, we have been looking for such black-hole-binary systems," says co-author Julia Bodensteiner, a research fellow at ESO in Germany. "I was very excited when I heard about VFTS 243, which in my opinion is the most convincing candidate reported to date."

To find VFTS 243, the collaboration searched nearly 1,000 massive stars in the Tarantula Nebula region of the Large Magellanic Cloud, looking for the ones that could have black holes as companions. Identifying these companions as black holes is extremely difficult, as so many alternative possibilities exist.

"As a researcher who has debunked potential black holes in recent years, I was extremely skeptical regarding this discovery," says Shenar.

The skepticism was shared by CfA co-author El-Badry, whom Shenar calls the "black hole destroyer." A recent Harvard Magazine story similarly calls El-Badry a "black hole debunker."

"When Tomer asked me to double-check his findings, I had my doubts. But I could not find a plausible explanation for the data that did not involve a black hole," explains El-Badry.

The discovery also allows the team a unique view into the processes that accompany the formation of black holes. Astronomers believe that a stellar-mass black hole forms as the core of a dying massive star collapses, but it remains uncertain whether or not this is accompanied by a powerful supernova explosion.

"The star that formed the black hole in VFTS 243 appears to have collapsed entirely, with no sign of a previous explosion," explains Shenar. "Evidence for this 'direct-collapse' scenario has been emerging recently, but our study arguably provides one of the most direct indications. This has enormous implications for the origin of black-hole mergers in the cosmos."

The black hole in VFTS 243 was found using six years of observations of the Tarantula Nebula by the Fiber Large Array Multi Element Spectrograph

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

(FLAMES) instrument on ESO's VLT. FLAMES allows astronomers to observe more than a hundred objects at once, a significant saving of telescope time compared to studying each object one by one.

Despite the nickname "black hole police," the team actively encourages scrutiny, and hope that their work will enable the discovery of other stellar-mass black holes orbiting massive stars, thousands of which are predicted to exist in Milky Way and in the Magellanic Clouds.

"Of course I expect others in the field to pore over our analysis carefully, and to try to cook up alternative models," El-Badry says. "It's a very exciting project to be involved in."

Phys Org, 18 July 2022

https://phys.org

Oxford study investigates the most effective drugs for insomnia

2022-07-18

A new study led by researchers from the University of Oxford has reviewed more than 150 clinical trials to present a comprehensive, comparative analysis of 30 different drug treatments for insomnia. The findings indicate many common insomnia drugs lack long-term safety data and popular treatments such as melatonin have little clinical evidence of effectiveness.

"We looked at all information published and unpublished – in journals and in online registries – to achieve the most transparent and comprehensive picture of all the data available," explained Andrea Cipriani, who led the research. "Clearly, the need to treat insomnia as effectively as possible is very important, as it can have knock-on effects for a patient's health, their home lives and the wider health system."

The study included data from 154 double-blind, randomized controlled trials, encompassing more than 44,000 people. Thirty different pharmacological treatments for insomnia were examined, with effectiveness and side effects tracked for both acute and long-term usage.

The ultimate findings pointed to two particular drugs demonstrating the most effective treatment profiles: lemborexant and eszopiclone. And more common insomnia treatments such as benzodiazepines and zolpidem were found to be helpful in the short-term, but lacked evidence for long-term efficacy or safety.

The study also found the popular insomnia treatment melatonin had poor efficacy data and little long-term study.

"Considering all the outcomes at different timepoints (ie, acute and long-term treatment), lemborexant and eszopiclone had the best profile in terms of efficacy, acceptability, and tolerability; however, eszopiclone might cause substantial adverse events and safety data on lemborexant were inconclusive," the study concluded.

Interestingly, both lemborexant and eszopiclone are yet to be approved in the European Union. Lemborexant in particular is a new kind of insomnia drug, only approved for use in the United States in 2019. Philip Cowen, co-author on the study, said the mechanism of action used by lemborexant may be improved in the future for better insomnia medications.

"It should also be noted that the drug lemborexant acted via a different pathway in the brain (the orexin neurotransmitter system), a relatively novel mechanism of action," Cowen explained. "More selective targeting of this pathway and orexin receptors could lead to better pharmacological treatments for insomnia."

The study also found the popular insomnia treatment melatonin had poor efficacy data and little long-term study. The lack of long-term data on insomnia drugs in general was highlighted in the study as a problem considering the condition is often persistent, requiring treatment for extended periods of time.

Cipriani does make clear this study only focused on pharmacological interventions for insomnia. Behavioral and lifestyle interventions were not included in the comparative review, so these alternative methods should always be considered either before, or alongside, any drug treatment.

"This study of pharmacological treatments is not a recommendation that drugs should always be used as the first line of support to treat insomnia, not least because some of them can have serious side effects," said Cipriani. "However, our research shows that some of these drugs can also be effective, and should be used in clinical practice, when appropriate. For example, where treatments such as improved sleep hygiene and Cognitive Behavioural Therapy have not worked, or where a patient wants to consider taking medication as part of their treatment."

The new study was published in The Lancet.

New Atlas, 18 July 2022

https://newatlas.com

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

Film captures wasted wavelengths of light to boost solar cell efficiency

2022-07-19

Solar cells are one of the most important technologies in the transition to renewable energy, but there's still plenty of room for improvement. Researchers at New York University (NYU) Tandon have now developed a thin film that boosts solar cell efficiency by converting wasted wavelengths of light into ones that can be used to produce electricity.

Silicon is the material of choice for most solar cells in use today, but while it excels at absorbing the red end of the visible spectrum of sunlight, it all but ignores shorter wavelengths like ultraviolet and blue light. Scientists have been experimenting with different solar cell designs, materials and dyes that might be able to make use of more of the spectrum, but so far it's been tricky to make meaningful headway.

Now, the NYU Tandon researchers may have made a breakthrough, with a thin film that can convert UV and blue photons from sunlight into near-infrared photons. The film could be used to boost the efficiency of an existing silicon solar cell by essentially allowing it to harvest energy that would otherwise go to waste.

Silicon is the material of choice for most solar cells in use today, but […] it all but ignores shorter wavelengths like ultraviolet and blue light.

Importantly, it doesn't block the other wavelengths of light that silicon can readily tap into. And as an added bonus, reducing the amount of UV radiation that hits the solar cell can help them last longer.

The film is made up of an inorganic perovskite material doped with small amounts of ytterbium. The perovskite is adept at absorbing blue light and transferring that energy to the ytterbium, which emits it as near-infrared light. These red photons can then be picked up by the silicon solar cell, supplementing its usual diet coming directly from the Sun.

In tests, the team found that the film could convert blue photons to red with an efficiency of 82.5 percent. It's important not to get this figure confused with the efficiency of the solar cell itself – those are still hovering in the mid-20s for silicon – but this new film should help boost that. To what extent is a question for further tests to address.

The researchers have already experimented with ways to improve their design. In a follow-up study, they changed the temperature of the production process to reduce the amount of bismuth that escapes the material. The resulting films boasted blue to red photon conversion efficiencies as high as 95 percent.

And there might still be room to go higher. The team says it could be possible to break the 100-percent efficiency barrier, which would mean that more red photons are being emitted than the number of blue photons striking the film. The path to that potential breakthrough remains murky for now though.

"We do not exactly know yet (how to boost efficiency over 100 percent)," Eray Aydil, lead author of the study, told New Atlas. "However, we have some ideas based on the hypothesis of how emission happens in the first place. We are taking two routes – (1) conducting experiments to find out about the details of what makes this material special, and (2) we are exploring similarly structured materials with different elemental substitutions."

The research was published in the journal Materials Horizons.

New Atlas, 19 July 2022
https://newatlas.com

Beloved monarch butterflies now listed as endangered

2022-07-22

The monarch butterfly fluttered a step closer to extinction Thursday, as scientists put the iconic orange-and-black insect on the endangered list because of its fast dwindling numbers.

"It's just a devastating decline," said Stuart Pimm, an ecologist at Duke University who was not involved in the new listing. "This is one of the most recognizable butterflies in the world."

The International Union for the Conservation of Nature added the migrating monarch butterfly for the first time to its "red list" of threatened species and categorized it as "endangered" — two steps from extinct.

The group estimates that the population of monarch butterflies in North America has declined between 22% and 72% over 10 years, depending on the measurement method.

"What we're worried about is the rate of decline," said Nick Haddad, a conservation biologist at Michigan State University. "It's very easy to imagine how very quickly this butterfly could become even more imperiled."

On Thursday, July 21, 2022, the International Union for the Conservation of Nature said migrating monarch butterflies have moved closer to extinction in the past decade.

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

Haddad, who was not directly involved in the listing, estimates that the population of monarch butterflies he studies in the eastern United States has declined between 85% and 95% since the 1990s.

In North America, millions of monarch butterflies undertake the longest migration of any insect species known to science.

After wintering in the mountains of central Mexico, the butterflies migrate to the north, breeding multiple generations along the way for thousands of miles. The offspring that reach southern Canada then begin the trip back to Mexico at the end of summer.

"It's a true spectacle and incites such awe," said Anna Walker, a conservation biologist at New Mexico BioPark Society, who was involved in determining the new listing.

A smaller group spends winters in coastal California, then disperses in spring and summer across several states west of the Rocky Mountains. This population has seen an even more precipitous decline than the eastern monarchs, although there was a small bounce back last winter.

Emma Pelton of the nonprofit Xerces Society, which monitors the western butterflies, said the butterflies are imperiled by loss of habitat and increased use of herbicides and pesticides for agriculture, as well as climate change.

"There are things people can do to help," she said, including planting milkweed, a plant that the caterpillars depend upon.

Nonmigratory monarch butterflies in Central and South America were not designated as endangered.

The United States has not listed monarch butterflies under the Endangered Species Act, but several environmental groups believe it should be listed.

The international union also announced new estimates for the global population of tigers, which are 40% higher than the most recent estimates from 2015.

The new figures, of between 3,726 and 5,578 wild tigers worldwide, reflect better methods for counting tigers and, potentially, an increase in their overall numbers, said Dale Miquelle, coordinator for the nonprofit Wildlife Conservation Society's tiger program.

In the past decade, tiger populations have increased in Nepal, northern China and perhaps in India, while tigers have disappeared entirely from Cambodia, Laos and Vietnam, said Miquelle. They remain designated as endangered.

AP News, 22 July 2022

https://apnews.com

MIT Discovers Semiconductor That Can Perform Far Better Than Silicon

2022-07-22

Researchers from MIT and elsewhere have found a material that can perform much better than silicon. The next step is finding practical and economic ways to manufacture it.

Silicon is one of the most plentiful elements on Earth, and in its pure form, the semiconductor material has become the foundation of much of modern technology, including microelectronic computer chips and solar cells. However, silicon's properties as a semiconductor are actually far from ideal.

One reason is that although silicon allows electrons to readily flow through its structure, it is much less accommodating to "holes" — electrons' positively charged counterparts —and harnessing both is crucial for particular types of devices. Furthermore, silicon does a poor job of transporting heat, which contributes to the frequent overheating problems and pricey cooling systems in computers.

Now, a team of scientists from MIT, the University of Houston, and other institutions has carried out experiments showing that a material called cubic boron arsenide overcomes both of these limitations. In addition to providing high mobility to both electrons and holes, it has excellent thermal conductivity. It is the best semiconductor material ever found, and maybe the best possible one, according to the researchers.

Cubic boron arsenide has so far only been made and tested in small, lab-scale batches that are not uniform. In fact, in order to test small regions within the material, the scientists had to use special methods originally developed by former MIT postdoc Bai Song. More work will be needed to determine whether cubic boron arsenide can be made in a practical, economical form, much less replace the ubiquitous silicon. But even in the near future, the researchers say, the material could find some uses where its unique properties would make a significant difference.

MIT researchers say cubic boron arsenide is the best semiconductor material ever found, and maybe the best possible one.

The findings were reported on July 21, 2022, in the journal Science, in a paper by MIT postdoc Jungwoo Shin and MIT professor of mechanical engineering Gang Chen; Zhifeng Ren at the University of Houston; and 14 others at MIT, the University of Houston, the University of Texas at Austin, and Boston College.

Earlier research, including work by David Broido, who is a co-author of the new paper, had theoretically predicted that the material would have high thermal conductivity. Subsequent work experimentally proved that prediction. This latest work completes the analysis by experimentally confirming a prediction made by Chen's group back in 2018: that cubic boron arsenide would also have very high mobility for both electrons and holes, "which makes this material really unique," says Chen.

The earlier experiments demonstrated that the thermal conductivity of cubic boron arsenide is almost 10 times greater than that of silicon. "So, that is very attractive just for heat dissipation," Chen says. They also showed that the material has a very good bandgap, a property that gives it great potential as a semiconductor material.

Now, the new work fills in the picture, showing that, with its high mobility for both electrons and holes, boron arsenide has all the main qualities needed for an ideal semiconductor. "That's important because of course in semiconductors we have both positive and negative charges equivalently. So, if you build a device, you want to have a material where both electrons and holes travel with less resistance," Chen says.

Silicon has good electron mobility but poor hole mobility, and other materials such as gallium arsenide, widely used for lasers, similarly have good mobility for electrons but not for holes.

"Heat is now a major bottleneck for many electronics," says Shin, the paper's lead author. "Silicon carbide is replacing silicon for power electronics in major EV industries including Tesla, since it has three times higher thermal conductivity than silicon despite its lower electrical mobilities. Imagine what boron arsenides can achieve, with 10 times higher thermal conductivity and much higher mobility than silicon. It can be a gamechanger."

Shin adds, "The critical milestone that makes this discovery possible is advances in ultrafast laser grating systems at MIT," initially developed by

Song. Without that technique, he says, it would not have been possible to demonstrate the material's high mobility for electrons and holes.

The electronic properties of cubic boron arsenide were initially predicted based on quantum mechanical density function calculations made by Chen's group, he says, and those predictions have now been validated through experiments conducted at MIT, using optical detection methods on samples made by Ren and members of the team at the University of Houston.

Not only is the material's thermal conductivity the best of any semiconductor, but the scientists also say it has the third-best thermal conductivity of any material — next to diamond and isotopically enriched cubic boron nitride. "And now, we predicted the electron and hole quantum mechanical behavior, also from first principles, and that is also proven to be true," Chen says.

"This is impressive because I actually don't know of any other material, other than graphene, that has all these properties," he says. "And this is a bulk material that has these properties."

The challenge now, he says, is to figure out practical ways of making this material in usable quantities. The current methods of making it produce very nonuniform material, so the team had to find ways to test just small local patches of the material that were uniform enough to provide reliable data. While they have demonstrated the great potential of this material, "whether or where it's going to actually be used, we do not know," Chen says.

"Silicon is the workhorse of the entire industry," says Chen. "So, OK, we've got a material that's better, but is it actually going to offset the industry? We don't know." While the material appears to be almost an ideal semiconductor, "whether it can actually get into a device and replace some of the current market, I think that still has yet to be proven."

And while the thermal and electrical properties have been shown to be excellent, there are many other properties of a material that have yet to be tested, such as its long-term stability, Chen says. "To make devices, there are many other factors that we don't know yet."

He adds, "This potentially could be really important, and people haven't really even paid attention to this material." Now that boron arsenide's desirable properties have become more clear, suggesting the material is

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

"in many ways the best semiconductor," he says, "maybe there will be more attention paid to this material."

For commercial uses, Ren says, "one grand challenge would be how to produce and purify cubic boron arsenide as effectively as silicon. … Silicon took decades to win the crown, having purity of over 99.99999999 percent, or '10 nines' for mass production today."

For it to become practical on the market, Chen says, "it really requires more people to develop different ways to make better materials and characterize them." Whether the necessary funding for such development will be available remains to be seen, he says.

SciTechDaily, 22 July 2022

https://scitechdaily.com

Mechanochemical breakthrough unlocks cheap, safe, powdered hydrogen

2022-07-18

Deakin researchers have described a novel mechanochemical process that can store gases safely in powders, using very little energy, in a repeatable process

Australian scientists say they've made a "eureka moment" breakthrough in gas separation and storage that could radically reduce energy use in the petrochemical industry, while making hydrogen much easier and safer to store and transport in a powder.

Nanotechnology researchers, based at Deakin University's Institute for Frontier Materials, claim to have found a super-efficient way to mechanochemically trap and hold gases in powders, with potentially enormous and wide-ranging industrial implications.

Mechanochemistry is a relatively recently coined term, referring to chemical reactions that are triggered by mechanical forces as opposed to heat, light, or electric potential differences. In this case, the mechanical force is supplied by ball milling – a low-energy grinding process in which a cylinder containing steel balls is rotated such that the balls roll up the side, then drop back down again, crushing and rolling over the material inside.

The team has demonstrated that grinding certain amounts of certain powders with precise pressure levels of certain gases can trigger a mechanochemical reaction that absorbs the gas into the powder and stores it there, giving you what's essentially a solid-state storage medium that can hold the gases safely at room temperature until they're needed. The gases can be released as required, by heating the powder up to a certain point.

The process is repeatable, and Professor Ian Chen, co-author on the new study published in the journal Materials Today, tells us via phone that the boron nitride powder used in the first experiments only loses "about a couple of percent" of its absorption capability each storage and release cycle. "Boron nitride is very stable," he tells us, "and graphene too. We're looking at a restoration treatment that can clean the powders and restore their absorption levels, but we need to prove that it'll work."

A revolutionary overhaul of the massive gas separation industry

The results are absolutely remarkable from a numbers standpoint. This process, for example, could separate hydrocarbon gases out from crude oil using less than 10% of the energy that's needed today. "Currently, the petrol industry uses a cryogenic process," says Chen. "Several gases come up together, so to purify and separate them, they cool everything down to a liquid state at very low temperature, and then heat it all together. Different gases evaporate at different temperatures, and that's how they separate them out."

Cryogenics, of course, is a highly energy-intensive process, and the Deakin team found that its ball milling process could be tuned to separate out gases just as effectively using far less energy. Different gases, they found, are absorbed at different milling intensities, gas pressures and time periods. Once the first gas is absorbed into the powder, it can be removed, and the process can be re-run with a different set of parameters to trap and store the next gas. Likewise, some gases are released from the powders at higher temperatures than others, offering a second way to separate gases if they're stored together.

In the team's experiments, they managed to separate out a combination of alkyne, olefin and paraffin gases using boron nitride powder. The process takes a while – some gases were fully absorbed after two hours, others were still only partially soaked up after 20 hours. But Chen says this should just be a matter of fine-tuning: "We're continuing to work on different gases, using different materials. We hope to have another paper published soon, and we also expect to work with industry on some real practical applications."

Even if it takes a while, the cost savings – and energy savings, and emissions savings – make an extraordinary case for widespread adoption. "The energy consumed by a 20-hour milling process is US$0.32," reads the paper. "The ball-milling gas adsorption process is estimated to consume 76.8 KJ/s to separate 1,000 liters (220 gal) of olefin/paraffin mixture, which is two orders less than that of the cryogenic distillation process."

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

Even when you take into account the energy needed to heat the powder up to several hundred degrees and release the gas, the process is hugely efficient. And cryogenic distillation is a vital and extremely energy-hungry process – according to one 2016 study published in Nature, cryo-dsitillative separation of just the olefins propene and ethene, which are required for plastics, consumes about as much energy globally as all of Singapore – 0.3% of the entire world's energy consumption. Distillation as a whole is responsible for a massive 10-15% of global energy use. So there's an opportunity here for this technology to make an enormous contribution globally.

Solid-state hydrogen storage: Another area of enormous potential

The gas separation use case would be a pretty huge advance all by itself, but by storing gas securely in powders, the team believes it's also unlocked a compelling way to store and transport hydrogen, which could play a key role in the coming clean energy transition.

Currently, pure hydrogen is either stored as a gas, or as a cryogenic liquid. The gaseous form must be stored at around 700 times the normal atmospheric pressure at sea level, or more than 10,100 psi, which means there's a considerable energy input to compress it, and it requires storage tanks capable of handling large pressure loads safely. The liquid form must be cooled to below the boiling point of hydrogen at atmospheric pressure: just 20.28 K (−252.87 °C, −423.17 °F), and it needs to be kept cold and sometimes pressurized for as long as you store it. This takes even more energy.

"The scientific community has been trying to find a suitable sponge-type material that can store large amounts of hydrogen for at least half a century," says Chen. "The technique we recently reported is for paraffin, but we can store much more hydrogen. It doesn't require a lot of energy, and it's safe; under normal conditions it's quite stable, and the hydrogen won't be released unless it's heated to a couple of hundred degrees. So there's a real hope for this to become a practical solid-state storage technology – not just for hydrogen, but for ammonia and other fuel gases."

While heating the powder up to several hundred degrees sounds like an energy-intensive process, Chen says the round trip from gas to powder and back to gas uses far less energy than even just compressed gas.

"It's difficult to give exact figures," he says, "because we're currently only conducting small-scale experiments compared with the gas separation study. But we believe it uses maybe one third, or even one quarter of the

energy it takes to compress hydrogen gas. And that can be improved at larger scales or by optimizing the grinding conditions and materials. We're working on reducing the energy required to release the gas – and the more gas you're storing, the less energy is required to release it. But there's still a lot of work to do."

With hydrogen safely stored in the powder, it can be moved around and warehoused extremely easily and safely – this could be a very compelling way to move bulk quantities of hydrogen for export or distribution, since it's both cheaper and easier to handle than gas or liquid, and the equipment needed to release the gas for use at the other end will be pretty simple.

Chen says the powder could also have potential as a direct fuel for cars and trucks. "It can also have advantages in mobile applications," he says, "which is currently the most challenging issue in the hydrogen energy community. But if you want to do this in a vehicle, we have to think about a suitable tank or container, how to release it at a controlled rate and speed, what the fueling process will look like ... it'll require more further work."

How does it fare in terms of density by volume and weight? Chen tells us the powder can store a hydrogen weight percentage of around 6.5%. "Every one gram of material will store about 0.065 grams of hydrogen," he says. "That's already above the 5% target set by the US Department of Energy. And in terms of volume, for every one gram of powder, we wish to store around 50 liters (13.2 gal) of hydrogen in there."

Indeed, should the team prove these numbers, they'd represent an instant doubling of the best current solid-state hydrogen storage mass fractions, which, according to Air Liquide, can only manage 2-3%.

It's complex to compare these weight and volume densities against gaseous or liquid hydrogen though – a lot of factors come into the equation. Fifty liters (11 gal) per gram sounds like a massive amount, for example, but at atmospheric pressures, hydrogen is 467 times less dense than it is when compressed to 700 bar in a tank. So each gram of powder is really going to store about the same amount of hydrogen as 0.11 liters (3.62 fl. oz) of compressed H2 gas.

Likewise 6.5% sounds like a very small weight fraction – for every kilogram of hydrogen you're carrying, you also need to lug 14.4 kilograms of boron nitride around. That would have to be a killer for any weight-sensitive use case, right? Not quite – as ZeroAvia's Val Miftakhov once told us, current

CHEMWATCH
Bulletin Board
Gossip
JUL. 29, 2022

compressed hydrogen tanks are much heavier than the fuel they're carrying too, so you're still carrying at least 9 kg of tank for every 1 kg of hydrogen within. So while the powder would still need its own container and heat-release system added to its system weight, it might not be that far out of the ballpark.

It certainly doesn't look like a solution for aviation, particularly considering the ultra-lightweight GTL cryogenic liquid tanks we looked at in April, which are claimed to boost the mass fraction of hydrogen up over 50% even with all ancillary equipment factored in, allowing hydrogen-fueled airliners to fly four times as far as current jet-fuel planes, for half the fuel cost.

But aviation is a particularly weight-sensitive transport class. Powder-sequestered hydrogen might prove so cheap, convenient and easy to handle that it becomes a no-brainer in long-haul trucking, for example. "We really want to collaborate with some truck companies," says Chen, "because our storage is way above the current best results. We want to work with them to see what challenges there might be to make this technology useful in vehicles. On this, we need industry support."

Boron nitride is easily available in industrial quantities, and relatively cheap, but Chen says the technique should work with other materials as well. "We're not limited to boron nitride," he says, "we're just using it as an example. You could also use graphene, to take another example, and we're continuing to investigate other materials."

Clearly, this advance has some potentially enormous implications, which could contribute greatly to energy use reduction, emissions reduction, the green energy transition and even reducing fuel and chemical prices. The team has submitted provisional patent applications, and we look forward to learning what's possible as the method is refined and tailored to useful applications.

The research is published in the journal Materials Today.

New Atlas, 18 July 2022

https://website

Glyphosate may be harming bumblebee hives

2022-07-11

As bees continue to decline, scientists have found many contributors, including climate change and landscape transformation. Now they've added another one: glyphosate.

Over the past few years, glyphosate, an herbicide most known as the active ingredient in Roundup that's used to regulate plant growth and kill off unwanted plant species, has become a subject of public concern as it is unclear whether or not it is harmful to the health of humans and other animal organisms.

First registered for use in the United States in 1974, glyphosate is applied annually to 298 million acres, one fourth of U.S. agricultural land, making it one of the most commonly used herbicides.

A recent study found that exposure to glyphosate can impair a bumblebee's ability to maintain hive temperature, which is critical for bees' ability to forage and reproduce to increase colony size.

Anja Weidenmüller, who led the study, has been researching bumblebee thermoregulation behavior for more than a decade. For this study, Weidenmüller prioritized the long term effects that glyphosate has on bumblebee behavior rather than looking at the immediate 24-48 hour time frame, normally used to determine if glyphosate is immediately lethal for bumblebees.

Contrary to many lab studies, the bumblebees were studied in environments of resource limitation and environmental stressors as most organisms would experience in the natural world. In fact, as bumblebees have declined, scientists have found there are multiple factors that play into this decline including climate change, landscape transformation, and harmful chemicals used on agriculture, such as pesticides. As a result, bumble bees have experienced a severe decline in recent decades: a 2021 U.S. Fish and Wildlife Service report found that over the past 20 years populations have disappeared or become rare in 16 states, and observations of the bees have declined by about 90%.

"When those [things] come together, an effect of an insecticide or pesticide may be very different than what usually tests these organisms in laboratories," Weidenmüller told EHN.

To imitate this complex environment, the researchers placed a brood of bees in the lab and exposed the bees to stressors such as glyphosate, and limited their sugar water to reproduce the resource limitations that they would be exposed to in agricultural landscapes.

New study finds the herbicide impacts bumblebees' ability to maintain brood temperature — which could spur population decline.

This study found that when exposed to glyphosate for just four hours, a bumblebee's ability to maintain brood temperature decreased by 25% when resources were limited, which could affect the health of bees and impair their ability to reproduce, leading to a decline in population.

"[The study] highlights the importance of these multiple stressors for bees, and for their health; those risk periods of resource limitation are often not accounted for in laboratory settings," Emily May, Pollinator Conservation Specialist and Agricultural Lead at Xerces Society, told EHN.

Biodiversity conservation

Extensive research has found that the conservation of bumblebees, and bees in general, is crucial for the survival of crops and wild ecosystems. Bees are effective pollinators and have been found to pollinate 80% of the world's flowering plants, including food crops.

"We really need them to be able to have these thriving systems, both for our food production and for wild ecosystems as well," said May.

Food systems are largely pollinator dependent and the conservation of biodiversity can be more beneficial long term for human health and agriculture production than chemicals used in modern agriculture for food yield and pest control, researchers have found.

"Agrichemicals might not actually be all that important for increasing yields," said James Crall, professor at the University of Wisconsin-Madison, researches bees and plant-pollinator interactions. Crop pollination has been found to improve produce yield more than increased fertilization.

Although glyphosate is currently approved for use in the U.S., at least 43 countries have banned or restricted the use of products containing glyphosate. Although there is research focused on the effects of glyphosate on humans and other organisms, such as the U.S. Department of Health's Agency for Toxic Substances acknowledgement of links between glyphosate and cancer, there are still potential long-term effects of which we may not yet be aware.

Environmental Health News, 11 July 2022

https://ehn.org

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

Dark Matter: Is a Revolution Coming to Physics?

2022-07-15

What is dark matter? It has never been observed, yet scientists estimate that it makes up 85% of the matter in the universe. The short answer is that no one knows what dark matter is. More than a century ago, Lord Kelvin offered it as an explanation for the velocity of stars in our own galaxy. Decades later, Swedish astronomer Knut Lundmark noted that the universe must contain much more matter than we can observe. Scientists since the 1960s and '70s have been trying to figure out what this mysterious substance is, using ever-more complicated technology. However, a growing number of physicists suspect that the answer may be that there is no such thing as dark matter at all.

The Backstory

Scientists can observe far-away matter in a number of ways. Equipment such as the famous Hubble telescope measures visible light while other technology, such as radio telescopes, measures non-visible phenomena. Scientists often spend years gathering data and then proceed to analyze it to make the most sense of what they are seeing.

What became abundantly clear as more and more data came in was that galaxies were not behaving as expected. The stars at the outer edges of some galaxies were moving far too fast. Galaxies are held together by the force of gravity, which is strongest at the center where most of the mass is. Stars at the outer edges of disk galaxies were moving so fast that the force of gravity generated by the observable matter there wouldn't have been able to keep them from flying out into deep space.

Scientists thought that there must be more matter present in these galaxies than we can currently observe. Something must be keeping the stars from flying away, and they called that something dark matter. They couldn't really say what properties it might have except that it must have gravitational pull, and there must be quite a bit of it. In fact, the vast majority of the universe (a whopping 85%) must be dark matter. Otherwise, galaxies wouldn't have been able to stick around as long as they seem to do. They would have broken up because there wouldn't have been enough gravity to keep the trillions of stars in place.

When it comes to science, the trouble with something that you can't observe is that it's hard to say much about it. Because dark matter does not interact with the electromagnetic force — which is responsible for visible light, radio waves, and x-rays — all of our evidence is indirect.

What is dark matter? Does it even exist, or do we just need an adjustment to our theory of gravity?

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

Scientists have been trying to figure out ways to observe dark matter and make predictions based on theories of it but without much success.

A Possible Solution

Newton's Theory of Gravity explains most large-scale events fairly well. Everything from throwing the first pitch at a Yankees game to the movements of constellations can be explained using Newton's theory. However, the theory is not foolproof. Einstein's theories of general and special relativity, for example, explained data that Newton's theory couldn't. Scientists still use Newton's theory because it works in the overwhelming majority of cases and has much simpler equations.

Dark matter was proposed as a way to reconcile Newtonian physics with the data. But what if, instead of reconciliation, a modified theory is needed. This is where an Israeli physicist named Mordehai Milgrom makes an entrance. He developed a theory of gravity (called Modified Newtonian Dynamics or "Mond" for short) in 1982 that postulates gravity functions differently when it becomes very weak, such as at the edge of disk galaxies.

His theory does not simply explain the behaviors of galaxies; it predicts them. The problem with theories is that they can explain just about anything. If you walk into a room and see that the lights are on, you can develop a theory that cosmic rays from the sun are hitting hidden mirrors in just the right way to light up the room. Another theory might be that someone flicked the light switch. One way to separate good theories from bad ones is to see which theory makes better predictions.

Recent analysis of Mond shows that it makes significantly better predictions than standard dark matter models. What that means is that, while dark matter can explain the behavior of galaxies quite well, it has little predictive power and is, at least on this front, an inferior theory.

Only more data and debate will be able to settle the score on dark matter and Mond. However, Mond coming to be accepted as the best explanation would shatter decades of scientific consensus and make one of the more mysterious features of the universe much more normal. A modified theory may not be as sexy as dark, unseen forces, but it may just have the advantage of being better science.

Sci Tech Daily, 15 July 2022

https://sctechdaily.com

Depression is probably not caused by a chemical imbalance in the brain, says new study

2022-07-20

For three decades, people have been deluged with information suggesting that depression is caused by a "chemical imbalance" in the brain—namely an imbalance of a brain chemical called serotonin. However, our latest research review shows that the evidence does not support it.

Although first proposed in the 1960s, the serotonin theory of depression started to be widely promoted by the pharmaceutical industry in the 1990s in association with its efforts to market a new range of antidepressants, known as selective serotonin-reuptake inhibitors or SSRIs. The idea was also endorsed by official institutions such as the American Psychiatric Association, which still tells the public that "differences in certain chemicals in the brain may contribute to symptoms of depression."

Countless doctors have repeated the message all over the world, in their private surgeries and in the media. People accepted what they were told. And many started taking antidepressants because they believed they had something wrong with their brain that required an antidepressant to put right. In the period of this marketing push, antidepressant use climbed dramatically, and they are now prescribed to one in six of the adult population in England, for example.

For a long time, certain academics, including some leading psychiatrists, have suggested that there is no satisfactory evidence to support the idea that depression is a result of abnormally low or inactive serotonin. Others continue to endorse the theory. Until now, however, there has been no comprehensive review of the research on serotonin and depression that could enable firm conclusions either way.

At first sight, the fact that SSRI-type antidepressants act on the serotonin system appears to support the serotonin theory of depression. SSRIs temporarily increase the availability of serotonin in the brain, but this does not necessarily imply that depression is caused by the opposite of this effect.

There are other explanations for antidepressants' effects. In fact, drug trials show that antidepressants are barely distinguishable from a placebo (dummy pill) when it comes to treating depression. Also, antidepressants appear to have a generalized emotion-numbing effect which may influence people's moods, although we do not know how this effect is produced or much about it.

For a long time, certain academics [...] have suggested that there is no satisfactory evidence to support the idea that depression is a result of abnormally low or inactive serotonin.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

First comprehensive review

There has been extensive research on the serotonin system since the 1990s, but it has not been collected systematically before. We conducted an "umbrella" review that involved systematically identifying and collating existing overviews of the evidence from each of the main areas of research into serotonin and depression. Although there have been systematic reviews of individual areas in the past, none have combined the evidence from all the different areas taking this approach.

One area of research we included was research comparing levels of serotonin and its breakdown products in the blood or brain fluid. Overall, this research did not show a difference between people with depression and those without depression.

Another area of research has focused on serotonin receptors, which are proteins on the ends of the nerves that serotonin links up with and which can transmit or inhibit serotonin's effects. Research on the most commonly investigated serotonin receptor suggested either no difference between people with depression and people without depression, or that serotonin activity was actually increased in people with depression—the opposite of the serotonin theory's prediction.

Research on the serotonin "transporter", that is the protein which helps to terminate the effect of serotonin (this is the protein that SSRIs act on), also suggested that, if anything, there was increased serotonin activity in people with depression. However, these findings may be explained by the fact that many participants in these studies had used or were currently using antidepressants.

We also looked at research that explored whether depression can be induced in volunteers by artificially lowering levels of serotonin. Two systematic reviews from 2006 and 2007 and a sample of the ten most recent studies (at the time the current research was conducted) found that lowering serotonin did not produce depression in hundreds of healthy volunteers. One of the reviews showed very weak evidence of an effect in a small subgroup of people with a family history of depression, but this only involved 75 participants.

Very large studies involving tens of thousands of patients looked at gene variation, including the gene that has the instructions for making the serotonin transporter. They found no difference in the frequency of varieties of this gene between people with depression and healthy controls.

Although a famous early study found a relationship between the serotonin transporter gene and stressful life events, larger, more comprehensive studies suggest no such relationship exists. Stressful life events in themselves, however, exerted a strong effect on people's subsequent risk of developing depression.

Some of the studies in our overview that included people who were taking or had previously taken antidepressants showed evidence that antidepressants may actually lower the concentration or activity of serotonin.

Not supported by the evidence

The serotonin theory of depression has been one of the most influential and extensively researched biological theories of the origins of depression. Our study shows that this view is not supported by scientific evidence. It also calls into question the basis for the use of antidepressants.

Most antidepressants now in use are presumed to act via their effects on serotonin. Some also affect the brain chemical noradrenaline. But experts agree that the evidence for the involvement of noradrenaline in depression is weaker than that for serotonin.

There is no other accepted pharmacological mechanism for how antidepressants might affect depression. If antidepressants exert their effects as placebos, or by numbing emotions, then it is not clear that they do more good than harm.

Although viewing depression as a biological disorder may seem like it would reduce stigma, in fact, research has shown the opposite, and also that people who believe their own depression is due to a chemical imbalance are more pessimistic about their chances of recovery.

It is important that people know that the idea that depression results from a "chemical imbalance" is hypothetical. And we do not understand what temporarily elevating serotonin or other biochemical changes produced by antidepressants do to the brain. We conclude that it is impossible to say that taking SSRI antidepressants is worthwhile, or even completely safe. People need all this information to make informed decisions about whether or not to take antidepressants.

MedicalXpress, 20 July 2022

https://medicalxpress.com

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

Reducing aerosol pollution could lead to an unexpected rise in ozone

2022-07-18

n 2013, China unveiled an ambitious plan to improve its air quality. The Chinese government implemented strict policies aimed at reducing fine particulate matter (PM 2.5), a type of pollution responsible for about 1 million deaths in the country each year. Thus far, the nation's efforts have been largely successful; by 2020, PM 2.5 levels dropped by nearly 40%. But new research suggests that by solving one pollution problem, China may have inadvertently caused another (Nat. Geosci. 2022, DOI: 10.1038/s41561-022-00972-9).

China's aggressive tactics for reducing PM 2.5 may have contributed to an increase in ozone, which can lead to a number of environmental and human health effects. According to the new study, ozone levels—which have risen in eastern China since 2013 (Environ. Sci. Technol. Lett. 2020, DOI: 10.1021/acs.estlett.0c00171)—are heavily dictated by the amount of particulates in the air.

But the effect isn't unique to these regions. Using a model that simulates the chemistry and transport of pollutants, the researchers estimated that by 2014, 21% of the Northern Hemisphere's population was living under similar atmospheric conditions. "Historically, we've thought about particulate matter pollution and ozone pollution as being separate problems," says the study's lead author Mathew Evans, an atmospheric chemist at the University of York. "What this shows is that, actually, they're often inextricably linked."

In the 1950s, scientists discovered that nitrogen oxides (NOx) and volatile organic compounds (VOCs) can react to produce ozone. Depending on the ratio of NOx to VOCs in the air, policymakers in many countries target either one or both of these compounds to keep local ozone concentrations under control. Particulates, meanwhile, are usually regulated separately, often by focusing on their emissions at the source, such as from power plants and automobiles.

However, scientists have recently proposed that PM 2.5 can actually inhibit ozone by absorbing peroxy radicals, chemical intermediates formed during ozone's production (Proc. Natl. Acad. Sci. U.S.A. 2018, DOI: 10.1073/pnas.1812168116). When Evans and colleagues included this chemistry in their model, they found that reducing PM 2.5 can cause ozone to increase by up to 30%, especially over heavily populated regions in China and India.

Air quality regulations focused on cutting particle pollution could be causing a 30% jump in ozone over China and India.

These findings "provide further evidence that aerosols may be the dominant factor in determining photochemical [ozone] production in regions with high levels of PM 2.5," says Qi Ying, an environmental engineer at Texas A&M University, who was not involved in the study.

Ying says there are still uncertainties in the model, though. For example, it's unclear how different aerosol compositions or environmental conditions affect the uptake of peroxy radicals by particulates. Evans notes that this is the next stage of research, but regardless, the takeaway is clear: "You have to think about air quality in this more holistic sort of way," he says. "The tales we tell ourselves in textbooks sometimes have to be changed."

Chemical and Engineering News, 18 July 2022

https://cen.acs.org

Allergies lasting longer? Blame light pollution

2022-07-16

City lights that blaze all night are profoundly disrupting urban plants' phenology—shifting when their buds open in the spring and when their leaves change colors and drop in the fall. New research I coauthored shows how nighttime lights are lengthening the growing season in cities, which can affect everything from allergies to local economies.

In our study, my colleagues and I analyzed trees and shrubs at about 3,000 sites in U.S. cities to see how they responded under different lighting conditions over a five-year period. Plants use the natural day-night cycle as a signal of seasonal change along with temperature.

We found that artificial light alone advanced the date that leaf buds broke in the spring by an average of about nine days compared to sites without nighttime lights. The timing of the fall color change in leaves was more complex, but the leaf change was still delayed on average by nearly six days across the lower 48 states. In general, we found that the more intense the light was, the greater the difference.

We also projected the future influence of nighttime lights for five U.S. cities—Minneapolis; Chicago; Washington, D.C.; Atlanta; and Houston—based on different scenarios for future global warming and up to a 1% annual increase in nighttime light intensity. We found that increasing nighttime light would likely continue to shift the start of the season earlier, though its influence on the fall color-change timing was more complex.

Light pollution is disrupting the seasonal rhythms of plants and trees, lengthening pollen season in U.S. cities.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

Why It Matters

This kind of shift in plants' biological clocks has important implications for the economic, climate, health, and ecological services that urban plants provide.

On the positive side, longer growing seasons could allow urban farms to be active over longer periods of time. Plants could also provide shade to cool neighborhoods earlier in spring and later in fall as global temperatures rise.

But changes to the growing season could also increase plants' vulnerability to spring frost damage. And it can create a mismatch with the timing of other organisms, such as pollinators, that some urban plants rely on.

A longer active season for urban plants also suggests an earlier and longer pollen season, which can exacerbate asthma and other breathing problems. A study in Maryland found a 17% increase in hospitalizations for asthma in years when plants bloomed very early.

What Still Isn't Known

How the fall-color timing will change going forward as night lighting increases and temperatures rise is less clear. Temperature and artificial light together influence the fall color in a complex way, and our projections suggested that the delay of coloring date due to climate warming might stop midcentury and possibly reverse because of artificial light. This will require more research.

How urban artificial light will change in the future also remains to be seen.

One study found that urban light at night had increased by about 1.8% per year worldwide from 2012 to 2016. However, many cities and states are trying to reduce light pollution, including requiring shields to control where the light goes and shifting to LED street lights, which use less energy and have less of an effect on plants than traditional streetlights with longer wavelengths.

Urban plants' phenology may also be influenced by other factors, such as carbon dioxide and soil moisture. Additionally, the faster increase of temperature at night compared to daytime could lead to different day-night temperature patterns, which might affect plant phenology in complex ways.

Understanding these interactions between plants and artificial light and temperature will help scientists predict changes in plant processes under a changing climate. Cities are already serving as natural laboratories.

Fast Company, 16 July 2022

https://fastcompany.com

Why Do Humans Sleep? Scientists Find Clues for Solving This Age-Old Mystery

2022-07-17

New insights into brain activity when sleeping may help in the creation of tools for those suffering from neurologic disease or damage

Why do humans sleep? This issue has been debated by scientists for hundreds of years, but a recent study from Massachusetts General Hospital (MGH) researchers that was carried out in collaboration with experts from Brown University, the Department of Veterans Affairs, and several other institutions adds new clues for solving this mystery. Their research, which was recently published in the Journal of Neuroscience, may help to explain how individuals remember things and pick up new skills. It may also help with the creation of assistive tools for those with neurological conditions or injuries.

According to the lead author of the research and neurologist Daniel Rubin, MD, Ph.D., of the MGH Center for Neurotechnology and Neurorecovery, scientists have long known that during sleep, a phenomenon known as "replay" takes place. Replay is thought to be a mechanism used by the brain to recall new information. When a mouse is taught to navigate a labyrinth, monitoring equipment may indicate that a precise pattern of brain cells, or neurons, light up as it follows the proper path. "Then, later on, while the animal is sleeping, you can see that those neurons will fire again in that same order," says Rubin. Scientists theorize that this is how the brain practices newly acquired knowledge during sleep, allowing memories to be consolidated—that is, turned from short-term memories to long-term memories.

Replay, however, has only been properly shown in lab animals. "There's been an open question in the neuroscience community: To what extent is this model for how we learn things true in humans? And is it true for different kinds of learning?" asks neurologist Sydney S. Cash, MD, Ph.D., co-director of the Center for Neurotechnology and Neurorecovery at MGH and co-senior author of the study. Importantly, says Cash, understanding whether replay occurs with the learning of motor skills could help guide the development of new therapies and tools for people with neurologic diseases and injuries.

According to the researchers, this study found the clearest indication of motor cortex replay during human sleep that has ever been seen.

To study whether replay occurs in the human motor cortex—the brain region that governs movement—Rubin, Cash, and their colleagues enlisted a 36-year-old man with tetraplegia (also called quadriplegia), meaning he is unable to move his upper and lower limbs, in his case due to a spinal cord injury. The man, identified in the study as T11, is a participant in a clinical trial of a brain-computer interface device that allows him to use a computer cursor and keyboard on a screen. The investigational device is being developed by the BrainGate consortium, a collaborative effort involving clinicians, neuroscientists, and engineers at several institutions with the goal of creating technologies to restore communication, mobility, and independence for people with neurologic disease, injury, or limb loss. The consortium is directed by Leigh R. Hochberg, MD, Ph.D., of MGH, Brown University, and the Department of Veterans Affairs.

In the study, T11 was asked to perform a memory task similar to the electronic game Simon, in which a player observes a pattern of flashing colored lights, then has to recall and reproduce that sequence. He controlled the cursor on the computer screen simply by thinking about the movement of his own hand. Sensors implanted in T11's motor cortex measured patterns of neuronal firing, which reflected his intended hand movement, allowing him to move the cursor around on the screen and click it at his desired locations. These brain signals were recorded and wirelessly transmitted to a computer.

That night, while T11 slept at home, activity in his motor cortex was recorded and wirelessly transmitted to a computer. "What we found was pretty incredible," says Rubin. "He was basically playing the game overnight in his sleep." On several occasions, says Rubin, T11's patterns of neuronal firing during sleep exactly matched patterns that occurred while he performed the memory-matching game earlier that day.

"This is the most direct evidence of replay from the motor cortex that's ever been seen during sleep in humans," says Rubin. Most of the replay detected in the study occurred during slow-wave sleep, a phase of deep slumber. Interestingly, replay was much less likely to be detected while T11 was in REM sleep, the phase most commonly associated with dreaming. Rubin and Cash see this work as a foundation for learning more about replay and its role in learning and memory in humans.

"Our hope is that we can leverage this information to help build better brain-computer interfaces and come up with paradigms that help people learn more quickly and efficiently in order to regain control after an injury," says Cash, noting the significance of moving this line of inquiry from animals to human subjects. "This kind of research benefits enormously from the close interaction we have with our participants," he adds, with gratitude to T11 and other participants in the BrainGate clinical trial.

Hochberg concurs. "Our incredible BrainGate participants provide not only helpful feedback toward the creation of a system to restore communication and mobility, but they also give us the rare opportunity to advance fundamental human neuroscience—to understand how the human brain works at the level of circuits of individual neurons," he says, "and to use that information to build next-generation restorative neurotechnologies."

Rubin is also an instructor in neurology at Harvard Medical School (HMS). Cash is an associate professor of Neurology at HMS. Hochberg is a senior lecturer on Neurology at HMS and a professor of Engineering at Brown University.

The study was funded by the National Institute of Neurologic Disease and Stroke, the American Academy of Neurology, the National Institute of Mental Health, Conquer Paralysis Now, the Department of Veterans Affairs, the MGH-Deane Institute, and the Howard Hughes Medical Institute at Stanford University.

SciTech Daily, 17 July 2022

https://scitechdaily.com

Ant colonies behave like neural networks when making decisions

2022-07-20

Temperatures are rising, and one colony of ants will soon have to make a collective decision. Each ant feels the rising heat beneath its feet but carries along as usual until, suddenly, the ants reverse course. The whole group rushes out as one—a decision to evacuate has been made. It is almost as if the colony of ants has a greater, collective mind.

A new study suggests that indeed, ants as a group behave similar to networks of neurons in a brain.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

Rockefeller's Daniel Kronauer and postdoctoral associate Asaf Gal developed a new experimental setup to meticulously analyze decision-making in ant colonies. As reported in the Proceedings of the National Academy of Sciences, they found that when a colony evacuates due to rising temperatures, its decision is a function of both the magnitude of the heat increase and the size of the ant group.

The findings suggest that ants combine sensory information with the parameters of their group to arrive at a group response—a process similar to neural computations giving rise to decisions.

"We pioneered an approach to understand the ant colony as a cognitive-like system that perceives inputs and then translates them into behavioral outputs," says Kronauer, head of the Laboratory of Social Evolution and Behavior. "This is one of the first steps toward really understanding how insect societies engage in collective computation."

"This is one of the first steps toward really understanding how insect societies engage in collective computation."

A new paradigm

At its most basic level, decision-making boils down to a series of computations meant to maximize benefits and minimize costs. For instance, in a common type of decision-making called sensory response thresholding, an animal has to detect sensory input like heat past a certain level to produce a certain costly behavior, like moving away. If the rise in temperature isn't big enough, it won't be worth it.

Kronauer and Gal wanted to investigate how this type of information processing occurs at the collective level, where group dynamics come into play. They developed a system in which they could precisely perturb an ant colony with controlled temperature increases. To track the behavioral responses of individual ants and the entire colony, they marked each insect with different colored dots and followed their movements with a tracking camera.

As the researchers expected, colonies of a set size of 36 workers and 18 larvae dependably evacuated their nest when the temperature hit around 34 degrees Celsius. This finding makes intuitive sense, Kronauer says, because "if you become too uncomfortable, you leave."

However, the researchers were surprised to find that the ants were not merely responding to temperature itself. When they increased the size of the colony from 10 to 200 individuals, the temperature necessary to trigger the decision to vacate increased. Colonies of 200 individuals, for example, held out until temperatures soared past 36 degrees. "It seems

that the threshold isn't fixed. Rather, it's an emergent property that changes depending on the group size," Kronauer says.

Individual ants are unaware of the size of their colony, so how can their decision depend on it? He and Gal suspect that the explanation has to do with the way pheromones, the invisible messengers that pass information between ants, scale their effect when more ants are present. They use a mathematical model to show that such a mechanism is indeed plausible. But they do not know why larger colonies would require higher temperatures to pack up shop. Kronauer ventures that it could simply be that the larger the colony's size, the more onerous it is to relocate, pushing up the critical temperature for which relocations happen.

In future studies, Kronauer and Gal hope to refine their theoretical model of the decision-making process in the ant colony by interfering with more parameters and seeing how the insects respond. For example, they can tamper with the level of pheromones in the ants' enclosure or create genetically altered ants with different abilities to detect temperature changes. "What we've been able to do so far is to perturb the system and measure the output precisely," Kronauer says. "In the long term, the idea is to reverse engineer the system to deduce its inner workings in more and more detail."

Phys Org, 20 July 2022

https://phys.org

Strange new phase of matter created in quantum computer acts like it has two time dimensions

2022-07-20

By shining a laser pulse sequence inspired by the Fibonacci numbers at atoms inside a quantum computer, physicists have created a remarkable, never-before-seen phase of matter. The phase has the benefits of two time dimensions despite there still being only one singular flow of time, the physicists report July 20 in Nature.

This mind-bending property offers a sought-after benefit: Information stored in the phase is far more protected against errors than with alternative setups currently used in quantum computers. As a result, the information can exist without getting garbled for much longer, an important milestone for making quantum computing viable, says study lead author Philipp Dumitrescu.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

The workhorses of the team's quantum computer are 10 atomic ions of an element called ytterbium.

The approach's use of an "extra" time dimension "is a completely different way of thinking about phases of matter," says Dumitrescu, who worked on the project as a research fellow at the Flatiron Institute's Center for Computational Quantum Physics in New York City. "I've been working on these theory ideas for over five years, and seeing them come actually to be realized in experiments is exciting."

Dumitrescu spearheaded the study's theoretical component with Andrew Potter of the University of British Columbia in Vancouver, Romain Vasseur of the University of Massachusetts, Amherst, and Ajesh Kumar of the University of Texas at Austin. The experiments were carried out on a quantum computer at Quantinuum in Broomfield, Colorado, by a team led by Brian Neyenhuis.

The workhorses of the team's quantum computer are 10 atomic ions of an element called ytterbium. Each ion is individually held and controlled by electric fields produced by an ion trap, and can be manipulated or measured using laser pulses.

Each of those atomic ions serves as what scientists dub a quantum bit, or "qubit." Whereas traditional computers quantify information in bits (each representing a 0 or a 1), the qubits used by quantum computers leverage the strangeness of quantum mechanics to store even more information. Just as Schrödinger's cat is both dead and alive in its box, a qubit can be a 0, a 1 or a mashup—or "superposition"—of both. That extra information density and the way qubits interact with one another promise to allow quantum computers to tackle computational problems far beyond the reach of conventional computers.

There's a big problem, though: Just as peeking in Schrödinger's box seals the cat's fate, so does interacting with a qubit. And that interaction doesn't even have to be deliberate. "Even if you keep all the atoms under tight control, they can lose their quantumness by talking to their environment, heating up or interacting with things in ways you didn't plan," Dumitrescu says. "In practice, experimental devices have many sources of error that can degrade coherence after just a few laser pulses."

The challenge, therefore, is to make qubits more robust. To do that, physicists can use "symmetries," essentially properties that hold up to change. (A snowflake, for instance, has rotational symmetry because it looks the same when rotated by 60 degrees.) One method is adding time symmetry by blasting the atoms with rhythmic laser pulses. This approach helps, but Dumitrescu and his collaborators wondered if they could go

further. So instead of just one time symmetry, they aimed to add two by using ordered but non-repeating laser pulses.

The best way to understand their approach is by considering something else ordered yet non-repeating: "quasicrystals." A typical crystal has a regular, repeating structure, like the hexagons in a honeycomb. A quasicrystal still has order, but its patterns never repeat. (Penrose tiling is one example of this.) Even more mind-boggling is that quasicrystals are crystals from higher dimensions projected, or squished down, into lower dimensions. Those higher dimensions can even be beyond physical space's three dimensions: A 2D Penrose tiling, for instance, is a projected slice of a 5-D lattice.

For the qubits, Dumitrescu, Vasseur and Potter proposed in 2018 the creation of a quasicrystal in time rather than space. Whereas a periodic laser pulse would alternate (A, B, A, B, A, B, etc.), the researchers created a quasi-periodic laser-pulse regimen based on the Fibonacci sequence. In such a sequence, each part of the sequence is the sum of the two previous parts (A, AB, ABA, ABAAB, ABAABABA, etc.). This arrangement, just like a quasicrystal, is ordered without repeating. And, akin to a quasicrystal, it's a 2D pattern squashed into a single dimension. That dimensional flattening theoretically results in two time symmetries instead of just one: The system essentially gets a bonus symmetry from a nonexistent extra time dimension.

Actual quantum computers are incredibly complex experimental systems, though, so whether the benefits promised by the theory would endure in real-world qubits remained unproven.

Using Quantinuum's quantum computer, the experimentalists put the theory to the test. They pulsed laser light at the computer's qubits both periodically and using the sequence based on the Fibonacci numbers. The focus was on the qubits at either end of the 10-atom lineup; that's where the researchers expected to see the new phase of matter experiencing two time symmetries at once. In the periodic test, the edge qubits stayed quantum for around 1.5 seconds—already an impressive length given that the qubits were interacting strongly with one another. With the quasi-periodic pattern, the qubits stayed quantum for the entire length of the experiment, about 5.5 seconds. That's because the extra time symmetry provided more protection, Dumitrescu says.

"With this quasi-periodic sequence, there's a complicated evolution that cancels out all the errors that live on the edge," he says. "Because of that,

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

the edge stays quantum-mechanically coherent much, much longer than you'd expect."

Though the findings demonstrate that the new phase of matter can act as long-term quantum information storage, the researchers still need to functionally integrate the phase with the computational side of quantum computing. "We have this direct, tantalizing application, but we need to find a way to hook it into the calculations," Dumitrescu says. "That's an open problem we're working on."

Phys Org, 20 July 2022

https://phys.org

All-in-one solar tower produces jet fuel from CO2, water and sunlight

2022-07-20

Taking carbon dioxide, water and sunlight as its only inputs, this solar thermal tower in Spain produces carbon-neutral, sustainable versions of diesel and jet fuel. Built and tested by researchers at ETH Zurich, it's a promising clean fuel project.

Why do we need sustainable aviation fuel (SAF)?

Fossil fuels can be replaced with batteries or hydrogen in cars and trucks – but aircraft are trickier. With more than 25,000 commercial airliners in service today, and service lifetimes around 25 years, airlines are looking to carbon-neutral fuels to bring down their emissions. It's a transitional step, but an important one until clean aviation tech is ready and the entire global fleet can be converted to something else.

Carbon-neutral fuels are drop-in replacements for today's kerosene Jet-A fuel; they mix in with regular fuel and get burned in jet engines as per normal, producing the normal amount of carbon emissions. The difference is that rather than pulling that carbon straight out of the ground, carbon-neutral fuels grab CO2 from elsewhere; it'll still end up in the atmosphere, but at least it does some useful work before it gets there, and every gallon burned is a gallon of conventional fuel that wasn't burned.

How is SAF currently made?

There are a lot of ways to make carbon-neutral fuels – and not all of those are acceptable for other reasons. Biofuels grown from specially raised corn crops, for example, create their own emissions, from fertilizers and farm

Fossil fuels can be replaced with batteries or hydrogen in cars and trucks – but aircraft are trickier.

equipment, and they use land that could otherwise be producing food. Chopping down forests and using the wood as biomass is also out, for reasons that should be obvious, but the fact that there are rules in place around this suggests that even in the sustainability game, there are still bad-faith operators.

Landfill waste-to-jet-fuel plants are popping up here and there, taking municipal garbage or old cooking oil and using that as a feedstock to create syngas, which can be refined into synthetic fuels. But the pyrolysis process usually involved requires a lot of energy – either dirty energy or clean energy that could be used elsewhere – and the feedstock is so wildly random that the resulting fuels sometimes need an extra, energy-intensive cleaning step before they're ready to go save the planet in a Dreamliner.

Another way is to capture carbon directly from other emissions sources, and convert that into fuel. This can be done by using green electricity to power an electrolyzer, then mixing the resulting hydrogen with carbon monoxide to create syngas, which can then be refined into fuels – but there are energy losses at each of these steps.

Which brings us to this new, much simpler design out of ETH Zurich, which has been built and tested at the IMDEA Energy Institute in Spain.

ETH Zurich's all-in-one carbon-neutral fuel tower

This pilot plant runs on concentrating solar thermal energy. One hundred and sixty-nine sun-tracking reflector panels, each presenting three square meters (~32 sq ft) of surface area, redirect sunlight into a 16-cm (6.3-in) hole in the solar reactor at the top of the 15-m-tall (49-ft) central tower. This reactor receives an average of about 2,500 suns' worth of energy – about 50 kW of solar thermal power.

This heat is used to drive a two-step thermochemical redox cycle. Water and pure carbon dioxide are fed in to a ceria-based redox reaction, which converts them simultaneously into hydrogen and carbon monoxide, or syngas. Because this is all being done in a single chamber, it's possible to tweak the rates of water and CO2 to live-manage the exact composition of the syngas.

This syngas is fed to a Gas-to-Liquid (GtL) unit at the bottom of the tower, which produced a liquid phase containing 16% kerosene and 40% diesel, as well as a wax phase with 7% kerosene and 40% diesel – proving that the ceria-based ceramic solar reactor definitely produced syngas pure enough for conversion into synthetic fuels.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

How much fuel does it make?

This is the big question, really, and I'm afraid the research paper doesn't make this information easy to divine. Overall, the researchers ran the system for nine days, running six to eight cycles a day, weather permitting. Each cycle lasted an average of 53 minutes, and the total experimental time was 55 hours. Several cycles had to be stopped due to overheating, when temperatures in the reactor rose past the targeted 1,450 °C (2,642 °F) to a critical temperature of 1,500 °C (2,732 °F).

In total, the experimental pilot plant produced around 5,191 liters (1,371 gal) of syngas over those nine days, but the researchers don't indicate exactly how much kerosene and diesel this became after the syngas was processed, so we can't give a simple figure for this pilot plant's output per day. Even if we could, it might not scale up in a linear fashion.

But to give you a sense of the size of the problem here, a Boeing 787 Dreamliner has a fuel capacity up to 126,372 L (36,384 gal), on which it can fly up to 14,140 km (8,786 miles) – roughly the distance from New York to Ho Chi Minh City. And there are tens of thousands of commercial aircraft out there flying multiple missions per day.

But these things don't necessarily have to replace all the fuel in question – synthetic fuel can be blended with regular fuel in whatever quantities it's available, and every bit helps reduce overall emissions.

Where to from here?

The team says the system's overall efficiency (measured by the energy content of the syngas as a percentage of the total solar energy input) was only around 4% in this implementation, but it sees pathways to getting that up over 20% by recovering and recycling more heat, and altering the structure of the ceria structure.

"We are the first to demonstrate the entire thermochemical process chain from water and CO2 to kerosene in a fully-integrated solar tower system," said ETH Professor Aldo Steinfeld, the corresponding author of the research paper. "This solar tower fuel plant was operated with a setup relevant to industrial implementation, setting a technological milestone towards the production of sustainable aviation fuels."

"The solar tower fuel plant described here represents a viable pathway to global-scale implementation of solar fuel production," reads the study.

The research is open access in the peer-reviewed journal Joule.

New Atlas, 20 July 2022

https://newatlas.com

How do galaxies evolve? A college student may have provided the missing link

2022-07-21

A University of Massachusetts Amherst undergraduate student has contributed significant work regarding the growth of stars and black holes, providing key insight into how they are linked. This new information will allow the James Webb Space Telescope (JWST) to more efficiently untangle how, exactly, galaxies work.

Astronomers know that the evolution of galaxies is powered by two processes: the growth of supermassive black holes at each galaxy's center and the formation of new stars. How these processes are related has remained a mystery and is one of the questions that the recently launched James Webb Space Telescope (JWST) will be exploring. Work by Meredith Stone, who graduated from UMass Amherst's astronomy program in May 2022, will help scientists better understand how they are linked.

"We know that galaxies grow, collide and change throughout their lives," says Stone, who completed this research under the direction of Alexandra Pope, professor of astronomy at the University of Massachusetts Amherst and senior author of a new paper, recently published in The Astrophysical Journal. "And we know that black hole growth and star formation play crucial roles. We think that the two are linked and that they regulate each other, but until now, it's been very hard to see exactly how."

Part of the reason that it has been difficult to study the interaction between black holes and stars is that we can't really see these interactions because they take place behind enormous clouds of galactic dust. "For galaxies that are actively forming stars, more than 90% of the visible light can be absorbed by dust," says Pope, "and this dust absorbs visible light."

However, there's a workaround: When the dust absorbs visible light, it heats up, and though the naked human eye can't see heat, infrared telescopes can. "We used the Spitzer Space Telescope," says Stone, who will begin her graduate studies in astronomy at the University of Arizona this fall, "collected during the Great Observatories All-sky LIRG Survey (GOALS) campaign, to look at the mid-infrared wavelength range of some of the

This new information will allow the James Webb Space Telescope (JWST) to more efficiently untangle how, exactly, galaxies work.

CHEMWATCH
Bulletin Board
Curiosities
JUL. 29, 2022

brightest galaxies that are relatively close to Earth." In particular, Stone and her co-authors were looking for particular tell-tale tracers that are the fingerprints of black holes and stars in the midst of formation.

The difficulty is that these fingerprints are exceedingly faint and nearly impossible to distinguish from the general noise of the infrared spectrum. "What Meredith did," says Pope, "is to calibrate the measurements of these tracers so that they are more distinct."

Once the team had these more distinct observations in hand, they could see that in fact, black hole growth and star formation are happening concurrently in the same galaxies and they do seem to be influencing each other. Stone was even able to calculate the ratio that describes how the two phenomena are linked.

Not only is this an exciting scientific achievement on its own, Stone's work can be taken up by the JWST, with its unprecedented access to the mid-infrared spectrum light, and used to zero in much more closely on the questions that remain. For though Stone and her co-authors, including UMass Amherst astronomy graduate student Jed McKinney, quantified how black holes and stars are linked in the same galaxy, why they're linked remains a mystery.

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CHEMWATCH

Bulletin Board

Technical Notes

JUL. 29, 2022

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

CHEMICAL EFFECTS

In vitro analysis of catalase and superoxide dismutase mimetic properties of blue tattoo ink

Developmental neurotoxicity induced by glutaraldehyde in neuron/astrocyte co-cultured cells and zebrafish

Phenols, Parabens, Phthalates and Puberty: a Systematic Review of Synthetic Chemicals Commonly Found in Personal Care Products and Girls' Pubertal Development

Nanotechnology in agriculture: Comparison of the toxicity between conventional and nano-based agrochemicals on non-target aquatic species

ENVIRONMENTAL RESEARCH

Long-term exposure to air pollution, coronary artery calcification, and carotid artery plaques in the population-based Swedish SCAPIS Gothenburg cohort

PHARMACEUTICAL/TOXICOLOGY

Effects of Glyphosate and Roundup™ on the mammalian nervous system: A review

Urinary nitrate and sodium in a high-risk area for upper gastrointestinal cancers: Golestan Cohort Study

OCCUPATIONAL

Characteristics and health effects of particulate matter emitted from a waste sorting plant

Occupational exposure to rare earth elements: Assessment of external and internal exposure

Identification of substances with a carcinogenic potential in spray-formulated engine/brake cleaners and lubricating products, available in the European Union (EU) - based on IARC and EU-harmonised classifications and QSAR predictions