

## Contents

CHEMWATCH

(click on page numbers for links)

### REGULATORY UPDATE

#### ASIA PACIFIC

Workplace exposure standards open for public comment – Release 8 .....	4
APVMA announces chemical review of neonicotinoids.....	5
Agencies join forces in methyl bromide monitoring program .....	6
China Officially Unveils Measures for Safety Administration of Road Transport of Dangerous Goods.....	7

#### AMERICA

EPA Takes Important Step to Advance PFAS Action Plan, Requests Public Input on Adding PFAS Chemicals to the Toxics Release Inventory..	12
EPA Bans All Retail Distribution of Methylene Chloride to Consumers for Paint and Coating Removal .....	15
Council approves ban on county use of herbicides .....	16

#### EUROPE

BPA study appraisal approach tested.....	18
RoHS Directive Annex III amended .....	18
Cosmetic Products Regulation Annexes V and VI amended.....	19

### REACH UPDATE

Companies need to improve communication of hazardous substances in products .....	20
ECHA does not consider dossier updates during evaluation decision making .....	21
Improving the quality of your REACH registration dossier – what authorities are planning and how you can prepare .....	22
New substance evaluation conclusion published.....	22
Public consultation on harmonised classification and labelling.....	23
Chesar upgrade now available .....	23

### JANET'S CORNER

More Fish in the Sea .....	25
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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

CHEMWATCH

### HAZARD ALERT

Selenium.....26

### GOSSIP

Could a new 2-D material allow semiconductors to keep getting smaller, stronger better and faster?.....32

How oxygen destroys the core of important enzymes .....33

Thorium superconductivity: Scientists discover a new high-temperature superconductor .....34

Tethered chem combos could revolutionize artificial photosynthesis.....35

A laser-sighted toxic goo gun is killing feral cats in Australia .....37

Batteries as transparent as glass could power devices in your home.....39

New Way to Develop Graphene-enhanced Electrodes for Lighter EVs .....40

Researchers develop thin heat shield for superfast aircraft .....41

Scientists design built-in controls for mini-chemical labs on a chip .....42

Chemists use light to build biologically active compounds.....43

A new kind of glue to bond polyethylene.....44

Breaking carbon dioxide faster, cheaper, and more efficiently .....45

Five-fold boost in formaldehyde yield.....46

New catalysts remove NOx pollutants at lower temperatures .....48

Atomically dispersed Ni is coke-resistant for dry reforming of methane ..49

Bottlebrushes rise up to control coatings .....50

Researchers create and stabilize pure polymeric nitrogen using plasma ..52

Gallium-based solvating agent efficiently analyses optically active alcohols.....54

Stretchable, degradable semiconductors .....55

Supercharged Trash Gas Could Produce More Green Energy .....56

Using aluminium and lasers to make bendable glass.....58

### CURIOSITIES

New Evidence Reveals 'Causal Connection' Between Sleep Quality And Anxiety .....59

Chronic Form of B12 Deficiency Can Cause Major Health Issues, And Is Often Misdiagnosed.....61

## Contents

**CHEMWATCH**

Massive Review Confirms House Plants Aren't Actually 'Purifying' The Air in Your Home .....	63
Exposed: A scientific stalemate leaves our hormones and health at risk ...	65
Steel and concrete are climate change's hard problem. Can we solve it? ..	79
Zero gravity made some astronauts' blood flow backwards.....	83
Researchers Find a Way to Treat Cyberchondria: Anxiety Over Googling Your Symptoms .....	84

### TECHNICAL NOTES

(Note: Open your Web Browser and click on Heading to link to section)...	87
ENVIRONMENTAL RESEARCH .....	87
MEDICAL RESEARCH.....	87
OCCUPATIONAL RESEARCH .....	87
PUBLIC HEALTH RESEARCH.....	88

## Regulatory Update

CHEMWATCH

### ASIA PACIFIC

#### Workplace exposure standards open for public comment – Release 8

2019-11-29

Safe Work Australia is evaluating the Workplace exposure standards for airborne contaminants to ensure they are based on the highest quality evidence and supported by a rigorous scientific approach. Release 8 is now open for public comment. Please note that this release includes chemicals that were deferred from previous releases as well as chemicals that do not currently have an Australian workplace exposure standard.

The chemicals in this release are:

- Dichloroethyl ether
- Dichlorotetrafluoroethane
- 2-Diethylaminoethanol
- Dimethylamine
- N,N-Dimethylethylamine
- 1,1-Dimethylhydrazine
- Disulfoton
- Enflurane
- Ethion
- Ethyl alcohol
- Ethyl butyl ketone
- Ethyl Cyanoacrylate\*
- Ethyl mercaptan
- Ethyl silicate
- Ethylene\*
- Ethylene chlorohydrin
- Ethylene thiourea\*
- 2-Ethylhexanoic acid\*

\*Chemicals that do not currently have an exposure standard

In particular, Safe Work Australia are seeking comments of a technical nature regarding:

- the toxicological information and data that the value is based upon, and

**Safe Work Australia is evaluating the Workplace exposure standards for airborne contaminants to ensure they are based on the highest quality evidence and supported by a rigorous scientific approach.**

## Regulatory Update

CHEMWATCH

- the measurement and analysis information provided.

Safe Work Australia consultation platform, Engage can be used to provide your comments on the draft evaluation reports and recommendations for Release 8. Please note evaluation reports for fenamiphos to hydrogenated terphelyls have been deferred to future releases. Public comment will close on 20 December 2019. The feedback received will be considered when making final recommendations for workplace exposure standards. The draft evaluation reports and recommendations for the remaining chemicals will be released throughout 2019 and 2020. If you know someone who has an interest in workplace exposure standards, please forward this email and recommend they subscribe to the 'chemicals exposure standards' mailing list to stay informed about the review and release dates.

Safe Work Australia, 25 November 2019

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

### **APVMA announces chemical review of neonicotinoids**

2019-11-29

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has announced a chemical review of a group of systemic insecticides known as the neonicotinoids. Based on possible risks, including to pollinators, aquatic invertebrates, birds and small mammals, the reassessment will be environment-focussed. The review will also consider whether product labels carry adequate instructions to protect community and worker health. "This reconsideration will allow us to reassess the risks posed by neonicotinoid use, and whether any regulatory changes are necessary to protect the health and safety of people, animals, plants, and the environment. "There has been a lot of global regulatory interest in neonicotinoids and a number of reports linking neonicotinoids with adverse environmental impacts, including on aquatic health and non-target and terrestrial invertebrates." said the APVMA Chief Executive Officer, Dr Chris Parker. "There is also a need to ensure our approved labels align with recently published APVMA guidelines (including for pollinators and managing spray drift)." The APVMA and the New Zealand Environmental Protection Agency (NZ EPA) plan to work together to identify areas of possible collaboration over the course of this review. "While NZ EPA and APVMA have their own legislative frameworks to operate under, this is an opportunity for the agencies to work together in a collaborative manner to achieve efficiencies that best serve our roles as chemical regulators both in Australia and New Zealand." said Dr Parker.

**The Australian Pesticides and Veterinary Medicines Authority (APVMA) has announced a chemical review of a group of systemic insecticides known as the neonicotinoids.**

## Regulatory Update

CHEMWATCH

The first stage of the review will seek public comment on the scope and work plan, which is available in the [Gazette](#). Submissions will close on 3 February 2020. More information on the review is available on the [APVMA website](#).

APVMA, 19 November 2019

<http://www.apvma.gov.au>

### Agencies join forces in methyl bromide monitoring program

2019-11-29

New Zealand's Environmental Protection Authority (EPA) is putting plans in place to increase methyl bromide monitoring following a theoretical modelling report about how the log fumigant disperses into the environment after use. This is additional monitoring, over and above the routine monitoring that industry is required to carry out every time methyl bromide fumigation occurs. The mathematical modelling of operations at the Port of Tauranga was commissioned by the Environmental Protection Authority (EPA) as part of a modified reassessment currently underway to review the rules around methyl bromide use. This modified reassessment is a statutory process where an independent decision-making committee considers evidence in relation to the way methyl bromide is used. The additional monitoring, to be carried out by WorkSafe, will feed into that process. The Ministry of Health is maintaining a watching brief on the monitoring programme and stresses there is no immediate public health concern. Gayle Holmes, Acting General Manager of the EPA's Hazardous Substances Group, says: "We know New Zealanders are concerned about methyl bromide use so it's important that we get accurate data on which to base our decisions." "Our mathematical modelling report conflicts with that put forward by industry as part of the current reassessment process, and others undertaken when methyl bromide was last reassessed in 2010. It is also at odds with routine monitoring data which industry is required to undertake whenever methyl bromide is used at ports around New Zealand." "Computer-based modelling is a tool that uses an array of mathematical assumptions which can differ from the actual measurements of air quality. Because the reports all reflect different outcomes, the EPA commissioned an independent peer review to further test the hypothesis of its own report. It confirms that more detailed data is necessary." "To gain more data, WorkSafe will begin monitoring air dispersal patterns following timber fumigations at the Port of Tauranga. Catherine Epps, Head of Health and Technical Services at WorkSafe says: "The tests

**New Zealand's Environmental Protection Authority (EPA) is putting plans in place to increase methyl bromide monitoring following a theoretical modelling report about how the log fumigant disperses into the environment after use.**

## Regulatory Update

CHEMWATCH

are highly sensitive and require laboratory analysis. It will take some weeks to build an accurate picture on which to better understand the accuracy of computer modelling." Data from the tests will fill the gap between what the modelling reflects and what can be detected in the air; it will track the chemical's dispersal patterns and concentration levels. This additional data will then be considered by the EPA Decision-making Committee which is responsible for deciding if changes are needed to the rules around methyl bromide use. The mathematical modelling report, subsequent peer review and all other related information being put forward as evidence to inform the modified reassessment of methyl bromide is available on our website. The EPA's Decision-making Committee is considering the modified reassessment of methyl bromide announced the public hearings, planned for December, will be deferred to the new year, so that this additional monitoring data can be taken into account. Further information is available at:

- [Read the Decision-making committee's direction and minute](#)
- [Read the mathematical modelling report commissioned by the EPA](#)
- [Read the peer review report of the latest modelling](#)
- [Read the latest information about this reassessment process](#)

NZ EPA, 18 November 2019

<http://www.epa.govt.nz>

### China Officially Unveils Measures for Safety Administration of Road Transport of Dangerous Goods

2019-11-29

On 25 November 2019, the Chinese Ministry of Transport (MOT), Ministry of Industry and Information Technology (MIIT), Ministry of Public Security (MPS), Ministry of Ecology and Environment (MEE), Ministry of Emergency Management (MEM) and State Administration for Market Regulation (SAMR) jointly released the long-awaited official version of the *Measures for Safety Administration of Road Transport of Dangerous Goods*. The Measures will take effect on 1 January 2020. The development of the Measures started from 2014. Over the past five years, relevant authorities have held seven consultations and 20-odd symposiums to pool wisdom, with an aim to flesh out its rules and enable it to address daunting challenges in road transport of dangerous goods in China. Based on lessons from major accidents, regulatory practices of local authorities and international experience in this regard, the Measures involves significant adjustments to various systems, including consignment and carriage of dangerous goods,

**The China's MOT, together with several other agencies, jointly issued the official version of the Measures for Safety Administration of Road Transport of Dangerous Goods**

## Regulatory Update

CHEMWATCH

goods transported in excepted quantities (EQ) and limited quantities (LQ), tank and tanker inspections, etc.

### Scope of Exemptions

The Measures does not apply to four categories of items, including:

- Dangerous goods transported in military vehicles
- Hazardous chemicals not listed in the *Regulations Concerning Road Transportation of Dangerous Goods (JT/T617)*
- Hazardous wastes of which the transfer and transport are exempted from regulation according to provisions in the National Catalogue of Hazardous Wastes
- Radioactive pharmaceuticals for diagnosis

For the latter three categories, their road transport should be regulated according to provisions separately developed by authorities in charge of transport or ecology and environment under the State Council.

### LQ/EQ Exemption for Road Transport of Dangerous Goods

The Measures finalise rules on road transport of dangerous goods packed in LQ or EQ, as illustrated in the table below.

	EQ	LQ
Standards for packaging, labelling, package testing, quantity limit of each inner package and outer package	JT/T617	

## Regulatory Update

**CHEMWATCH**

	<b>EQ</b>	<b>LQ</b>
Shipping documents	Consignors should provide carriers with written declarations which state that the packaging meets requirements in JT/T 617; and carriers should require vehicle drivers to carry such declarations along with them. The dangerous goods consignment inventory offered by consignors should include indication of dangerous goods packed in EQ and the number of EQ packages.	Consignors should provide carriers with packaging performance test reports or written declarations which state that the packaging meets requirements in JT/T 617; and carriers should require vehicle drivers to carry such declarations along with them. The dangerous goods consignment inventory offered by consignors should include indication of dangerous goods packed in LQ, and the number and the gross mass (packaging included) of LQ packages.
Mixed stowage and segregation	It should be prohibited to mix and transport LQ packages of dangerous goods together with explosives. In the case of mixed stowage of LQ and EQ packages of dangerous goods, other dangerous goods and general goods, relevant businesses are exempted from segregation requirements.	
Quantity limit for per transport vehicle	Number of packages offered as EQ $\leq$ 1,000	Gross mass (packaging included) of packaged offered as LQ $\leq$ 8,000 kg

Notably, in the third draft, it was specified that dangerous goods packed in EQ/LQ do not include highly toxic chemicals, explosives (Hazard Class 1), and infectious substances (Hazard Class 6, Division 6.2). However, the rule has been removed in the official version.

### Obligations of Consignors and Carriers of Dangerous Goods

According to the Measures, in order to ensure safe transport of dangerous goods, consignors and carriers are required to fulfil their respective obligations.

## Regulatory Update

CHEMWATCH

	Obligations
Consignors	<p>Entrust goods to qualified carriers</p> <p>Make sure the classification, name, packaging, etc. are compliant with standards in JT/T617; where any reaction inhibitor or stabilising agent is needed, consignors should add such substances and inform carriers of the addition</p> <p>Do not mix dangerous goods with non-dangerous goods, make false declarations or transport dangerous goods disguised as general ones</p> <p>Package dangerous goods in line with JT/T617, and put up indication of dangerous goods on the outer package</p> <p>Provide the carrier with a dangerous goods consignment inventory in either paper or electronic form and well preserve the inventory for no less than 12 months thereafter</p> <p>Acquire relevant documents for the transport or transfer of highly toxic chemicals, civil explosives, Type I radioactive materials and hazardous wastes (medical wastes included)</p> <p>...</p>

## Regulatory Update

CHEMWATCH

	Obligations
Carriers	<p>Accept only consignment within the approved business scope and operate in line with <i>Provisions on the Road Transport of Dangerous Goods</i> (MOT Order 2 of 2013)</p> <p>Use vehicles and equipment of which the technical conditions meet national standards and match with the properties and weight of dangerous goods</p> <p>Prepare and carry along a dangerous goods waybill in either paper or electronic form which should be kept for no less than 12 months thereafter; in the case of hazardous waste, carriers should also fill in and carry along a hazardous waste transfer manifest in either paper or electronic form</p> <p>Check the technical conditions of vehicles, tanks of tankers, portable tanks, tank containers as well as satellite positioning devices and keep records before deploying vehicles, and inform drivers and escorts of relevant safety precautions</p> <p>Check the appearance of vehicles, tanks of tankers, portable tanks and tank containers: drivers and escorts should ensure that relevant marks are installed or hung on vehicles in line with <i>Marks for Vehicles in Road Transport of Dangerous Goods</i><sup>[3]</sup>; where vehicles are used to transport explosives and highly toxic chemicals, drivers and escorts should ensure that vehicles are marked with safety signs in line with <i>Safety Specifications for Road Transportation Vehicle of Explosive Substance and Chemical Toxic Substance</i><sup>[4]</sup></p> <p>...</p>

The Measures also provides rules concerning loading and unloading of dangerous goods, requirements for vehicles and equipment used in road

## Regulatory Update

CHEMWATCH

transport of dangerous goods, and penalties against anyone violating the Measures.

Chemlinked, 26 November 2019

<http://chemlinked.com/en/news>

### AMERICA

#### **EPA Takes Important Step to Advance PFAS Action Plan, Requests Public Input on Adding PFAS Chemicals to the Toxics Release Inventory**

2019-11-29

The United States Environmental Protection Agency (EPA) is asking the public for input on potentially adding certain per- and polyfluoroalkyl substances (PFAS) to the list of chemicals companies are required to report to the agency as part of the Toxics Release Inventory (TRI). This action supports the agency's February 2019 [PFAS Action Plan](#), which describes EPA's long- and short-term actions to address PFAS. "EPA continues to show critical leadership on addressing PFAS as we aggressively implement our PFAS Action Plan—the most comprehensive cross-agency plan to address an emerging chemical ever taken by EPA," said EPA Administrator Andrew Wheeler. "I started at the agency as a career employee in the TRI program and exploring the addition of certain PFAS chemicals to the TRI is an important step that can enhance this tool and provide important information to the public on these chemicals for the first time." EPA's TRI is an important tool that provides the public with information about the use of certain chemicals by tracking their management and associated activities. U.S. facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy recovery, and treatment. TRI helps support informed decision-making by companies, government agencies, non-governmental organisations and the public. Currently, no PFAS chemicals are included on the list of chemicals required to report to TRI. As EPA considers whether to add these chemicals, the agency will use public comments and information received in response to today's [Advance Notice of Proposed Rulemaking \(ANPRM\)](#) for two purposes. First, the public input will help the agency determine whether data and information are available to fulfil the TRI chemical listing criteria. Second, EPA will use the input to help evaluate the extent and usefulness of the data that would be gathered under TRI. All comments and information received in

**The United States Environmental Protection Agency (EPA) is asking the public for input on potentially adding certain per- and polyfluoroalkyl substances (PFAS) to the list of chemicals companies are required to report to the agency as part of the Toxics Release Inventory (TRI).**

## Regulatory Update

CHEMWATCH

response to this ANPRM will be evaluated along with previously collected and assembled studies. If EPA decides to move forward with adding PFAS chemicals to the TRI, the agency will publish a proposed rule and seek public comment on the proposal. To view the ANPRM, visit <https://www.epa.gov/toxics-release-inventory-tri-program/pre-publication-version-advance-notice-proposed-rulemaking>. The comment period will open upon publication of the Federal Register Notice on [www.regulations.gov](http://www.regulations.gov).

For more information on PFAS, visit [www.epa.gov/pfas](http://www.epa.gov/pfas)

For more information on TRI, visit [www.epa.gov/tri](http://www.epa.gov/tri)

### Background

PFAS are a large group of man-made chemicals used in consumer products and industrial processes. In use since the 1940s, PFAS are resistant to heat, oils, stains, grease, and water—properties which contribute to their persistence in the environment. The agency's PFAS Action Plan is the first multi-media, multi-program, national research, management and risk communication plan to address a challenge like PFAS. The plan responds to the extensive public input the agency received during the PFAS National Leadership Summit, multiple community engagements, and through the public docket. The PFAS Action Plan outlines the tools EPA is developing to assist states, tribes, and communities in addressing PFAS. EPA continues to make progress under its PFAS Action Plan to protect the environment and human health. To date, EPA has:

### Highlighted Action: Drinking Water

The Agency is moving forward with the drinking water standard setting process outlined in the Safe Drinking Water Act (SDWA) for PFOA and PFOS. As a next step, EPA will propose a regulatory determination for PFOA and PFOS by the end of this year. The Agency is also gathering and evaluating information to determine if regulation is appropriate for other chemicals in the PFAS family.

### Highlighted Action: Clean-up

On 10 June 2019, EPA concluded public comment on the draft *Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS*, when finalised it will provide clean-up guidance for federal clean-up programs (e.g., CERCLA and RCRA) that will be helpful to states and tribes. EPA is initiating the regulatory development process for listing certain PFAS as hazardous substances under CERCLA.

## Regulatory Update

CHEMWATCH

### Highlighted Action: Monitoring

EPA will propose nationwide drinking water monitoring for PFAS under the next UCMR monitoring cycle.

### Highlighted Action: Toxics

EPA has issued a proposed advanced notice of proposed rulemaking that would allow the public to provide input on adding PFAS to the Toxics Release Inventory toxic chemical list. A supplemental proposal to ensure that certain persistent long-chain PFAS chemicals cannot be manufactured in or imported into the United States without notification and review under the TSCA is currently undergoing interagency review at the Office of Management and Budget.

### Highlighted Action: Surface Water Protection

EPA plans to develop national Clean Water Act human health and aquatic life criteria for PFAS, as data allows. EPA is examining available information about PFAS released into surface waters by industrial sources to determine if additional study is needed for potential regulation.

### Highlighted Action: Biosolids

EPA will be developing risk assessments for PFOA and PFOS to understand any potential health impacts.

### Highlighted Action: Research

EPA continues to compile and assess human and ecological toxicity information on PFAS to support risk management decisions. EPA continues to develop new analytical methods to test for additional PFAS in drinking water. The Agency is also validating analytical methods for surface water, ground water, wastewater, soils, sediments and biosolids; developing new methods to test for PFAS in air and emissions; and improving laboratory methods to discover unknown PFAS. EPA is developing exposure models to understand how PFAS moves through the environment to impact people and ecosystems. EPA continues to assess and review treatment methods for removing PFAS in drinking water. EPA is working to develop tools to assist officials with the clean-up of contaminated sites. EPA is evaluating the effectiveness technologies and evaluating data on methods for managing the end-of-life disposal of PFAS-contaminated materials.

### Highlighted Action: Enforcement

## Regulatory Update

CHEMWATCH

EPA uses enforcement tools, when appropriate, to address PFAS exposure in the environment and assists states in enforcement activities.

### Highlighted Action: Risk Communications

EPA will work collaboratively to develop a risk communication toolbox that includes multi-media materials and messaging for federal, state, tribal, and local partners to use with the public.

U.S EPA, 25 November 2019

<http://www.epa.gov>

### **EPA Bans All Retail Distribution of Methylene Chloride to Consumers for Paint and Coating Removal**

2019-11-29

The United States Environmental Protection Agency's (EPA) regulations to prohibit the manufacture (including import), processing, and distribution of methylene chloride in all paint removers for consumer use will go into effect after 22 November 2019. From this time, it will be unlawful for any person or retailer to sell or distribute paint removal products containing methylene chloride for consumer use, including e-commerce sales.

"EPA's action keeps paint and coating removers that contain the chemical methylene chloride out of consumers' hands," said EPA Administrator Andrew Wheeler. "It is against the law to sell or distribute methylene chloride for paint and coating removal in the retail marketplace—a step that will provide important public health protections for consumers." EPA is encouraging all consumers to stop using methylene chloride products that they may have already purchased for paint and coating removal. EPA is also reminding all retailers that sales of these products to consumers is prohibited by EPA regulations under the authority of section 6 of the Toxic Substances Control Act (TSCA). To learn more about how to comply with the regulations, including recordkeeping requirements, please visit: [www.epa.gov/assessing-and-managing-chemicals-under-tsca/small-entity-compliance-guidance-regulation-methylene](http://www.epa.gov/assessing-and-managing-chemicals-under-tsca/small-entity-compliance-guidance-regulation-methylene)

The final regulation on methylene chloride for consumer paint and coating removal use was published on 27 March 2019, and the prohibition related to manufacturing, processing and distribution of methylene chloride for consumer paint and coating removal use is in now effect. A variety of effective, less harmful substitutes are readily available for paint removal. EPA is continuing to work through the process outlined in TSCA to review the risks associated with other uses of methylene chloride. This process is

**The United States Environmental Protection Agency's (EPA) regulations to prohibit the manufacture (including import), processing, and distribution of methylene chloride in all paint removers for consumer use will go into effect after 22 November 2019.**

## Regulatory Update

CHEMWATCH

designed to thoroughly evaluate available science before taking action to manage the risk associated with the other uses of the chemical.

Learn more about methylene chloride: [www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-methylene-chloride](http://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-methylene-chloride)

U.S EPA, 22 November 2019

<http://www.epa.gov>

### Council approves ban on county use of herbicides

2019-11-29

Urged on by new mothers, beekeepers, organic farmers and a soccer coach, a Hawaiian County Council recently passed a bill banning the county's use of herbicides on public property, making Hawaii County the first local government in the state to do so. Bill 101, sponsored by Kona Councilwoman Rebecca Villegas, will, throughout a four-year period, ban the use of Roundup and 29 other herbicides in parks and alongside roads, bikeways, sidewalks, trails, drainageways and waterways owned or maintained by the county. Villegas said she got support from Mayor Harry Kim's administration before introducing the bill. But Kim said after the vote he'd have to analyse it carefully and run it past staff before committing to signing it. "There is no disagreement we want to do this," Kim said. "We must know the consequences of it and be able to mitigate them; we've got to plan for it and be willing to pay for it." Dozens of testifiers supported the bill, while a fewer number, primarily farmers, nursery owners and flower growers, opposed it. The state last year banned the pesticide chlorpyrifos, used to kill insects and worms. The state Department of Education banned herbicides on its campuses about five years ago. Maui County administration and the state Department of Transportation have scaled back on herbicide use on Maui, but no legislation has been passed making it mandatory. Several Maui residents came to testify, including former DOT Highways Superintendent Stephen Rodgers, who said switching to organic herbicides and long-armed mowers enabled his crews to eliminate glyphosate, the active ingredient in the non-selective herbicide Roundup, from the mix without increasing labor costs. "They weren't perfect, but they did work," Rodgers said. The 6-3 vote didn't come without controversy. Kohala Councilman Tim Richards, Hilo Councilman Aaron Chung and Hilo Councilwoman Sue Lee Loy voted against the measure. The bill doesn't apply to private property or citizens who maintain land adjacent to county easements or lease agricultural land from the county. But Richards, a veterinarian, rancher and staunch proponent of agriculture,

**Urged on by new mothers, beekeepers, organic farmers and a soccer coach, a Hawaiian County Council recently passed a bill banning the county's use of herbicides on public property, making Hawaii County the first local government in the state to do so.**

## Regulatory Update

### CHEMWATCH

expressed concerns that the bill could be used as a “stepping stone” to a countywide ban. He noted that three of the banned chemicals target weeds in soybeans and corn, which the county doesn’t grow. Richards called the bill “too overarching, too far-reaching.” “The last thing we need to do is put anything in the way of agriculture to prevent it growing forward,” Richards said. “I completely support the intent, but I do not support the way this bill is written.” Supporters cited scientific studies showing herbicides are linked to cancer, decreased cognitive function and behavioural problems in children and damage to marine environments. Opponents worried about the cost and increased county liability when mechanical measures such as weed trimming and mowing replace chemicals to keep weeds down. Parks and Recreation Director Roxcie Waltjen estimated she’d need 400 additional park maintenance workers at about \$39,000 salaries. Public Works Director David Yamamoto said he’d also need more staff and equipment, but he didn’t have an estimate. Both departments said they already cut their herbicide use by half. In addition, four parks were selected for pilot projects that involve the cessation of herbicide use: Hilo soccer field No. 4, Old A Park football field, Waikoloa Park and Pahoa District Park. Lee Loy said her research showed there would be more downtime for county employees as well. Since 2014, no workers have claimed comp time for exposure to herbicides or other pesticides, but there were 33 claims of injuries associated with mowers and trimmers, costing \$382,000. Chung and Lee Loy had asked for an exemption for Hilo Municipal Golf Course, and said they were disappointed the bill wasn’t amended to reflect that. Chung had also asked earlier for an explanation of the 30 chemicals on the banned list, but wasn’t satisfied he knew what they all did. “Why we don’t stick to (banning) glyphosate? I don’t know what these other chemicals are and I can’t responsibly vote to ban them,” Chung said. The bill calls for a transition period starting 1 January 2020, with an outright ban being implemented by 1 January 2024. A seven-member “vegetation management transition committee,” appointed by the mayor and confirmed by the council, will monitor the county’s progress during the transition period. Rules would be put in place during the transition period for the county departments of Environmental Management, Parks and Recreation and Public Works requiring posted notices, blocking off of areas treated during a drying period, the use of a blue dye to identify treated areas and adherence to label directions, such as restrictions during wind and rain conditions.

Hawaii Tribune Herald, 21 November 2019

<https://www.hawaiitribune-herald.com>

## Regulatory Update

CHEMWATCH

### EUROPE

#### BPA study appraisal approach tested

2019-11-29

In 2017, the European Food Safety Authority's (EFSA) CEP Panel endorsed a protocol for use in the ongoing re-evaluation of potential BPA hazards. It defines how to select, appraise and integrate the evidence from studies on BPA. A new report presents the outcome of testing of the study appraisal methodology in the 2017 BPA hazard assessment protocol. To ensure consistency between past and future BPA assessments, our experts applied the study appraisal methodology to a selection of studies from EFSA's 2015 assessment and compared the results with those achieved at the time. The key study used to derive a temporary tolerable daily intake (TDI, see below) for BPA in 2015 was assessed to be of high quality applying both the new and previous methodologies. The appraisal outcomes were also comparable with both methodologies for the other selected studies. Therefore, EFSA's experts considered the EFSA 2015 BPA methodology sufficiently robust even though it was not as structured as the new one. One of the main benefits of the new methodology is that the rationale for decisions taken during the evaluation is well documented at all stages. The testing has helped our scientists to further refine and improve the protocol in support of the current ongoing re-evaluation of recent studies on BPA toxicity. A webinar on 14th November 2019 helped to explain and discuss the results of testing the study appraisal methodology with interested stakeholders. Further information is available at: Scientific report: Testing the 2017 BPA study appraisal protocol methodology

EFSA, November 2019

<http://www.efsa.europa.eu>

#### RoHS Directive Annex III amended

2019-11-29

Annex III to the Restriction of Hazardous Substances Directive 2011/65/EU (RoHS 2) has been amended as per Commission Delegated Directive (EU) 2019/1845 and Commission Delegated Directive (EU) 2019/1846, both of

**In 2017, the European Food Safety Authority's (EFSA) CEP Panel endorsed a protocol for use in the ongoing re-evaluation of potential BPA hazards.**

## Regulatory Update

CHEMWATCH

8 August 2019. Annex III contains a list of all the RoHS exemptions that are specific to EEE categories 1 - 7 and 10 - 11.

Yorda's Hive, 26 November 2019

<https://www.yordasgroup.com/hive/news>

### **Cosmetic Products Regulation Annexes V and VI amended**

2019-11-29

The new substance has been added to Annex V of the Cosmetic Products Regulation (EC) No. 1223/2009 (CPR) as per Commission Regulation (EU) 2019/1858 of 6 November 2019. The new substance is:

- 4-(3-ethoxy-4-hydroxyphenyl)butan-2-one

The following substance has been amended in Annex VI of the CPR as per Commission Regulation (EU) 2019/1857 of 6 November 2019:

#### Titanium dioxide

Yorda's Hive, 26 November 2019

<https://www.yordasgroup.com/hive/news>

## REACH Update

CHEMWATCH

### Companies need to improve communication of hazardous substances in products

2019-11-29

A Forum pilot enforcement project in 15 participating countries has found that 12 % of inspected products contain substances of very high concern (SVHCs). The majority (88 %) of suppliers of these products are failing to communicate sufficient information to their customers about SVHCs in products they supply. The results of the pilot project show that companies need to improve their knowledge on the products they supply to their customers and to better communicate information so that products containing substances of very high concern can be used safely. In this project, 405 companies across 15 countries were inspected and 682 articles were checked. 84 (12 %) of the 682 articles were found to contain substances listed as being of high concern to human health or the environment (Candidate List substances) in concentrations above 0.1 % weight by weight. The products checked by inspectors were selected especially as they were highly likely to contain targeted Candidate List substances. Such products included clothing, footwear and home textiles; wires, cables and electronic accessories; plastic or textile floorings; wall coverings; and other plastic and rubber products. "While nearly 90 % of the products do not contain substances of very high concern above 0.1 %, the report clearly shows a failure of communication in the supply chain. Improvement is needed if we want to make REACH work in all aspects, contribute to the objectives of the circular economy and to have a good database as required under the Waste Framework Directive," says *Erwin Annys*, Head of ECHA's Support and Enforcement Unit. The duty to communicate information down the supply chain about the presence of Candidate List substances in articles was applicable to 45 articles containing those substances. Suppliers did not do so for 40 (89 %) of them, and 37 out of 42 companies (88 %) failed to provide the name of the substance to recipients of their articles. For companies supplying articles directly to consumers only, 22 suppliers (51 %) out of 43 were considered to have insufficient information available to fulfil their obligation to provide required information to consumers, when requested. The results show that, in almost all cases, only the name of the Candidate List substance was communicated in the supply chain, and this may not be sufficient to allow safe handling. For the 12 % of articles placed on the EU market containing Candidate List substances, the results of the project show a high rate of non-compliance. This situation hinders the safe use of Candidate List substances in produced and imported articles, in particular those used by consumers. The ECHA Secretariat and the

**A Forum pilot enforcement project in 15 participating countries has found that 12 % of inspected products contain substances of very high concern (SVHCs).**

## REACH Update

CHEMWATCH

Forum will further analyse the results from this enforcement project and the recommendations included in the Forum's final report, and consider further actions that could improve the situation.

### Background

The Forum for Exchange of Information on Enforcement (Forum) is a network of authorities responsible for the enforcement of the REACH, CLP, BPR, PIC and POP regulations in the EU, Norway, Iceland and Liechtenstein. The term 'product' in this text refers to an article, defined by REACH as 'an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition'. Further information is available at:

- [Final report on the Forum Pilot Project on Substances in Articles](#)
- [Annex to the press release](#)
- [Enforcement Forum](#)
- [Forum Enforcement Projects](#)

ECHA, 18 November 2019

<http://echa.europa.eu>

### **ECHA does not consider dossier updates during evaluation decision making**

2019-11-29

Once the European Chemicals Agency (ECHA) has sent a draft decision to registrants, it does not consider dossier updates during evaluation decision making. Registrants need to keep their registration dossiers up to date at all times. REACH is based on the principle that registrants must ensure that substances used and placed on the market do not adversely affect human health or the environment. Therefore, registrants are legally obliged to submit a registration dossier that complies with the REACH information requirements and to keep their dossiers up to date with the latest information to be validly on the market. Consequently, under dossier evaluation, ECHA only takes into account dossier updates submitted before it issues a draft decision. If new information becomes available after that, registrants must submit this through their comments to the draft decision. The Agency will consider the information in the comments and may amend the decision accordingly. Furthermore, ECHA does not take new information on tonnage, uses and exposure into account after it has sent the draft decision to registrants for comments. Registrants cannot retrospectively downgrade their tonnage band or remove certain uses

**Once the European Chemicals Agency (ECHA) has sent a draft decision to registrants, it does not consider dossier updates during evaluation decision making.**

## REACH Update

CHEMWATCH

from their registration to remove requests for information from ECHA's decisions. This is because the registration dossier has to comply with the REACH information requirements for the registered tonnage band and uses at the time the dossier evaluation was opened.

ECHA's website provides information for registrants on how to improve their dossiers: recommendations, a practical guide and questions and answers. These have been reviewed to reflect certain points made in a recent decision of the Board of Appeal. Further information is available at:

- [Recommendations to registrants on how to improve registration dossiers](#)
- [Practical guide: How to act in dossier evaluation](#)
- [Updated Q&As](#)
- [Board of Appeal decision in case A-001-2018](#)
- [Evaluation](#)
- [Compliance checks](#)

ECHA, 26 November 2019

<http://echa.europa.eu>

### Improving the quality of your REACH registration dossier – what authorities are planning and how you can prepare

2019-11-29

Did you miss the European Chemicals Agency's (ECHA) webinar on how ECHA and industry are planning to address dossier compliance issues? The recording and presentations are now available. The webinar provided the latest information about ECHA's and industry's action plans for addressing the lack of compliance of REACH registration dossiers. Further information is available at:[More](#)

ECHA News, 27 November 2019

<http://echa.europa.eu>

### New substance evaluation conclusion published

2019-11-29

The European Chemicals Agency (ECHA) has published 3 new substance evaluation conclusion documents. The new document is now available on ECHA's website for:

**Did you miss the European Chemicals Agency's (ECHA) webinar on how ECHA and industry are planning to address dossier compliance issues? The recording and presentations are now available.**

## REACH Update

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- Phenol, dodecyl-, branched (EC 310-154-3; CAS 121158-58-5), added to the CoRAP list in 2018 and evaluated by Germany;
- Quaternary ammonium compounds, di-C16-18-alkyldimethyl, chlorides (EC 295-835-2; CAS 92129-33-4), added to the CoRAP list in 2015 and evaluated by Italy; and
- ethyl methacrylate (EC 202-597-5; CAS 97-63-2), added to the CoRAP list in 2014 and evaluated by Italy.

Further information is available at:

- Community rolling action plan
- Substance evaluation

ECHA News, 27 November 2019

<http://echa.europa.eu>

### Public consultation on harmonised classification and labelling

2019-11-29

The European Chemicals Agency (ECHA) is looking for comments on the harmonised classification and labelling proposals for:

- Margosa, ext. [from the kernels of Azadirachta indica extracted with water and further processed with organic solvents] (EC 283-644-7; CAS 84696-25-3); and
- Perfluoroheptanoic acid; tridecafluoroheptanoic acid (EC 206-798-9; CAS 375-85-9).

The deadline for comments is 24 January 2020.

Further information is available at: [Give comments](#)

ECHA News, 27 November 2019

<http://echa.europa.eu>

### Chesar upgrade now available

2019-11-29

The European Chemicals Agency (ECHA) has announced that the new version of Chesar (3.5.) includes various improvements and new features, including:

- a possibility to create a substance directly in Chesar;
- calculation of MSafe for environment;

**ECHA seeking comments on new harmonised classification and labelling proposals.**

## REACH Update

CHEMWATCH

- compatibility with the latest version of IUCLID (6.4.) – released on 30 October 2019 - as well as the earlier version.

More details can be found in the release notes. Also, installation and user manuals as well as FAQs have been updated to reflect the changes.

- [Chesar news](#)
- [Download Chesar](#)

ECHA News, 27 November 2019

<http://echa.europa.eu>

## Janet's Corner

CHEMWATCH

### More Fish in the Sea

2019-11-29



<https://environmentalscience-research.weebly.com/humor.html>

## Hazard Alert

CHEMWATCH

### Selenium

2019-11-17

Selenium is a chemical element with symbol Se and atomic number 34.[1]

It is an odourless metalloid (an element which has both metallic and non-metallic properties). It can be a grey (the 'metallic' and most stable form), red or black solid. [2]

In nature selenium is usually combined with sulphide minerals or with silver, copper, lead, and nickel. [3]

### USES [4]

Selenium has good photovoltaic and photoconductive properties, and it is used extensively in electronics, such as photocells, light metres and solar cells. The second largest use of selenium is in the glass industry: selenium is used to remove colour from glass, to give a red colour to glasses and enamels. The third main use is sodium selenite for animal feeds and food supplements. In addition, selenium can find applications in photocopying, in the toning of photographs. Its artistic use is to intensify and extend the tonal range of black and white photographic images. Other uses of selenium are in metal alloys such as the lead plates used in storage batteries and in rectifiers to convert AC current in DC current. Selenium is used to improve the abrasion resistance in vulcanised rubbers. Some selenium compounds are added to anti-dandruff shampoos.

**Selenium is a chemical element with symbol Se and atomic number 34.[1]**

### SOURCES & ROUTES OF EXPOSURE

#### Sources of Exposure [4]

Selenium exposure takes place either through food or water, or through contact with soil or air that contains high concentrations of selenium. The exposure to selenium mainly takes place through food, because selenium is naturally present in grains, cereals and meat. Humans need to absorb certain amounts of selenium daily, in order to maintain good health. Food usually contains enough selenium to prevent disease caused by shortages. Selenium uptake through food may be higher than usual in many cases, because in the past many selenium-rich fertilisers have been applied on farmland. In addition, people that live near hazardous waste-sites will experience a higher exposure through soil and air. Selenium from hazardous waste-sites and from farmland will end up in groundwater or surface water through irrigation. This phenomenon causes selenium to end up in local drinking water, so that exposure to selenium through

## Hazard Alert

### CHEMWATCH

water will be temporarily increased. People that work in metal industries, selenium-recovery industries and paint industries also tend to experience a higher selenium exposure, mainly through breathing. Selenium is released to air through coal and oil combustion. People that eat a lot of grains that grow near industrial sites may experience a higher exposure to selenium through food. Exposure to selenium through drinking water may be increased when selenium from hazardous waste disposals ends up in water wells. Exposure to selenium through air usually only occurs in the workplace.

#### **Routes of Exposure [3]**

- Inhalation (breathing) – Not a significant route of exposure for the general population, but is the primary route of exposure for selenium workers.
- Ingestion– Primary route of exposure for the general population via consumption of food.
- Dermal – Not a significant route of exposure to selenium.

#### **HEALTH EFFECTS [5]**

##### **Acute Effects**

Acute exposure of humans via inhalation to selenium compounds (selenium dioxide, hydrogen selenide) results primarily in respiratory effects. Acute inhalation exposure to elemental selenium dust results in irritation of the mucous membranes in the nose and throat, producing coughing, nosebleeds, dyspnea, bronchial spasms, bronchitis, and chemical pneumonia. Gastrointestinal effects including vomiting and nausea; cardiovascular effects; neurological effects such as headaches and malaise; and irritation of the eyes were reported in humans acutely exposed to selenium compounds via inhalation. Acute human exposure to selenium compounds via the oral route has resulted in pulmonary oedema and lesions of the lung; cardiovascular effects such as tachycardia; gastrointestinal effects including nausea, vomiting, diarrhoea, and abdominal pain; effects on the liver; and neurological effects such as aches, irritability, chills, and tremors. "Blind staggers" disease is a disease in livestock that results from acute consumption of plants high in selenium. It is characterised by impaired vision, aimless wandering behaviour, reduced consumption of food and water, and paralysis. Acute animal tests in rats, mice, and guinea pigs, have shown hydrogen selenide to have extreme toxicity from inhalation exposure, sodium selenite to have extreme toxicity

## Hazard Alert

CHEMWATCH

from oral exposure, and elemental selenium to have low toxicity from oral exposure.

### Chronic Effects

No information is available on the chronic effects of selenium in humans from inhalation exposure. In epidemiological studies of populations exposed to high levels of selenium in food and water, discoloration of the skin, pathological deformation and loss of nails, loss of hair, excessive tooth decay and discoloration, garlic odour in breath and urine, lack of mental alertness, and listlessness were reported. "Alkali disease" is a disease in livestock resulting from chronic consumption of high levels of selenium; it is characterised by hair loss, deformation and sloughing of the hooves, erosion of the joints of the bones, anaemia, and effects on the heart, kidney, and liver. EPA has not established a Reference Concentration (RfC) for selenium. The Reference Dose (RfD) for selenium is 0.005 milligrams per kilogram body weight per day (mg/kg/d) based on clinical selenosis in humans.

### Selenium Deficiencies

Two diseases, "Keshan disease" and "Kashin-Beck disease" have been reported in humans in selenium-deficient populations in China. Keshan disease is characterised by heart failure, cardiac enlargement, abnormalities of EKG, and cardiogenic shock. Kashin-Beck disease, which occurs primarily in children between the ages of 5 and 13 years, is characterised by atrophy, degeneration, and necrosis of cartilage tissue. Some epidemiological studies have suggested that selenium deficiency may contribute to cardiovascular disease in humans. However, these studies are inconclusive due to confounding factors.

### Reproductive/Developmental Effects

No information is available on the developmental or reproductive effects of selenium in humans. The consumption of high levels of selenium in the diet by pigs, sheep, and cattle has been shown to interfere with normal foetal development and to produce foetal malformations. Sodium selenate, administered in the drinking water to mice, did not result in birth defects, but did result in an increased incidence of foetal deaths and a high proportion of runts, while chronic exposure of mice to selenium in the diet has been shown to affect their fertility and to reduce the viability of the offspring of pairs that are able to breed.

## Hazard Alert

CHEMWATCH

### Cancer Risk

In one study of workers exposed to selenium (form not specified) over a 26-year period, no statistically significant increase in cancer deaths was reported. Human studies have reported that patients with cancer, particularly gastrointestinal cancer, prostate cancer, or Hodgkin's lymphoma, had significantly lower selenium levels in the blood than healthy patients. Epidemiological studies that used the selenium concentration in crops as an indicator of dietary selenium have generally reported an inverse association between selenium levels and cancer occurrence. Animal studies have reported that selenium supplementation, as sodium selenate, sodium selenite, and organic forms of selenium, results in a reduced incidence of several tumour types. The only selenium compound that has been shown to be carcinogenic in animals is selenium sulphide, which resulted in an increase in liver tumours in rats and mice and lung tumours in female mice from oral exposure. Selenium sulphide is a pharmaceutical compound used in anti-dandruff shampoos and is very different than the inorganic or organic selenium compounds found in foods and the environment. EPA has classified elemental selenium as a Group D, not classifiable as to human carcinogenicity, and selenium sulphide as a Group B2, probable human carcinogen.

### **SAFETY [6]**

#### First Aid Measures

- Eye Contact: Check for and remove any contact lenses. Do not use an eye ointment. Seek medical attention.
- Skin Contact: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.
- Inhalation: Allow the victim to rest in a well-ventilated area. Seek immediate medical attention.
- Serious Inhalation: Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

## Hazard Alert

CHEMWATCH

- Ingestion: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

### Exposure Controls & Personal Protection

#### Engineering Controls

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

#### Personal Protective Equipment

The recommended personal protective equipment includes:

- Splash goggles;
- Lab coat;
- Dust respirator (be sure to use an approved/certified respirator or equivalent);
- Gloves

Personal Protection in Case of a Large Spill:

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

### **REGULATION [2,6,7]**

#### United States

- EPA Office of Drinking Water regulates the amount of selenium allowed in drinking water. Public water supplies are not allowed to exceed 50 ppb total selenium.
- FDA regulations allow a level of 50 ppb of selenium in bottled water.

## Hazard Alert

CHEMWATCH

- OSHA exposure limit for selenium compounds in the air for an 8-hour period is 0.2 mg selenium/m<sup>3</sup>.

### Australia

- Australian Drinking Water Guidelines (NHMRC and ARMCANZ, 1996): Maximum of 0.01 mg/L
- Worksafe Australia has set the exposure standard for selenium compounds (excluding selenium hydride) to 0.2 milligram/m<sup>3</sup> (TWA, as selenium). The exposure standard for selenium hydride and selenium hexafluoride is 0.05 ppm or 0.16 milligram/m<sup>3</sup> (TWA, as selenium). Selenium and selenium compounds are classified as toxic by inhalation and if swallowed.

### REFERENCES

1. <http://en.wikipedia.org/wiki/Selenium>
2. <http://www.npi.gov.au/substances/selenium/index.html>
3. <http://www.atsdr.cdc.gov/toxguides/toxguide-92.pdf>
4. <http://www.lenntech.com/periodic/elements/se.htm>
5. <http://www.epa.gov/ttn/atw/hlthef/selenium.html>
6. <http://www.sciencelab.com/msds.php?msdsId=9924874>
7. <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=151&tid=28>

## Gossip

## CHEMWATCH

### Could a new 2-D material allow semiconductors to keep getting smaller, stronger better and faster?

2019-11-20

Not everything is bigger in Texas—some things are really, really small. A group of engineers at The University of Texas at Austin may have found a new material for manufacturing even smaller computer chips that could replace silicon and help overcome one of the biggest challenges facing the tech industry in decades: the inevitable end of Moore's Law. In 1965, Gordon Moore, founder of Intel, predicted the number of transistors that could fit on a computer chip would double every two years, while the cost of computers would be cut in half. Almost a quarter century later and Moore's Law continues to be surprisingly accurate. Except for one glitch. Silicon has been used in most electronic devices because of its wide availability and ideal semiconductor properties. But chips have shrunk so much that silicon is no longer capable of carrying more transistors. So, engineers believe the era of Moore's Law may be coming to an end, for silicon at least. There simply isn't enough room on existing chips to keep doubling the number of transistors. Researchers in the Cockrell School of Engineering are searching for other materials with semiconducting properties that could form the basis for an alternative chip. Yuanyue Liu, an assistant professor in the Walker Department of Mechanical Engineering and a member of UT's Texas Materials Institute, may have found that material. In a paper published in the Journal of the American Chemical Society, Liu and his team, postdoctoral fellow Long Cheng and graduate student Chenmu Zhang, outline their discovery that, in its 2-D form, the chemical element antimony may serve as a suitable alternative to silicon. Antimony is a semi-metal that is already used in electronics for some semiconductor devices, such as infrared detectors. As a material, it is only a couple of atomic layers thick and has a high charge mobility—the speed a charge moves through a material when being pulled by an electric field. Antimony's charge mobility is much higher than other semiconductors with similar size, including silicon. This property makes it promising as the building block for post-silicon electronics. Liu has only demonstrated its potential through theoretical computational methods but is confident it can exhibit the same properties when tested with physical antimony samples, which is the team's next step. But the findings have even broader significance than simply identifying a potential replacement for silicon in the race to maintain Moore's Law into the future. "More importantly, we have uncovered the physical origins of why antimony has a high mobility,"

**Not everything is bigger in Texas—some things are really, really small.**

## Gossip

## CHEMWATCH

Liu said. "These findings could be used to potentially discover even better materials."

Phys.org, 5 November 2019

<http://phys.org>

### How oxygen destroys the core of important enzymes

2019-11-20

Certain enzymes, such as hydrogen-producing hydrogenases, are unstable in the presence of oxygen. Researchers at Ruhr-Universität Bochum (RUB) have identified the reasons on the atomic level. They outline their results in the Journal of the American Chemical Society (JACS), published online on 14 October 2019. The experiments were carried out jointly by three RUB groups: the photobiotechnology research group was represented by Dr. Julian Esselborn -- today at the University of California, San Diego --, Professor Thomas Happe and Dr. Leonie Kertess. The team collaborated with Professor Eckhard Hofmann from the Protein Crystallography Group and Dr. Ulf-Peter Apfel from the Chair of Inorganic Chemistry I. The interdisciplinary cooperation at the interface between biology, chemistry and physics was embedded in the Ruhr Explores Solvation Cluster of Excellence, Resolv for short, and the Research Training Group Microbial Substrate Conversion, Micon for short.

#### Structural changes due to oxygen

The researchers analysed a hydrogenase from the bacterium *Clostridium pasteurianum*. The unique aspect about this class of enzymes is that their structure consists of six iron and six sulphur atoms. The so-called cofactor constitutes the core of the protein, where the actual hydrogen production takes place. The researchers stored several samples of the enzyme with oxygen for different lengths of time. They then used X-ray structure analysis to study how the three-dimensional structure of the proteins had changed. "This method is very complex and complicated, but it helped us trace the destructive process on an atomic level," says Julian Esselborn. Incubation with oxygen only altered individual atoms of the enzyme, namely certain iron atoms of the cofactor. This gradually led to the disintegration of the entire active centre. By understanding which iron atoms are particularly affected, the researchers hope to be able to better protect biotechnologically interesting proteins against oxygen in future.

Science Daily, 4 November 2019

<http://www.sciencedaily.com>

**Certain enzymes, such as hydrogen-producing hydrogenases, are unstable in the presence of oxygen. Researchers have identified the reasons on the atomic**

## Gossip

## CHEMWATCH

### Thorium superconductivity: Scientists discover a new high-temperature superconductor

2019-11-20

A group of scientists led by Artem Oganov, Professor at Skoltech and MIPT, and Dr. Ivan Troyan at the Institute of Crystallography of RAS have succeeded in synthesising thorium decahydride (ThH<sub>10</sub>), a new superconducting material with a very high critical temperature (161 K). The results of their study supported by a Russian Science Foundation (RSF) grant were published in the journal *Materials Today*. A truly remarkable property of quantum materials, superconductivity is a complete loss of electrical resistance under quite particular, and sometimes, very harsh conditions. Despite the tremendous potential for quantum computers and high-sensitivity detectors, the application of quantum materials is hindered by the fact that superconductivity typically manifests itself at very low temperatures or extremely high pressures. Until recently, the list of superconductors was topped by mercury-containing cuprate that becomes superconducting at 135 K (-138 °C). This year, lanthanum decahydride, LaH<sub>10</sub>, has set a new record of -13 °C, which is very close to room temperature, although in the case of LaH<sub>10</sub> superconductivity is achieved at nearly 2 million atmospheres, a pressure that can hardly be attained in real life. It is important to achieve superconductivity at temperatures and pressures close to room levels. In 2018, Alexander Kvashnin, a research scientist at the lab directed by Skoltech and MIPT professor, Artem R. Oganov, predicted a new material, thorium polyhydride (ThH<sub>10</sub>), with a critical temperature of -32 °C at THE pressure of 1 million atmospheres. In their recent study, scientists from the Institute of Crystallography of RAS, Skoltech, MIPT and the Lebedev Institute of Physics of RAS have successfully obtained ThH<sub>10</sub> and studied its transport properties and superconductivity. Their findings corroborated the theoretical predictions, proving that ThH<sub>10</sub> exists at pressures above 0.85 million atmospheres and displays outstanding high-temperature superconducting performance. The scientists could only determine the critical temperature at 1.7 million atmospheres and found it to be -112 °C, which is consistent with the theoretical prediction for this pressure value, placing ThH<sub>10</sub> among the record-breaking high-temperature superconductors. "Modern theory, and in particular, the USPEX method developed by myself and my students, yet again displayed their amazing predictive power. ThH<sub>10</sub> pushes the boundaries of classical chemistry and possesses unique properties that were predicted theoretically and recently confirmed by experiment. Most notably, the experimental results obtained by Ivan Troyan's lab are of very high quality," says Artem R. Oganov, co-

**A group of scientists led by Artem Oganov, Professor at Skoltech and MIPT, and Dr.**

## Gossip

## CHEMWATCH

director of the study and professor at Skoltech and MIPT. "We discovered that superconductivity predicted in theory does exist at -112 oC and 1.7 million atmospheres. Given the strong consistency between theory and experiment, it would be interesting to check whether ThH10 will show superconductivity at up to -30-40°C and lower pressures as predicted," says co-director of the study, Dr. Ivan Troyan. "Thorium hydride is just one of the elements in a large and rapidly growing class of hydride superconductors. I believe that in the coming years, hydride superconductivity will expand beyond the cryogenic range to find application in the design of electronic devices," says the first author of the study and Skoltech PhD student, Dmitry Semenov.

EurekAlert, 7 November 2019

<http://www.eurekalert.org>

### **Tethered chem combos could revolutionize artificial photosynthesis**

2019-11-20

Scientists at the United States Department of Energy's Brookhaven National Laboratory have doubled the efficiency of a chemical combo that captures light and splits water molecules so the building blocks can be used to produce hydrogen fuel. Their study, selected as an American Chemical Society "Editors' Choice" that will be featured on the cover of the Journal of Physical Chemistry C, provides a platform for developing revolutionary improvements in so-called artificial photosynthesis—a lab-based mimic of the natural process aimed at generating clean energy from sunlight. In natural photosynthesis, green plants use sunlight to transform water (H<sub>2</sub>O) and carbon dioxide (CO<sub>2</sub>) into carbohydrates such as sugar and starches. The energy from the sunlight is stored in the chemical bonds holding those molecules together. Many artificial photosynthesis strategies start by looking for ways to use light to split water into its constituents, hydrogen and oxygen, so the hydrogen can later be combined with other elements—ideally the carbon from carbon dioxide—to make fuels. But even getting the hydrogen atoms to recombine as pure hydrogen gas (H<sub>2</sub>) is a step toward solar-powered clean-fuel generation. To achieve water splitting, scientists have been exploring a wide range of light-absorbing molecules (also called chromophores, or dyes) paired with chemical catalysts that can pry apart water's very strong hydrogen-oxygen bonds. The new approach uses molecular "tethers"—simple carbon chains that have a high affinity for one another—to attach the chromophore to the catalyst. The tethers hold the particles close enough together to

**Scientists at the United States Department of Energy's Brookhaven National Laboratory have doubled the efficiency of a chemical combo that captures light and splits water molecules so the building blocks can be used to produce hydrogen fuel.**

## Gossip

## CHEMWATCH

transfer electrons from the catalyst to the chromophore—an essential step for activating the catalyst—but keeps them far enough apart that the electrons don't jump back to the catalyst. "Electrons move fast, but chemical reactions are much slower. So, to give the system time for the water-splitting reaction to take place without the electrons moving back to the catalyst, you have to separate those charges," explained Brookhaven Lab chemist Javier Concepcion, who led the project. In the complete setup, the chromophores (tethered to the catalyst) are embedded in a layer of nanoparticles on an electrode. Each nanoparticle is made of a core of tin dioxide ( $\text{SnO}_2$ ) surrounded by a titanium dioxide ( $\text{TiO}_2$ ) shell. These different components provide efficient, stepwise shuttling of electrons to keep pulling the negatively charged particles away from the catalyst and sending them to where they are needed to make fuel. Here's how it works from start to finish: Light strikes the chromophore and gives an electron enough of a jolt to send it from the chromophore to the surface of the nanoparticle. From there the electron moves to the nanoparticle core, and then out of the electrode through a wire. Meanwhile, the chromophore, having lost one electron, pulls an electron from the catalyst. As long as there's light, this process repeats, sending electrons flowing from catalyst to chromophore to nanoparticle to wire. Each time the catalyst loses four electrons, it becomes activated with a big enough positive charge to steal four electrons from two water molecules. That breaks the hydrogen and oxygen apart. The oxygen bubbles out as a gas (in natural photosynthesis, this is how plants make the oxygen we breathe!) while the hydrogen atoms (now ions because they are positively charged) diffuse through a membrane to another electrode. There they recombine with the electrons carried by the wire to produce hydrogen gas—fuel!

### Building on experience

The Brookhaven team had tried an earlier version of this chromophore-catalyst setup where the light-absorbing dye and catalyst particles were connected much more closely with direct chemical bonds instead of tethers. "This was very difficult to do, taking many steps of synthesis and purification, and it took several months to make the molecules," Concepcion said. "And the performance was not that good in the end." In contrast, attaching the carbon-chain tethers to both molecules allow them to self-assemble. "You just dip the electrode coated with the chromophores into a solution in which the catalyst is suspended and the tethers on the two types of molecules find one another and link up," said Stony Brook University graduate student Lei Wang, a co-author on the current paper and lead author on a paper published earlier this year

## Gossip

## CHEMWATCH

that described the self-assembly strategy. The new paper includes data showing that the system with tethered connections is considerably more stable than the directly connected components, and it generated twice the amount of current—the number of electrons flowing through the system. “The more electrons you generate from the light coming in, the more you have available to generate hydrogen fuel,” Concepcion said. The scientists also measured the amount of oxygen produced. “We found that this system, using visible light, is capable of reaching remarkable efficiencies for light-driven water splitting,” Concepcion said. But there’s still room for improvement, he noted. “What we’ve done to this point works to make hydrogen. But we would like to move to making higher value hydrocarbon fuels.” Now that they have a system where they can easily interchange components and experiment with other variables, they are set to explore the possibilities. “One of the most important aspects of this setup is not just the performance, but the ease of assembly,” Concepcion said. “Because these combinations of chromophores and catalysts are so easy to make, and the tethers give us so much control over the distance between them, now we can study, for example, what is the optimal distance. And we can do experiments combining different chromophores and catalysts without having to do much complex synthesis to find the best combinations,” he said. “The versatility of this approach will allow us to do fundamental studies that would not have been possible without this system.”

Phys.org, 4 November 2019

<http://phys.org>

### **A laser-sighted toxic goo gun is killing feral cats in Australia**

2019-11-20

A device that kills feral cats by spraying them with a lethal gel that they lick off while cleaning themselves is being trialled as a way to save endangered Australian wildlife. Since their introduction to Australia in the 18th century, cats have severely harmed the local ecosystem by preying on native birds and small mammals. They have contributed to the extinction of more than 20 Australian animals – including the paradise parrot, broad-faced potoroo, rusty numbat and desert bandicoot – and continue to threaten many more. In 2015, the Australian government set a target of culling 2 million of the estimated 6 million cats living in the wild by 2020. But this has been challenging because the cats prefer hunting live prey to eating poison baits and are too numerous to be controlled by shooting.

**A device that kills feral cats by spraying them with a lethal gel that they lick off while cleaning themselves is being trialled as a way to save endangered Australian wildlife.**

## Gossip

### CHEMWATCH

To address these problems, John Read at the University of Adelaide and his colleagues have invented an automated device for culling cats that takes advantage of their compulsive self-grooming rituals. The solar-powered device, called a "Felixer grooming trap", has laser sensors that detect when a cat walks past based on its size, shape and gait. When activated, the sensors trigger the release of a toxic gel that squirts onto the cat's fur. The cat later licks the gel off while routinely cleaning its coat. The gel contains a commonly used poison called sodium fluoroacetate or "1080" that halts the production of energy in cells. The poison is thought to euthanise cats painlessly because it causes unconsciousness before shutting down brain activity, says Read. "In most cases, they get wobbly and sleepy, then lie down and die," he says. An initial trial with two cats in a pen found they passed out within 6 hours of being squirted and died within 10 hours. Another benefit of sodium fluoroacetate is that Australian animals have evolved some resistance to its toxic effects because it naturally occurs in several native plants, says Read. As a test, the researchers recently installed 20 Felixer devices in a 2600-hectare fenced paddock in South Australia that is inhabited by feral cats and native wildlife. Cameras showed that the traps correctly identified, sprayed and killed feral cats, causing their population to decline by about two-thirds over six weeks. No native animals activated the traps and none died. The effectiveness of the traps was confirmed by the observation that cat numbers didn't decline in an adjacent paddock where no devices were installed. In a separate experiment on Kangaroo Island, the researchers showed they could prevent pet cats from activating the traps by fitting them with special wireless tags. Read will present the results at the annual meeting of the Ecological Society of Australia later this month. The traps currently cost \$A15,000 each, but they should become cheaper once they are commercialised, says Read. He is seeking approval from the Australian Pesticides and Veterinary Medicines Authority to sell them to accredited land managers across the country. Some cat protection groups say the most humane way of controlling Australia's feral cats would be to trap them, surgically sterilise them, then return them to the wild. But Di Evans at animal charity RSPCA Australia says this is impractical because feral cats often live in remote, hard-to-access areas. Felixer traps are preferable to poison baits because they specifically target cats and are therefore less likely to harm other animals, says Evans. However, the RSPCA would like to see more research on the feasibility of reducing feral cat numbers with

## Gossip

## CHEMWATCH

contraception – possibly administered as single injections or slow-release implants – instead of lethal methods, she says.

New Scientist, 15 November 2019

<http://www.newscientist.com/>

### Batteries as transparent as glass could power devices in your home

2019-11-20

A transparent battery could replace glass in windows. The battery still has a low output, but could eventually add extra energy storage to smart glasses or cars. Most battery research focuses on increasing power output or energy density, a measure of how much energy can be stored in a certain volume. But Hironobu Minowa and his colleagues at Japanese communications giant NTT decided instead to focus on making a battery that is as inconspicuous as possible. The team had to create new versions of battery components to reduce overall light absorption and reflection. The result is a battery the size of an A4 or a US letter sheet of paper that is as see-through as window glass. The battery lacks the capacity of a conventional one: it holds only 1 milliamp hour (mAh) compared with more than 1000 in an AA battery. But it lets 69 per cent of light pass through it, which is at the lower end of what window glass achieves. This is enough, however, to power an LED or a digital clock, says Minowa, who demonstrated the battery at NTT's R&D Forum in Tokyo. As homes fill up with sensors and small smart devices, used for everything from monitoring temperature to optimising lighting, transparent batteries like this could help clear up the associated mess of wires and battery packs. Since building the prototype battery last year, the team has already doubled its output and tripled its transparency, says Minowa. Although the team can't yet make batteries any larger than an A4 sheet, it is possible to link multiple panes together to boost capacity. The ability to turn a window into a battery could be revolutionary, says Kevin Curran at Ulster University, UK. Transparent batteries could also have applications in smart glasses, cars and even sensor-packed contact lenses, he says.

New Scientist, 16 November 2019

<http://www.newscientist.com/>

**A transparent battery could replace glass in windows.**

## Gossip

## CHEMWATCH

### **New Way to Develop Graphene-enhanced Electrodes for Lighter EVs**

2019-11-20

A research team from the Texas A&M University College of Engineering is approaching a mass problem from a unique angle. They are focusing on the most significant of challenges, that has to do with mass, as even the most current electric vehicle batteries and supercapacitors are incredibly heavy.

#### New Method for Lighter Vehicles

Most of the research aimed at lowering the mass of electric vehicles has focused on increasing the energy density, thus reducing the weight of the battery or supercapacitor itself. However, a team led by Dr. Jodie Lutkenhaus, professor in the Artie McFerrin Department of Chemical Engineering, believes that lighter electric vehicles and aircraft can be achieved by storing energy within the structural body panels. This approach presents its own set of technical challenges, as it requires the development of batteries and supercapacitors with the same sort of mechanical properties as the structural body panels. Specifically, batteries and supercapacitor electrodes are often formed with brittle materials and are not mechanically strong.

#### Creating New Supercapacitor Electrodes

In an article published in Matter, the research team described the process of creating new supercapacitor electrodes that have drastically improved mechanical properties. In this work, the research team was able to create very strong and stiff electrodes based on dopamine functionalised graphene and Kevlar nanofibres. Dopamine, which is also a neurotransmitter, is a highly adhesive molecule that mimics the proteins that allow mussels to stick to virtually any surface. The use of dopamine and calcium ions leads to a significant improvement in mechanical performance.

#### Graphene-based Electrodes with Highest Multi-functional Efficiency

In fact, in the article, researchers report supercapacitor electrodes with the highest, to date, multifunctional efficiency (a metric that evaluates a multifunctional material based on both mechanical and electrochemical performance) for graphene-based electrodes. This research leads to an entirely new family of structural electrodes, which opens the door to the development of lighter electric vehicles and aircraft. While this work is

**A research team from the Texas A&M University College of Engineering is approaching a mass problem from a unique angle.**

## Gossip

## CHEMWATCH

mostly focused on supercapacitors, Lutkenhaus hopes to translate the research into creating sturdy, stiff batteries.

Omnexus, 11 November 2019

<https://omnexus.specialchem.com/>

### Researchers develop thin heat shield for superfast aircraft

2019-11-20

The world of aerospace increasingly relies on carbon fibre reinforced polymer composites to build the structures of satellites, rockets and jet aircraft. But the life of those materials is limited by how they handle heat. A team of FAMU-FSU College of Engineering researchers from Florida State University's High-Performance Materials Institute is developing a design for a heat shield that better protects those extremely fast machines. Their work will be published in the November edition of Carbon. "Right now, our flight systems are becoming more and more high-speed, even going into hypersonic systems, which are five times the speed of sound," said Professor Richard Liang, director of HPMI. "When you have speeds that high, there's more heat on a surface. Therefore, we need a much better thermal protection system." The team used carbon nanotubes, which are linked hexagons of carbon atoms in the shape of a cylinder, to build the heat shields. Sheets of those nanotubes are also known as "buckypaper," a material with incredible abilities to conduct heat and electricity that has been a focus of study at HPMI. By soaking the buckypaper in a resin made of a compound called phenol, the researchers were able to create a lightweight, flexible material that is also durable enough to potentially protect the body of a rocket or jet from the intense heat it faces while flying. Existing heat shields are often very thick compared to the base they protect, said Ayou Hao, a research faculty member at HPMI. This design lets engineers build a very thin shield, like a sort of skin that protects the aircraft and helps support its structure. After building heat shields of varying thicknesses, the researchers put them to the test. One test involved applying a flame to the samples to see how they prevented heat from reaching the carbon fibre layer they were meant to protect. After that, the researchers bent the samples to see how strong they remained. They found the samples with sheets of buckypaper were better than control samples at dispersing heat and keeping it from reaching the base layer. They also stayed strong and flexible compared to control samples made without protective layers of nanotubes. That flexibility is a helpful quality. The nanotubes are less vulnerable to cracking at high

**Engineers are now developing a design for a heat shield that better protects those extremely fast machines.**

## Gossip

## CHEMWATCH

temperatures compared to ceramics, a typical heat shield material. They're also lightweight, which is helpful for engineers who want to reduce the weight of anything on an aircraft that doesn't help the way it flies. The project received second place among peer-reviewed posters at the 2019 National Space and Missile Materials Symposium and received third place at the Society for the Advancement of Material and Process Engineering 2019 University Research Symposium. That recognition is helpful for showing the United States Air Force Office of Scientific Research, which partially supported the work, the promise of further research, Hao said.

Science Daily, 14 November 2019

<http://www.sciencedaily.com>

### Scientists design built-in controls for mini-chemical labs on a chip

2019-11-20

Since the 1990s, scientists have been exploring the possibilities of miniaturized chemical "laboratories" on a chip, which have potential as point-of-care diagnostics, analysis kits for field research and someday even conducting chemical tests on other planets. In a normal lab, chemists use beakers to mix chemicals and study reactions. In a miniaturised laboratory, microfluidic systems can conduct chemical experiments on a chip through a series of small connected tubes the size of a hair. This technology currently is in use, most notably in the medical field, which creates organs-on-a chip for research. However, the technology's potential has not fully been reached because the chemical reactions are controlled by large equipment that is often external to the chip. In a recent study published in *Nature*, researchers from Saint Louis University along with colleagues from Northwestern University and Normandie Universite shared their discovery of a way to program built-in controls in a microfluidic network. "We took our inspiration from electronics, in which a chip's controls are self-contained," said Istvan Kiss, Ph.D., professor of chemistry at Saint Louis University. "When we started the research in this field, we said 'Why don't we build tiny little reactors, sub-millimetre-sized. We used only a small number of reactors, so directing the flow was easy with simple, tiny tubes. But now, to advance the technology, we need the chip to be a bit more complicated, with many reactors and tubes in between, to operate more like a circuit.'" To solve this problem, researchers combined network theory and fluid mechanics and created controls operated entirely on the chip. Together with Yifan Liu, Ph.D., graduate research assistant at SLU and other colleagues, Kiss designed a network with a nonlinear relationship

**In a miniaturised laboratory, micro-fluidic systems can conduct chemical experiments on a chip through a series of small connected tubes the size of a hair.**

## Gossip

## CHEMWATCH

between the applied pressure and flow rate, which can be used to switch the direction of liquid flow simply by changing the input and output pressure. Taking a cue from a counterintuitive theory about traffic patterns, the scientists found that shortcuts aren't always the fastest way from point A to point B. A phenomenon known as Braess's paradox has demonstrated -- in traffic patterns, electronics, springs -- that sometimes having more pathways to travel actually slows down traffic rather than speeds it up. "We've built a network that shows that paradox," Kiss said. "As we studied how water molecules go around obstacles, it created a 'valve.' Water molecules are diverted from their paths. At low flow rates, they go towards the obstacles, while at high flow rates, they go the opposite way." "When we close a shortcut channel, it results in a higher, rather than lower, total flow rate. We're interested in how such changes in flow rates and directions will eventually change the chemical reactions in the reactors." This technology could be used to create portable lab testing systems as well as to design new applications, such as health monitoring wearables or deployable space systems.

Science Daily, 14 November 2019

<http://www.sciencedaily.com>

### Chemists use light to build biologically active compounds

2019-11-20

Some of the most biologically active molecules, including synthetic drugs, contain a central, nitrogen-containing chemical structure called an isoquinuclidine. This core has a three-dimensional shape which means it has the potential to interact more favourably with enzymes and proteins than flat, two-dimensional molecules. Unfortunately, methods to make isoquinuclidines and the related dehydroisoquinuclidines suffer from a number of drawbacks which make it more difficult for scientists to discover new medicinal compounds. A team of researchers led by Prof. Frank Glorius at the University of Münster (Germany) have now published a new method of enabling this reaction. The study was published in the journal Chem. Several methods for the preparation of three-dimensional core structures involve the addition of another molecule across a flat structure. The internal bonds of both molecules are reorganised to create new bonds between them in a transformation called a cycloaddition. In the case of isoquinuclidines, there is a high energy barrier to this chemical reaction since the flat starting molecule, a so-called pyridine, is very stable. This means that simple heating of the reaction is not enough to allow

## Gossip

## CHEMWATCH

it to occur. In the newly developed method, a special “photocatalyst” is able to transfer light energy from blue LEDs to excite a carbon-carbon double bond containing starting material to a high energy state. The excited molecule is then capable of addition into a nearby pyridine to give a dehydroisoquinuclidine. The scientists disclosed 44 examples of these compounds, which could afterwards be transformed into isoquinuclidines and other useful structures. A highlight of the research is the recyclability of the photocatalyst, which can be used more than ten times without any decrease in its activity. The scientists also carried out experiments to understand the mechanistic details of how the reaction works, supported by computational calculations. “We hope that the work will inspire other chemists to explore the area of so-called ‘energy-transfer catalysis’ and that easier access to these valuable molecules will accelerate the development of new drug molecules,” says Dr. Jiajia Ma, first author of the study.

Science Daily, 14 November 2019

<http://www.sciencedaily.com>

### **A new kind of glue to bond polyethylene**

2019-11-20

A team of researchers from the University of Victoria and the University of British Columbia, both in Canada, has developed a new kind of glue that is able to bond polyethylene materials together. In their paper published in the journal *Science*, the group explains how they created a carbene crosslinker with two diazirine motifs. Felix de Zwart, Johan Bootsma and, Bas de Bruin with the University of Amsterdam have published a Perspective piece in the same journal issue outlining the work by the team. As de Zwart, Bootsma and de Bruin note, scientists would like to develop universal products that could be used for crosslinking polymeric materials. Doing so would allow for creating new products out of such materials as polyethylene and polypropylene—both of which lack crosslinking properties. In this new effort, the team in Canada has developed a crosslinker that can be used to bond such materials together. As de Zwart, Bootsma and de Bruin further note, singlet carbenes (and transition metal carbene complexes) are able to undergo direct C-H insertion, resulting in covalent C-C bonds. Carbenes are molecules that have a divalent carbon atom (the carbon atom sits as an intermediary between two other atoms) and are commonly used as catalysts and backbones for polymers. In this new effort, the researchers created a new carbene using an N<sub>2</sub>-expelling motif that could be used to bond polyethylene materials together. The researchers report that they “rationally” created a bis-diazirine molecule

**A team of researchers from the University of Victoria and the University of British Columbia, both in Canada, has developed a new kind of glue that is able to bond polyethylene materials together.**

## Gossip

## CHEMWATCH

that decomposes into a carbene under controllable conditions—such as exposure to heat or light. In this instance, “rationally” means that they balanced the risk of explosion or ignition with reactivity—choosing bis-diazirine compounds that offered the best results taking both into consideration. The result was a molecule that was able to insert into C-H polymer bonds. They report that it was capable of crosslinking between assorted polymer chains, including both polyethylene and polypropylene. They note that when used with polypropylene, molecular weight increase was proportional to the amount of crosslinker used. They also looked into the possibility of using their crosslinker with a high-density polyethylene. They note that testing with a commercial product (Super Glue) was ineffective—their product worked much better.

Phys.org, 15 November 2019

<http://phys.org>

### Breaking carbon dioxide faster, cheaper, and more efficiently

2019-11-20

A new catalyst breaks carbon dioxide into useful chemicals faster, cheaper, and more efficiently than the standard method, reports a team of researchers in this week's issue of PNAS. The discovery could make it possible to economically turn carbon dioxide into fuels. Carbon dioxide is a stable, abundant gas. In fact, it's a little too abundant, and the extra carbon dioxide in the atmosphere is changing the planet's climate. Knowing this, many chemists are working on efficient ways to turn carbon dioxide into other useful products. But carbon dioxide's stability makes this tough. It's hard to get the molecule, happy on its own, to react with anything else. The best existing technique to electrochemically break carbon dioxide into pieces that will chemically react uses a catalyst made of platinum. But platinum is a rare, expensive metal. Now, a team of researchers led by Yongtao Meng, a former UConn graduate student in the lab of Institute for Materials Science Director Steve Suib and now a researcher at Stanford University, has come up with a better way. They created an electrochemical cell filled with a porous, foamy catalyst made of nickel and iron. Both metals are cheap and abundant. When carbon dioxide gas enters the electrochemical cell, and a voltage is applied, the catalyst helps the carbon dioxide (a carbon atom with two oxygens) break off oxygen to form carbon monoxide (a carbon atom with one oxygen.) The carbon monoxide is very reactive and a useful precursor for making many kinds of chemicals, including plastics and fuels such as gasoline. Not

**A discovery by a team of researchers could make it more feasible to turn carbon dioxide into fuels.**

## Gossip

## CHEMWATCH

only does the new nickel-iron catalyst work well; it's actually more efficient than the expensive platinum process it could replace. The electrochemical cell using the nickel-iron catalyst gets almost 100% efficiency. "It's almost unheard of. Typically, in a good system you'll get 90 to 95% efficiency, but it might not be stable, might not work at the same low voltage or might not be cheap," says Suib. This process has all of that. Suib's lab used scanning transmission electron microscopy to map cross-sections of the new nickel-iron catalyst, revealing its internal structure. Technically it's a nickel iron hydroxide carbonate, with a porous structure that allows the carbon dioxide gas to flow through it. Suib's microscopy work showed the catalyst stayed intact and did not degrade from use. The next step in the process is to see if it can be scaled up, made in bulk, and tested in industrial situations such as power plants that produce large amounts of carbon dioxide as a waste product.

Phys.org, 15 November 2019

<http://phys.org>

### Five-fold boost in formaldehyde yield

2019-11-20

Environmentally benign methods for the industrial production of chemicals are urgently needed. LMU researchers recently described such a procedure for the synthesis of formaldehyde, and have now improved it with the aid of machine learning. Formaldehyde is one of the most important feedstocks employed in the chemical industry, and serves as the point of departure for the synthesis of many more complex chemical products. Industrial production of formaldehyde is currently based on a large-scale procedure which consumes fossil fuels and requires a high energy input. More efficient and more sustainable modes of synthesis are therefore urgently needed, which could make a significant contribution to the mitigation of climate. LMU chemist Professor Oliver Trapp and his colleagues have now developed a new workflow for the production of formaldehyde, which is based on an algorithm constructed with the aid of machine learning. The new procedure increases yields of the compound by a factor of 5, as the team now reports in the journal *Chemical Science*. The authors of the study are convinced that their novel approach has great potential and can in principle be applied to other synthetic procedures. Industrial synthesis of formaldehyde begins with syngas [a mixture of carbon monoxide (CO) and molecular hydrogen (H<sub>2</sub>)] – to which methanol is added before being oxidized with the help of a catalyst. However, the production of syngas itself requires high temperatures and fossil fuels

**Environmentally benign methods for the industrial production of chemicals are urgently needed.**

## Gossip

## CHEMWATCH

such as natural gas or coal. In a previous study, the LMU researchers described the development of a reaction scheme which allowed a formaldehyde derivative to be synthesized in a single step from a mixture of hydrogen gas and carbon dioxide, in the presence of a homogeneous catalyst, under moderate conditions of temperature and pressure. On addition of methanol, this derivative could then be converted into the desired end-product. The strategy has a number of advantages over the conventional procedure. "First of all, it allows CO<sub>2</sub>, which is a by-product of several industrial processes (for example, in the production of steel) to be recycled. So, this approach not only enhances the efficiency of formaldehyde synthesis, it also reduces the rate of accumulation of CO<sub>2</sub> in the atmosphere. In the light of ongoing climate change, this is a much sought-after and very welcome side-effect of the procedure," says Trapp. "In addition, the whole process requires far less energy than alternative routes of synthesis, as it occurs at lower temperatures and involves fewer steps." The group has now optimised this procedure by varying no less than seven parameters that affect the yield of formaldehyde synthesis in their system, and using machine learning to identify the parameter combinations that give the best results. The essential feature of machine-learning algorithms is that they are capable of learning from experience, when provided with appropriate 'training' datasets. "In the method that we employed, called random forest, the initial datasets contain valid results obtained on the basis of empirical observations or calculations," says Trapp. A subset of these data is used to train the algorithm, so that it can construct a mathematical relationship between these input data and the corresponding results. So, the outcome of this step is a mathematical model. The model's ability to account for the rest of the data can then be evaluated, and the model can be progressively tuned. Using this method, the LMU team was able to determine the optimal reaction conditions for their chemical system. By appropriately tuning the input parameters in a new reaction setup, they were able to test the efficacy of the algorithm directly. "The new reaction scheme increased the efficiency of synthesis by 500% relative to that of the conventional mode of formaldehyde production," says Trapp. "This result significantly exceeded our expectations, and it demonstrates the potential of modern algorithms to maximise outcomes with minimal practical effort." The authors are confident that their results will motivate chemical engineers to adopt the process and implement it on a technical scale. "BASF, our partner in the project, is already engaged in assessing the industrial relevance of the process," says Trapp. Given that annual global production of formaldehyde exceeds 20 million tons by a considerable margin, and demand for the compound continues to rise, this comparatively benign alternative to the

## Gossip

## CHEMWATCH

current mode of synthesis could make an appreciable contribution to the reduction of greenhouse gases.

Phys.org, 13 November 2019

<http://phys.org>

### New catalysts remove NO<sub>x</sub> pollutants at lower temperatures

2019-11-20

Scientists from Tokyo Metropolitan University have developed a low-temperature catalyst for removing NO<sub>x</sub> gas from industrial exhaust using ammonia. Composed of bulk “defective” vanadium oxide instead of vanadium oxides supported on titanium oxide like in commercial catalysts, the catalyst works at lower temperatures (< 150 degrees Celsius) with much higher efficiency. The team demonstrated a clear improvement in performance, and identified the reaction mechanisms responsible for the difference. Nitrogen monoxide (NO) and nitrogen dioxide (NO<sub>2</sub>), or nitrogen oxides (NO<sub>x</sub>), are common atmospheric pollutants created by burning fossil fuels, coal and natural gas. They are a major cause of photochemical smog and acid rain, which makes their removal from vehicle and factory emissions extremely important. A key technology for removing nitrogen oxides is their reaction with ammonia via selective catalytic reduction (SCR), where NO<sub>x</sub> is rendered harmless via reduction to nitrogen and water. In particular, vanadium oxides supported on titania are known to have excellent selectivity for conversion to nitrogen, and have been successfully applied to stationary boilers. However, a significant bottleneck for supported catalysts is the high temperature required for catalytic activity, often 200 to 400 degrees Celsius. This often results in units being placed close to e.g. the boiler in power plants, where they can be easily damaged not only physically by ash but by the accumulation of ammonium sulfates. These deactivating factors can be avoided if the unit is placed downstream after an electrostatic precipitator for removing dust and a desulfation system to remove sulfate deposits. However, this approach requires high catalytic activity at lower temperatures, since the temperature of the exhaust gas has generally dropped to around 100 degrees Celsius by this point. A catalyst is needed that works at lower temperatures. Now, a team led by Yusuke Inomata and Toru Murayama from Tokyo Metropolitan University have developed a catalyst based on bulk vanadium oxides. Vanadium (V) oxide (V<sub>2</sub>O<sub>5</sub>) is a common state of vanadium oxide; the team however successfully synthesized a mixture of vanadium (V) and vanadium (IV) oxides, or “defective” vanadium oxide, by

**Bulk ‘defective’ vanadium oxide for NO<sub>x</sub> removal from industrial exhaust at temperatures lower than 150 degrees Celsius**

## Gossip

## CHEMWATCH

heating a precursor to 270 degrees Celsius. They found that this “defective” catalyst had excellent catalytic activity at temperatures down to 100 degrees Celsius; at this temperature, the speed at which NO<sub>x</sub> is converted to harmless nitrogen was 10 times faster than conventional titania supported vanadium oxide catalysts, showing exceptional performance where conventional catalysts fall short. The improvement was attributed to the presence of V(IV) which creates “Lewis acid” (electron-accepting) sites, promoting the reaction of nitrogen oxide with ammonia to become nitrogen. Beyond practical application to industrial catalysis, the team hope that the mechanisms they have uncovered serve as a model system for further scientific studies.

EurekaAlert, 15 November 2019

<http://www.eurekaalert.org>

### Atomically dispersed Ni is coke-resistant for dry reforming of methane

2019-11-20

Dry reforming of methane (DRM) is the process of converting methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) into synthesis gas (syngas). Since CO<sub>2</sub> and CH<sub>4</sub> are the two most important atmospheric greenhouse gases (GHGs), as well as abundant and low-cost carbon sources, DRM has the potential to mitigate rising GHG emissions and simultaneously realize clean(er) fossil fuel utilisation. Ni catalysts are the most promising candidates for DRM due to their low cost and high initial activity. However, in situ catalyst deactivation caused mainly by carbon deposition (coking) has hindered their commercial use. Scientists at the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences have now developed completely coke-resistant Ni-based single-atom catalyst (SAC). Their findings were published in Nature Communications. The researchers first developed a hydroxyapatite- (HAP) supported Ni SAC, studied its DRM performance, and found that both HAP-supported Ni SAC and Ni nanocatalyst deactivated quickly during high-temperature DRM. However, characterisation of the used samples revealed that the deactivation mechanisms were totally different: Deactivation of nanocatalyst originated from the coke, while deactivation of Ni SAC stemmed from the sintering of Ni single atoms without any coke formation. These results implied that highly stable and coke-resistant Ni SAC could be obtained if Ni single atoms were effectively stabilised upon reaction. The scientists then doped HAP with cerium to stabilise Ni single atoms through strong metal-support interaction. The resulting HAP-Ce-supported Ni SAC was highly stable

**Dry reforming of methane (DRM) is the process of converting methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) into synthesis gas (syngas).**

## Gossip

## CHEMWATCH

upon reaction, without any coke formation. Further studies revealed that Ni SAC is intrinsically coke-resistant. In other words, no coke was formed at all during the reaction (in contrast with coke being formed then removed). The coke resistance of Ni SAC derives from the catalyst's unique capacity for selective activation of the first C-H bond in CH<sub>4</sub>.

EurekaAlert, 15 November 2019

<http://www.eurekaalert.org>

### Bottlebrushes rise up to control coatings

2019-11-20

A microscopic polymer in the form of a common kitchen implement could give industry exquisite control over coatings. Bottlebrush copolymers have long been a topic of study for Rafael Verduzco, a chemical and biomolecular engineer at Rice University's Brown School of Engineering. Now, he and his collaborators have developed models and methods to refine surface coatings to make them, for instance, more waterproof or more conductive. The researchers discovered that bottlebrushes mixed with linear polymers tend to migrate to the top and bottom of a thin film as it dries. These films, as coatings, are ubiquitous in products, for instance as waterproof layers to keep metals from rusting or fabrics from staining. When the migration happens, the linear polymers hold the centre while the bottlebrushes are drawn to the air above or the substrate below. This, Verduzco said, effectively decouples the properties of the bulk coating from its exposed surfaces. Computational models and experiments showed that variations in the bottlebrush itself could be used to control surface characteristics. Bottlebrush polymers remain challenging to make in bulk, Verduzco said, but their potential uses are vast. Applications could include drug delivery via functionalised bottlebrushes that form micelles, lubricants, soft elastomers, anti-fouling filters and surfaces that heal themselves, he said. The details appear in the American Chemical Society journal *Macromolecules*. The Rice lab, with help from peers at the University of Tennessee, Knoxville; Oak Ridge National Laboratory and the University of Houston, characterized various bottlebrushes made of polystyrene and poly(methyl methacrylate) (aka PMMA) while studying what causes the polymers to migrate. Resembling their macro kitchen cousins (as well as certain flowers), bottlebrushes consist of small polymer chains that radiate outward from a linear polymer rod. The bottlebrushes self-assemble in a solution, which can be manipulated to adjust their properties. Coatings are ubiquitous, Verduzco said. "If we didn't have the right coatings, our materials would degrade quickly," he said. "They would

**Rice University engineers find bottlebrush copolymers can be tailored for applications**

## Gossip

## CHEMWATCH

react in ways we don't want them to. So, coating a surface is usually a separate process; you make something and then you have to find a way to deposit a coating on top of it. "What we're looking at is a kind of universal additive, a molecule you can blend with whatever you're making that will spontaneously go to the surface or the interface," he said. "That's how we ended up using bottlebrushes." Bottlebrushes can be tuned by varying the number of side chains, their length or the length of the backbone polymer, Verduzco said. The side chains themselves can be of mixed type, and small molecules or proteins can be added to their end groups. "The chemistry of these materials is advanced sufficiently that you can pretty much put just about any kind of polymer as one of these bristles on the side chain," he said. "You can put them in different order." The researchers found entropic and enthalpic thermodynamics drove bottlebrushes almost completely away from the interior of the films and toward the interfaces as they dried. Even where linear polymers were designed to pair with the surface interface, the bottlebrushes still rose to the exposed surface. Verduzco noted the findings were made possible by the time of flight-secondary ion mass spectrometer acquired by Rice in 2018 through a National Science Foundation grant. The spectrometer allowed the researchers to characterize not only the surface of coatings by bombarding them with ions, but also how coatings changed as microscopic layers were removed from the top down. Rice graduate student Hao Mei is lead author of the paper. Co-authors are Rice research assistant Jiabei Li and research specialist Tanguy Terlier; graduate student Travis Laws of the University of Tennessee; postdoctoral researcher Jyoti Mahalik of the University of Tennessee and Oak Ridge National Laboratory; Rice and University of Houston alumna Adeline Mah, now at Element Biosciences, San Diego; and researcher Peter Bonnesen and technician David Uhrig of Oak Ridge. Research scientist Rajeev Kumar of Oak Ridge and Gila Stein, the Prados Associate Professor of Chemical and Biomolecular Engineering at the University of Tennessee, are co-principal investigators. Verduzco is an associate professor of chemical and biomolecular engineering and of materials science and nanoengineering. The National Science Foundation, Welch Foundation and the Department of Energy Office of Science supported the research.

EurekAlert, 14 November 2019

<http://www.eurekalert.org>

## Gossip

## CHEMWATCH

### Researchers create and stabilize pure polymeric nitrogen using plasma

2019-11-20

Scientists have long theorized that the energy stored in the atomic bonds of nitrogen could one day be a source of clean energy. But coaxing the nitrogen atoms into linking up has been a daunting task. Researchers at Drexel University's C&J Nyheim Plasma Institute have finally proven that it's experimentally possible -- with some encouragement from a liquid plasma spark. Reported in the *Journal of Physics D: Applied Physics*, the production of pure polymeric nitrogen -- polynitrogen -- is possible by zapping a compound called sodium azide with a jet of plasma in the middle of a super-cooling cloud of liquid nitrogen. The result is six nitrogen atoms bonded together -- a compound called ionic, or neutral, nitrogen-six -- that is predicted to be an extremely energy-dense material. "Polynitrogen is being explored for use as a 'green' fuel source, for energy storage, or as an explosive," said Danil Dobrynin, PhD, an associated research professor at the Nyheim Institute and lead author of the paper. "Versions of it have been experimentally synthesised -- though never in a way that was stable enough to recover to ambient conditions or in pure nitrogen-six form. Our discovery using liquid plasma opens a new avenue for this research that could lead to a stable polynitrogen." Previous attempts to generate the energetic polymer have used high pressure and high temperature to entice bonding of nitrogen atoms. But neither of those methods provided enough energy to excite the requisite ions -- atomic bonding agents -- to produce a stable form of nitrogen-six. And the polymeric nitrogen created in these experiments could not be maintained at a pressure and temperature close to normal, ambient conditions. It's something like trying to glue together two heavy objects but only being strong enough to squeeze a few drops of glue out of the bottle. To make a bond strong enough to hold up, it takes a force strong enough to squeeze out a lot of glue. That force, according to the researchers, is a concentrated ion blast provided by liquid plasma. Liquid plasma is the name given to an emission of an ion-dense matter generated by a pulsed electrical spark discharged in a liquid environment -- kind of like lightning in a bottle. Liquid plasma technology has barely been around for a decade though it already holds a great deal of promise. It was pioneered by researchers at the Nyheim Institute who have explored its use in a variety of applications, from health care to food treatment. Because the plasma is encased in liquid it is possible to pressurize the environment, as well as controlling its temperature. This level of control is the key advantage that the researchers needed to synthesize polynitrogen

**Researchers have reported the production of the first pure polymeric nitrogen compound at near-ambient conditions.**

## Gossip

## CHEMWATCH

because it allowed them to more precisely start and stop the reaction in order to preserve the material it produced. Dobrynin and his collaborators first reported their successful attempt to produce polynitrogen using plasma discharges in liquid nitrogen in a letter in the *Journal of Physics D: Applied Physics* over the summer. In their most recent findings, the plasma spark sent a concentrated shower of ions toward the sodium azide -- which contains nitrogen-three molecules. The blast of ions splits the nitrogen-three molecules from the sodium and, in the excited state, the nitrogen molecules can bond with each other. Not surprisingly, the reaction produces a good bit of heat, so putting the brakes on it requires an incredible blast of cold -- the one provided by liquid nitrogen. "We believe this procedure was successful at producing pure polynitrogen where others fell short, because of the density of ions involved and the presence of liquid nitrogen as a quenching agent for the reaction," Dobrynin said. "Other experiments introduced high temperatures and high pressures as catalysts, but our experiment was a more precise combination of energy, temperature, electrons and ions." Upon inspection with a Raman spectrometer -- an instrument that identifies the chemical composition of a material by measuring its response to laser stimulus -- the plasma-treated material produced readings consistent with those predicted for pure polynitrogen. "This is quite significant because until now scientists have only been able to synthesise stable polynitrogen compounds in the form of salts -- but never in a pure nitrogen form like this at near-ambient conditions," Dobrynin said. "The substance we produced is stable at atmospheric pressure in temperatures up to about -50 Celsius." Plasma, in its original gas-laden environment, has been under development for decades as a sterilisation technology for water, food and medical equipment and it is also being explored for coating materials. But this is the first instance of liquid plasma being used to synthesise a new material. So, this breakthrough could prove to be an inflection point in plasma research, at the Nyheim Institute and throughout the field. "This discovery opens a number of exciting possibilities for producing polymeric nitrogen as a fuel source," said Alexander Fridman, PhD, John A. Nyheim Chair professor in Drexel's College of Engineering and director of the C&J Nyheim Plasma Institute and co-author of the paper. "This new, clean energy-dense fuel could enable a new age of automobiles and mass transportation. It could even be the breakthrough necessary to allow the exploration of remote regions of space."

Science Daily, 14 November 2019

<http://www.sciencedaily.com>

## Gossip

## CHEMWATCH

### Gallium-based solvating agent efficiently analyses optically active alcohols

2019-11-20

A KAIST research team has developed a gallium-based metal complex enabling the rapid chiral analysis of alcohols. A team working under Professor Hyunwoo Kim reported the efficient new alcohol analysis method using nuclear magnetic resonance (NMR) spectroscopy in *iScience*. Enantiopure chiral alcohols are ubiquitous in nature and widely utilized as pharmaceuticals. This importance of chirality in synthetic and medicinal chemistry has advanced the search for rapid and facile methods to determine the enantiomeric purities of compounds. To date, chiral analysis has been performed using high-performance liquid chromatography (HPLC) with chiral columns. Along with the HPLC technique, chiral analysis using NMR spectroscopy has gained tremendous attention as an alternative to traditionally employed chromatographic methods due to its simplicity and rapid detection for real-time measurement. However, this method carries drawbacks such as line-broadening, narrow substrate scope, and poor resolution. Thus, compared with popular methods of chromatographic analysis, NMR spectroscopy is infrequently used for chiral analysis. In principle, a chiral solvating agent is additionally required for the NMR measurement of chiral alcohols to obtain two distinct signals. However, NMR analysis of chiral alcohols has been challenging due to weak binding interactions with chiral solvating agents. To overcome the intrinsic difficulty of relatively weak molecular interactions that are common for alcohols, many researchers have used multifunctional alcohols to enhance interactions with solvating agents. Instead, the KAIST team successfully varied the physical properties of metal complexes to induce stronger interactions with alcohols rather than the strategy of using multifunctional analytes, in the hopes of developing a universal chiral solvating agent for alcohols. Compared to the current method of chiral analysis used in the pharmaceutical industry, alcohols that do not possess chromophores can also be directly analysed with the gallium complexes. Professor Kim said that this method could be a complementary chiral analysis technique at the industry level in the near future. He added that since the developed gallium complex can determine enantiomeric excess within minutes, it can be further utilized to monitor asymmetric synthesis. This feature will benefit a large

**A research team has developed a gallium-based metal complex enabling the rapid chiral analysis of alcohols.**

## Gossip

## CHEMWATCH

number of researchers in the organic chemistry community, as well as the pharmaceutical industry.

Science Daily, 14 November 2019

<http://www.sciencedaily.com>

### Stretchable, degradable semiconductors

2019-11-20

To seamlessly integrate electronics with the natural world, materials are needed that are both stretchable and degradable -- for example, flexible medical devices that conform to the surfaces of internal organs, but that dissolve and disappear when no longer needed. However, introducing these properties to electronics has been challenging. Now, researchers reporting in ACS Central Science have developed stretchable, degradable semiconductors that could someday find applications in health and environmental monitoring. Semiconductors, which are essential components of almost all computers and electronic devices, have properties somewhere between conductors and resistors. Most semiconductors are currently made of silicon or other rigid inorganic materials. Scientists have tried making flexible, degradable semiconductors using different approaches, but the products either didn't break down completely or had reduced electrical performance when stretched. Zhenan Bao and colleagues wanted to see if they could solve these problems by combining a rubbery organic polymer with a semiconducting one. To make their new material, the researchers synthesized and mixed the two degradable polymers, which self-assembled into semiconducting nanofibers embedded in an elastic matrix. Thin films made of these fibres could be stretched to twice their normal length without cracking or compromising electrical performance. When placed in a weak acid, the new material degraded completely within 10 days, but it would likely take much longer in the human body, Bao says. The semiconductor was also non-toxic to human cells growing on the material in a petri dish. According to the researchers, this is the first example of a material that simultaneously possesses the three qualities of semiconductivity, intrinsic stretchability and full degradability.

Science Daily, 13 November 2019

<http://www.sciencedaily.com>

**Researchers have developed stretchable, degradable semiconductors that could someday find applications in health and environmental monitoring.**

## Gossip

## CHEMWATCH

### Supercharged Trash Gas Could Produce More Green Energy

2019-11-20

Synthetic compounds called “siloxanes” from everyday products like shampoo and motor oil are finding their way into landfills and supercharging the biogas those landfills produce, researchers report. While it’s a problem today, the researchers say it could be an opportunity to get more energy out of landfill gas. The compounds efficiently conduct heat and interact with water, and as such their popularity has increased in a variety of consumer products. That means more and more siloxanes are headed to your local landfill. Biogas refers to fuel gases that are synthesized from different biological or organic feedstocks like landfill gas and wastewater treatment plants. In recent years, it has become clear that siloxanes have been damaging the power-generating equipment that’s fuelled with landfill gas. But the researchers say it may be possible to harness the siloxanes to produce more energy.

#### “Like Rocket Fuel”

The researchers conducted the first chemical analysis of how siloxanes affect biogas. They found that siloxanes increase the reactivity of biogas, leading to faster ignition in engines and the release of more energy. But the siloxanes in the biogas can damage those engines—typically power-generating gas turbines and reciprocating piston engines. “Siloxanes are highly ignitable,” says Margaret Wooldridge, professor of mechanical engineering and director of the Dow Sustainability Fellows Program at the University of Michigan. “They change the chemistry of biogas like crazy. The stuff is like rocket fuel, literally—crazy-reactive.” The siloxanes essentially change the biogas’s “flame speed,” which is a measure of how quickly a fuel combusts and drives a turbine or piston. Biogas is composed mainly of methane. There’s methane gas in nature but it’s also produced when organic material decomposes in landfills, along with hydrogen, carbon monoxide, and other hydrocarbons. Methane is the main component of natural gas and biogas, making both valuable sources of fuel and energy that are cleaner than coal. In the atmosphere, however, methane is particularly good at trapping heat, adding to our global warming problem. In particular, methane is 30 times more effective a greenhouse gas than CO<sub>2</sub>. And according to the EPA, municipal solid waste landfills account for 14% of all human-related methane emissions in the US each year—the third-largest source behind the gas and petroleum industry and agriculture. That property has spurred efforts to capture

**Synthetic compounds called “siloxanes” from everyday products like shampoo and motor oil are finding their way into landfills and supercharging the biogas those landfills produce, researchers report.**

## Gossip

### CHEMWATCH

methane from landfills and use it as a fuel, instead of allowing it to escape unchecked.

#### Measuring 'Ignitability'

In this study, the researchers separately tested hydrogen and carbon monoxide mixtures containing two siloxanes—trimethylsilanol (TMSO) and hexamethyldisiloxane (HMDSO)—against hydrogen and carbon monoxide mixtures with no siloxanes. Specifically, the researchers clocked how long it took for each mixture to ignite. Scientists consider fuels that have a shorter ignition delay more ignitable or reactive—and hydrogen is one of the most reactive fuels we use. Hydrogen and carbon monoxide with TMSO produced ignition delay times that were 37% faster than the reference case. And HMDSO-infused methane produced delay times 50% faster. Researchers hope their work sheds light on how siloxanes alter engine performance when used as a fuel. “Trace concentrations of siloxanes have been a known problem in biogas applications—leading to the formation of abrasive silica deposits on engine components,” says study co-author Rachel Schwind, a doctoral student. “For this reason, most prior research in this area has focused on how to remove them from the captured gas.”

#### The Potential of Siloxanes

Along with the problem siloxanes pose, there is also potential. Wooldridge says siloxanes could be key to deriving bolstered energy production from biogas. “We would love to be able to harness them as an energy source,” she says. Analysing the combustion chemistry is a step in that direction. “That would potentially negate the need for scrubbing or removal during biogas processing and reduce costs,” Schwind says. “If we can reduce those costs, it moves biogas closer to being a truly carbon neutral fuel. And if we can make landfill gas a more economically attractive option, landfill operators will have more incentive to capture and utilize this harmful greenhouse gas.” The research appears in the journal *Combustion and Flame*. The US Department of Energy’s Basic Energy Sciences program supported the research.

Futurity, 15 November 2019

<http://www.futurity.org>

## Gossip

### CHEMWATCH

#### Using aluminium and lasers to make bendable glass

2019-11-20

An international team of researchers has found a way to make bendable glass using lasers fired at crystalline aluminium oxide. In their paper published in the journal *Science*, the group describes their technique and the features of the glass they produced. Lothar Wondraczek with the University of Jena has published a companion piece in the same journal issue outlining the history of scientists attempting to overcome the brittleness of glass. Glass is somewhat strong, but only up to a point; it is also very brittle. If you drop a drinking glass, it will likely shatter on the floor. As Wondraczek notes, scientists have been searching for ways to make glass less brittle for as long as people have been making glass. Bendable glass would mean drinking glasses that survive a fall, or smartphone screens that do not crack. In this new effort, the researchers say they have taken a step toward that goal. Ordinary glass is made from silica and oxygen, and it is known as an amorphous solid—a state in which a material's molecules are locked together—in the case of glass, in a random fashion. It is transparent because photons can pass through it without interacting with any of the electrons in the glass. In this new effort, the researchers used crystalline aluminium oxide instead of sand to make some tiny glass samples. To do so, they fired intense bursts of laser light at a sample to turn it into a purple plasma. The material was then allowed to cool on a substrate. Testing of the resulting material (sheets 60 nanometres thick and two micrometres wide) showed it to be transparent and far less brittle than ordinary glass. The sheets were also bendable and stretchable. The researchers found they could stretch them up to 8 percent and compress them to half their length. The researchers also took a close look at their bendable glass using an electron microscope. Using what they found, they created computer simulations of the material they had created to better understand its properties. The model showed that the glass had a very tightly packed network of atoms that was defect free, making it bendable. Its atoms were able to switch places when exposed to pressure. More work is required before the bendable glass can be commercialized—it is still not clear if the process could be used to make bigger sheets of glass, or if it is even amenable to manufacturing.

Phys.org, 15 November 2019

<http://phys.org>

**An international team of researchers has found a way to make bendable glass using lasers fired at crystalline aluminium oxide.**

## Curiosities

### CHEMWATCH

### **New Evidence Reveals ‘Causal Connection’ Between Sleep Quality And Anxiety**

2019-11-21

Everybody knows to get a good night's sleep if they want to feel their best, but the emotional consequences of not having adequate rest could be far greater than we ever realised, according to new neurological research. In a new study analysing the brain scans of healthy volunteers, scientists say they've established a "causal connection" between the quality of sleep people get and resulting anxiety levels the next day – a link that could have "societal relevance", given the anxiety epidemic gripping America and elsewhere. "We have identified a new function of deep sleep, one that decreases anxiety overnight by reorganising connections in the brain," says neuroscientist Matthew Walker from the University of California, Berkeley. "Deep sleep seems to be a natural anxiolytic (anxiety inhibitor), so long as we get it each and every night." Of course, none of this should come as an outright shock. For years, scientists have been warning about what happens in the brain when we don't get enough sleep, and numerous extreme experiments have charted the grave physiological consequences of sleep deprivation. Despite this, millions upon millions of us don't sleep as much as we know we're supposed to, and Walker's new research illustrates another big problem stemming from that. The researchers scanned the brains of 18 healthy young adults in two experimental sessions, during which they watched video clips depicting 'aversive' scenarios, designed to elicit an emotional response. One of these sessions occurred in the morning, after the participants enjoyed a full night of sleep. The other session took place on another morning, after they'd stayed up all night in the laboratory, doing things like reading, watching movies, and playing board games (while being monitored to ensure they didn't rest). After the sessions, the participants had their anxiety levels measured by a psychological test called the State-Trait Anxiety Inventory, and the results showed the sleepless night effectively triggered a 30 percent increase in anxiety levels. "Notably, 78 percent of all participants in the sleep-deprived condition reported an increase in anxiety, confirming a robust impact of sleep loss on the escalation of anxiety in healthy individuals," the authors explain in their paper. What's more, half of the sleep-deprived participants actually exceeded anxiety levels that serve as a base threshold for symptoms of clinical anxiety disorders – and all it took to get there was one sleepless night. "Without sleep, it's almost as if the brain is too heavy on the emotional accelerator pedal, without enough brake," Walker says. The fMRI scans from the sessions showed increased emotional reactivity following sleep loss in the amygdala (which

**In a new study analysing the brain scans of healthy volunteers, scientists say they've established a "causal connection" between the quality of sleep people get and resulting anxiety levels the next day**

## Curiosities

### CHEMWATCH

helps control our fight or flight reflex) and the dorsal anterior cingulate, which flares during negative emotional responses. While activity in those brain regions was heightened in the sleepless volunteers, activity in the medial prefrontal cortex – which helps regulate emotions like anxiety – was basically shut down. Conversely, polysomnographic readings taken while the sleeping participants slept indicated that the least anxiety was experienced by those who enjoyed the longest periods of deep sleep, called non-REM (NREM) slow-wave sleep (SWS). “Our experimental studies demonstrate that, within this interaction, sleep loss can causally and directionally instigate high levels of anxiety in individuals who were otherwise non-clinically anxious when sleep-rested,” the researchers explain. “This finding defines a causal influence of disrupted sleep on the development of anxiety, beyond simply a co-occurring symptom of anxiety disorders.” The team shared their initial research last year, but their now published, peer-reviewed paper describes additional experiments that back up their primary findings. These include an additional cohort of 32 participants that repeated the polysomnographic experiment (replicating the first results), and online research involving over 300 participants, who answered questions about their night-to-night sleep and day-to-day anxiety levels – offering insights on how even small disruptions in sleep over time can affect and predict anxiety. Taken together, the team says the data suggest both a “neural framework explaining how and why insufficient sleep may contribute to anxiety” and also a palliative function of NREM sleep “capable of ameliorating anxiety”. “Consistent with the anxiogenic impact of sleep deprivation, we establish that even subtle perturbations in sleep quality from one night to the next negatively impact anxiety,” they write. “Shifting to prevention, our findings suggest that even modest improvements in sleep quality may have the potential to reduce subjective anxiety, serving as a non-pharmacological prophylactic.” In other words, sleep is good for you. More to the point, as Walker says, “the decimation of sleep throughout most industrialised nations and the marked escalation in anxiety disorders in these same countries is perhaps not coincidental, but causally related”. It’s a statement (and a study) that all just sounds like so much common sense – while at the same time seeming entirely profound. Either way, deep sleep sounds like the anti-anxiety drug many of us have been searching for, and we should definitely try it out sometime. The findings are reported in *Nature Human Behaviour*.

Science Alert, 6 November 2019

<http://www.sciencealert.com.au>

## Curiosities

CHEMWATCH

### Chronic Form of B12 Deficiency Can Cause Major Health Issues, And Is Often Misdiagnosed

2019-11-21

An estimated 6 percent of people in the United States and United Kingdom suffer from vitamin B12 deficiency. The condition is recognised by the World Health Organisation as a global health problem that could impact millions of lives. B12 deficiency is typically characterised by symptoms such as extreme tiredness, lack of energy, muscle weakness, and even problems with memory. Not only that, but it can cause a number of serious health problems, such as irreversible nerve damage, anxiety or depression, or disorders which affect coordination, balance, and speech. While some B12 deficiencies are caused by diet, the most common reason for low B12 levels worldwide is an autoimmune disorder called pernicious anaemia. This is a chronic form of low B12 that can have serious consequences on health if left untreated long-term. However, because symptoms of the condition typically look like other common conditions, it's often misdiagnosed as depression or anxiety. Not only does the condition cause physical distress, the stigma of living with this chronic condition can also cause serious psychological harm, as I've shown in my research. Vitamin B12 – otherwise known as cobalamin – is a water-soluble vitamin found in animal by-products, such as meat, fish and dairy. Other sources include fortified cereal, breads and plant milks. People who don't regularly consume animal products are at risk of becoming deficient in B12. To reduce this risk, vegans are recommended to consume at least three micrograms of B12 daily through fortified foods, or by taking a regular B12 supplement. However, most low B12 levels are more caused by pernicious anaemia. The condition makes it difficult for people to process vitamin B12 because the immune system impacts on the functioning of important parietal cells within the stomach. These cells produce a protein called "intrinsic factor" which is essential for vitamin absorption. People with pernicious anaemia will produce an antibody to Intrinsic Factor that destroys any Intrinsic Factor that has been produced. And so, without any Intrinsic Factor to bind to food, they are unable to extract any B12. Without B12, the body isn't able to produce enough healthy red blood cells. The condition can also be caused by a weakened stomach lining. This may happen because of atrophic gastritis, chronic inflammation in the stomach that eventually weakens the lining.

#### A lifelong condition

An estimated five in every 100,000 people in the UK have pernicious anaemia. It affects people of all ages, and symptoms can start at any time.

**An estimated 6 percent of people in the United States and United Kingdom suffer from vitamin B12 deficiency.**

## Curiosities

### CHEMWATCH

However, the condition is more common in people over 60, as older adults are more likely to develop atrophic gastritis, which increases the risk of B12 deficiency. The number of people with the condition worldwide might be higher than estimated. However, it's difficult to reliably estimate levels of B12 deficiency because there's no agreed definition of how low B12 levels must be to be classified as deficient. New guidelines have been made to address problems with current diagnosis methods. They state that a patient's symptoms are the best indicator of any deficiency. It also states that if there's inconsistency with the test result and the patient's reported symptoms, the patient should still be treated with replacement B12 to prevent any potential irreversible damage. B12 deficiency causes a wide range of debilitating neurological and physical symptoms. The most common symptoms of pernicious anaemia are fatigue, memory loss and problems with concentration. However, the subtle, nonspecific nature of the condition's initial symptoms can make it difficult to properly diagnose people. One study interviewing members of the Pernicious Anaemia Society found that nearly half had been misdiagnosed. A further 20 percent had waited two years or more for a proper diagnosis. For many, symptoms were initially attributed to a hectic lifestyle or diagnosed as anxiety or depression. Low levels of B12 can lead to nerve damage, as the vitamin is essential to producing myelin, which protects nerve cells from damage. Symptoms of low B12 might initially feel like tingling or numbness in hands and feet, or difficulty with balance. If pernicious anaemia is left untreated, symptoms can become debilitating and nerve damage irreversible. The term "pernicious" was used to describe the condition as historically it resulted in death. When Vitamin B12 deficiency is caused by poor diet, it's treated by prescribing B12 tablets or injections of hydroxocobalamin. Once the deficiency has been corrected, levels can be managed by changing diet or regularly taking a supplement. However, treatment is lifelong for people with pernicious anaemia. In the UK, many need frequent injections every 8 to 12 weeks to replace the vitamin. Despite this, many people continue experiencing debilitating symptoms, or find their symptoms return before their next scheduled injection because their treatment hasn't been sufficient. When patients raised concerns about insufficient treatment or requested more frequent injections, our research found that many health care professionals responded negatively, even questioning the legitimacy of the patient's illness. These kinds of questions can increase psychological distress and impact on quality of life. Patients with pernicious anaemia also anticipated high levels of health-related stigma. Many people with chronic health conditions fear that their health status will lead them to be devalued by wider society, or be a source of discrimination. Stigma not only impacts on

## Curiosities

### CHEMWATCH

relationships with health care providers, but can cause increased incidence of anxiety and depression. The lack of appropriate guidelines for diagnosis and treatment of pernicious anaemia is problematic and there is an urgent need for this to be reviewed. It is important that both the general public and health professionals have increased awareness of the symptoms that arise from inadequate levels of B12 so that the condition can be diagnosed before long term damage occurs.

Science Alert, 9 November 2019

<http://www.sciencealert.com.au>

### Massive Review Confirms House Plants Aren't Actually 'Purifying' The Air in Your Home

2019-11-21

Filling your house with potted plants might make you happier and more productive, but it's not going to make the air you breathe any cleaner. That is, unless you had a ludicrous number of indoor plants: somewhere between 10 and 1,000 for every square metre of your living space. A critical review, drawing on 30 years of research, has once again found that houseplants have little - if any - real value as air removers. Using data from a dozen different studies over the years, the authors reiterate that for a normal 140 m<sup>2</sup> house or office (1,500 ft<sup>2</sup>), you'd need 680 house plants or five per square metre to achieve the same airflow as a couple open windows. Obviously, that's not a smart use of space. Even one plant per square metre is ineffective and impractical for most people. If you wanted to improve air quality in your house beyond what windows, doors or a normal building's air handling system can do, you'd need roughly a hundred plants per square metre, the authors say. And nobody has the time, space or patience to accommodate that much greenery. "This has been a common misconception for some time," says environmental engineer Michael Waring at Drexel University. "Plants are great, but they don't actually clean indoor air quickly enough to have an effect on the air quality of your home or office environment." The idea for this myth really took root in 1989, when NASA conducted a study on plants to see if they could filter cancer-causing chemicals on space stations. The research only got so far as placing a plant in an air-tight chamber smaller than a cubic metre, although the results were remarkable. Within a day, the authors reported up to 70 percent of the toxic pollutants in the air had been removed by the plants. But a small sealed chamber is very different to a real indoor environment in a big building. Over time, the NASA study and subsequent research has been largely taken out of context. In a

**Filling your house with potted plants might make you happier and more productive, but it's not going to make the air you breathe any cleaner.**

## Curiosities

### CHEMWATCH

normal building, the authors argue, stale indoor air is continuously being replaced with fresh air from the outdoors, orders of magnitude faster than the chamber experiments. The authors demonstrated this by taking 196 experimental results and translating them into clean air delivery rates (CADR). Using this metric, they calculated that for nearly all the studies, the rate at which plants cleaned volatile organic compounds (VOCs) from the air was so slow as to be irrelevant. "The CADR is the standard metric used for scientific study of the impacts of air purifiers on indoor environments," says Waring, "but many of the researchers conducting these studies were not looking at them from an environmental engineering perspective and did not understand how building air exchange rates interplay with the plants to affect indoor air quality." While a few of the studies did measure real indoor environments, Waring and Cummings say the equipment they used was prone to inaccuracies and they used unrealistically high concentrations of toxic pollutants. What's more, absolutely none of them controlled or measured the outdoor air exchange rate. "Only two publications were found that not only acknowledge these issues, but explicitly refute the notion that common houseplants improve indoor air quality," they write. These two studies were also written by indoor air and building scientists. And even in the 2009 review, their conclusions were much the same as now. "Although ventilation dominates the VOC removal processes in virtually all real-world buildings, ventilation was not measured in any of these studies," they wrote at the time. "It is not possible to obtain meaningful quantitative results of pollutant removal in a field study without also measuring ventilation rates. The ventilation rate variability in most buildings is simply too large a confounder." A decade later, Cummings and Waring are in strong agreement. In a building with an extremely low air flow and under the most generous CADR assumptions, they found one potted plant per square metre might achieve 20 percent effectiveness. But that number quickly falls when the air exchange rate is changed even a little bit. That's not to say we shouldn't keep doing research on plants in sealed chambers. Finding out how plants filter indoor VOCs could potentially be useful for 'biopurifiers', which mechanically pull air through a porous substrate for plants. Still, it's important that researchers and the media don't extrapolate such findings to real world environments. Filling your house with plants may make you feel great, but you don't have to do it just to make an impact on air quality. Especially when you consider some plants actually release VOCs, spores and other bioparticles. "This is certainly an example of how scientific findings can be misleading or misinterpreted over time," Waring says. "But it's also a great example of how scientific research should continually re-examine and question findings to get closer to the ground truth of understanding

## Curiosities

### CHEMWATCH

what's actually happening around us." The study was published in the *Journal of Exposure Science & Environmental Epidemiology*.

Science Alert, 8 November 2019

<http://www.sciencealert.com.au>

### Exposed: A scientific stalemate leaves our hormones and health at risk

2019-11-21

This investigation examines the science surrounding the chemical BPA and the U.S. regulatory push to discredit independent evidence of harm while favouring pro-industry science despite significant shortcomings. Bisphenol A is likely coursing through your body right now. Every day, you're inadvertently consuming and absorbing trace amounts as it migrates from can and bottle linings into your food and drink, and from thermal paper receipts onto your skin. Scientists have found BPA in more than 90 percent of Americans tested. Yet whether exposures to such small amounts of the common chemical pose any real health hazard remains highly controversial. On one side of a deep rift are academics who are adamant about the adverse effects; on the other side are U.S. Food and Drug Administration scientists who declare there are no dangers. Only one side has any control over what actually makes its way into your body. "This is a chasm that is not going to be breached," Daniel Doerge, a biochemical toxicologist with the FDA for nearly 30 years, said during a panel at the European Food Safety Authority (EFSA) conference in Parma, Italy, last September. Doerge and other federal scientists were attending the conference to share details of an unprecedented multimillion-dollar project co-led by the FDA, the Consortium Linking Academic and Regulatory Insights on BPA Toxicity, or Clarity for short. The effort aims to settle the long-standing dispute between government and academic scientists over the health effects of BPA. Yet Doerge's words did not indicate any hope for such a reconciliation. He wore a green polo shirt, dark glasses and a grey moustache. And he exuded frustration — if not also a bit of arrogance — as he spoke. "Tribal dynamics," he said, are at play among the academics. Doerge alleged they were creating their "own narrative," and "staying in a bubble that turns into an echo chamber." The struggle has been fermenting below the surface for years: Academics with modern methods and a sophisticated understanding of human physiology versus government and industry scientists who lean on decades-old established science in their evaluation of industrial chemicals. The suite of traditional toxicology tests recommended by the FDA for assessing a

**American industry, aided by federal regulators, is conducting a large-scale, consequential experiment with our hormones and the developing brains and reproductive systems of our children.**

## Curiosities

### CHEMWATCH

chemical's health risks hasn't been meaningfully updated since the early 1980s, before Doerge took his job and well before scientists began to understand how minuscule concentrations of certain chemicals common in consumer products, such as BPA, could mimic and mess with hormones in the body. Scientists have long known that a tiny change in a natural hormone concentration — the equivalent of one drop of water in 20 Olympic-sized swimming pools — is enough to trigger instructions via the human endocrine system that impact growth, metabolism, sleep, reproduction and other critical functions of the body. BPA is just the tip of the iceberg. Tens of thousands of manufactured chemicals are on the market; hundreds are believed to be endocrine disruptors — capable of scrambling hormone signals and, therefore, raising risks of health problems such as cancer, diabetes, obesity, infertility and behavioural problems. Other pervasive hormone imposters include phthalates, which are found in plastic food containers and personal care products, and per- and polyfluoroalkyl substances (PFAS), which are added to non-stick cookware and other goods to repel oil and water. Also on the list are flame retardants and pesticides such as DDT, glyphosate and chlorpyrifos. Even bisphenol S and dozens of other BPA replacements have been found to tinker with hormones. Yet the FDA has remained reluctant to accept new science and independent evidence of harm. While the agency clings to the claim that BPA poses no health risks in the amounts it is used, thousands of peer-reviewed studies from academics suggest otherwise: Absorbing or ingesting the ubiquitous chemical may harm people at doses 20,000 times lower than what the FDA says is safe, comparable to levels at which most of us are exposed.

Even back in 1982, a scientific committee established by the FDA had warned of the potential for very low concentrations of chemicals to bind to hormone receptors and that technology in the future might find this interference alters the endocrine system's influential messages. The agency continues to miss opportunities to keep pace with scientific developments, noted Maricel Maffini, an independent consultant based in Germantown, Maryland. Instead, she told EHN, they primarily rely on tests devised decades ago that aren't designed to detect some significant effects that chemicals can have on our health. If we followed the academics' science, BPA and its close relatives would effectively have to be banned, not reduced, in order to protect our health. "Really, if you look at the data, we shouldn't be making these compounds, period," Terrence Collins, a green chemist at Carnegie Mellon University, told Environmental Health News. An investigation by EHN has uncovered a pattern of dissonance between academic scientists and federal agencies,

## Curiosities

### CHEMWATCH

as well as between the agencies themselves, regarding the evaluation and regulation of BPA and other endocrine disruptors. No one smoking gun surfaced. Yet putting together all the pieces creates a persuasive picture of wilful blindness. Based on hundreds of emails obtained via Freedom of Information Act requests — along with dozens of studies and reports, and more than 50 conversations with scientists, regulators and other stakeholders — evidence suggests that regulators may be operating at the fringes of scientific integrity, possibly with the intent to keep the current testing and regulatory regime intact and to avoid scrutiny. EHN's findings include:

- Insistence by the FDA on a study design that limited Clarity's robustness to reveal health effects, including the use of a strain of animal that had been shown to be insensitive to hormone disruptors, the choice of a stressful means to deliver BPA to the animals, and the allocation of small numbers of animals provided to some of the participating academic scientists.
- Potential BPA contamination of the control animals, which may have further masked true differences in health effects between control animals and animals receiving administered doses of BPA.
- Statistical approaches in the government's side of Clarity, a traditional regulatory toxicology study dubbed the Core Study, that set a high bar to detect differences and disregarded patterns in the data that did not fit outdated assumptions on the relationship between a dose of an endocrine-disrupting chemical and its health effects.
- Framing of the government's Clarity Core Study draft report and corresponding press release that downplayed the health effects that did emerge in the data.
- Hints of potential industry influence, such as the FDA's reliance on industry-funded studies.

Clarity, the intended remedy for the government-academics impasse, was launched in 2012 by the FDA, the National Institute of Environmental Health Sciences (NIEHS) and the National Toxicology Program (NTP). The effort combines a traditional regulatory toxicology study from the government and investigational studies from academics. The FDA took the lead on raising and treating the study animals and on performing the Core Study, which was published under the auspices of the NTP. The NIEHS awarded grants to participating academics and worked with the NTP to coordinate the study. The government and most of the 14 participating academic scientists completed their respective studies for the collaborative project in the months preceding the September 2018

## Curiosities

### CHEMWATCH

EFSA conference in Italy. Everyone used the same breed of lab rats, and followed government-approved standards as they investigated possible health impacts. To prevent bias, all Clarity scientists were blinded to the BPA exposure levels of the animals and tissues that they received for study. Earlier in the Italy meeting, Doerge and his federal colleagues presented the government's Core Study. Once again, they relayed results that they said generally absolved BPA. They did not discuss findings from the participating academics. In fact, during the panel, Doerge seems to dismiss those studies, many of which challenged BPA's safety. "I don't see a lot of advantages in, so far anyway, in what the extramural research funding initiative has brought into the Clarity project," he said. (The FDA did not make Doerge available for an interview.) Sitting in the audience in Italy was Heather Patisaul, a biologist at North Carolina State University and one of the academics participating in the massive BPA study. "I was screaming in my chair," she told EHN. "He said it so smugly." An integrated report that pulls all of the Clarity studies together is underway, co-authored by the FDA and other participants. John Bucher, a senior scientist with NTP and NIEHS, told EHN that he expects the report to be completed by the end of this year. It will then be up to the FDA whether or not those results will spur any reshaping of U.S. regulations. Several of the academic scientists are concurrently working on their own independent review of the Clarity data. Cheryl Rosenfeld, a biologist at the University of Missouri and another Clarity investigator, is among the co-authors on that report. "Many of us are not happy with the FDA," she told EHN, adding that she and others are sceptical of what will end up in the official integrated report and if it will have any impact on policy. In the U.S., what the government considers a safe exposure level for BPA — 50 micrograms of BPA per day per kilogram of body weight — has remained untouched for more than 30 years, leaving us all exposed daily to the chemical. Meanwhile, other countries represented at the EFSA meeting have begun reaching agreements and acting on BPA. France has enacted the strictest regulations, banning the use of the chemical in all food and beverage packaging and utensils after an assessment by the French Agency for Food, Environmental Health and Safety determined that it is hazardous at much lower doses than the FDA considers hazardous. A Danish Food Institute Clarity-like study, too, recognized effects at low doses. Many more countries are keeping a close eye on Clarity. EFSA, which is funded by the European Union to conduct risk assessment but not to create policy, told EHN that it will consider the results as part of its ongoing evaluation of BPA. In January 2015, based on the latest information, EFSA dropped its safety limit from 50 to 4 micrograms of BPA per day per kilogram of body weight. The scientific, economic and political stakes are high. For

## Curiosities

### CHEMWATCH

decades, modern commerce across the Western world has depended on BPA. The chemical is used in the production of goods that pervade our lives: reusable water bottles, food containers, canned goods, store receipts, medical devices and dental sealants. And despite growing concerns, the manufacturing of BPA remains on the rise. The global BPA market is increasing about 3 percent per year, and is projected to reach \$22.5 billion by 2022 and top 7 million tons by the end of 2023. "BPA is very cheap to make," said Collins. "I believe the regulatory bodies of the country are locked up by the monetary implications of addressing endocrine disruption." While the clash continues over how endocrine-disrupting chemicals are tested and thereby regulated, irreversible changes to our bodies and health may be happening now. Collins pointed to declining sperm counts and rising rates of endometriosis, which he suggested could be a consequence of these exposures given that the chemicals have been shown to induce such effects in animals. "Endocrine disruptors are harming people and we're not regulating them to any extent right now," Carol Kwiatkowski, executive director of The Endocrine Disruption Exchange, a non-profit research institute that advocates against the production and use of chemicals that interfere with healthy hormone function, told EHN. "A lot of endocrine scientists have been banging their heads against that wall for a long time and haven't made any progress in changing the risk assessment process." It is clear that the FDA is not using modern science in protecting the public from potentially toxic chemicals. It is also clear that BPA and other endocrine disruptors threaten to disrupt the status quo of toxic chemical regulation. "BPA creates a tipping point," Laura Vandenberg, an environmental health researcher at the University of Massachusetts-Amherst's School of Public Health, told EHN. "If the FDA finds out that they have been wrong about BPA — or wrong about how they evaluate chemicals for safety — that means they are wrong about the 10,000 other chemicals behind BPA in line for the same sort of evaluation." Vandenberg, who is not involved in Clarity, is among scientists sceptical that the ground-breaking effort will result in a fair assessment of BPA. The FDA, she said, has "a vested interest in not being wrong."

### Imposter's poster child

In the 1930s, a British medical researcher discovered that BPA could mimic the activity of oestrogen — a female sex hormone — in the human body. The chemical was briefly considered for use as a pharmacological hormone but ultimately lost to another synthetic oestrogen, diethylstilbestrol (DES). While DES was prescribed to millions of pregnant women over the next 30 years before its own health risks became known,

## Curiosities

### CHEMWATCH

BPA was never turned into a drug. Beginning in the 1950s, BPA became a key ingredient in polycarbonate plastic and epoxy resins — finding its way into everything from Tupperware to the lining of food cans. “That’s where the problem starts,” Ana Soto, an endocrinologist at Tufts University and another Clarity investigator, told EHN. The FDA officially approved BPA for use in food and beverage containers in 1963. They classified it as a “generally regarded as safe” (GRAS) compound, since it had already been around for a few years and there was no obvious evidence of harm. By the late 1980s, the U.S was producing nearly a billion pounds of BPA a year. Even scientific laboratories began working with BPA-laden instruments. In 1993, endocrinologists at Stanford University discovered that BPA was leaching from polycarbonate flasks in their laboratory. The first published studies to raise concern about BPA’s low-dose health effects came a few years later, in 1997. Frederick vom Saal and his colleagues had found exposure to tiny amounts of BPA altered the prostates and reproductive systems of laboratory mice. Vom Saal, a professor of biology at the University of Missouri-Columbia and another Clarity investigator, warned viewers in a February 1998 episode of PBS’s Frontline about the threat posed by endocrine-disrupting chemicals used in plastics and other consumer products. “We understand now, with new techniques, that, in fact, cells are extremely responsive to these chemicals,” vom Saal stated on the show. “What you have now is clearly enough scientific information to warrant concern and a change in the regulatory approach to these chemicals.” Concern grew, as did the body of research. By 2008, enough evidence had accumulated that the NTP labelled the chemical as possibly harmful for babies. Canada responded by declaring BPA toxic and manufacturers across North America, including baby bottle and sippy cup makers, started phasing it out of their products. Wal-Mart, REI, Lululemon, Toys-R-Us and other retailers, too, began pulling products with BPA off their shelves. The market was soon flooded with BPA-free products — although most of the substitutes that landed in stores share similar chemistry with BPA and pose similar health concerns. “The science is growing exponentially. We can’t keep up with it,” said Kwiatkowski, of The Endocrine Disruption Exchange. “And we have to take it all very seriously, because the preponderance of endocrine-related disorders in humans today is just skyrocketing.” Pregnant women, infants and young children face the greatest risks, as a healthy functioning endocrine system is especially critical during development. “If you perturb it, it is not going to be reversible,” Linda Birnbaum, former director of the NIEHS and the NTP, told EHN. “Whatever happens, it is done.” In-utero BPA exposure, for example, may derail the normal growth of the brain and other organs and manifest later in life as early puberty or an increase in anxiety-related

## Curiosities

### CHEMWATCH

behaviours or attention deficit hyperactivity disorder (ADHD). And, again, BPA is just one of many chemical threats to our hormones. We are exposed daily to a cocktail of stuff suspected of altering our endocrine system. "When we talk about endocrine-disrupting chemicals, it might be that the real story is in the mixture," Chris Gennings, the director of biostatistics and an environmental medicine researcher at the Icahn School of Medicine at Mount Sinai in New York, told EHN. While the level of exposure to any single chemical might not surpass a safety threshold, she explained, "if you put all of them together, then the mixture can reach a level of concern." It is not only the potential health consequences that are leading many scientists to urge a more substantial overhaul of the testing and oversight of endocrine-disrupting chemicals. There are economic concerns: In 2014, researchers conservatively estimated that just the cases of childhood obesity and adult heart disease attributable to BPA cost the U.S. \$3 billion annually. A 2016 study that considered a few endocrine-disrupting chemicals and a few specific diseases calculated an annual \$340 billion in U.S. health costs and lost wages — or about 2.3 percent of the GDP. (Editor's note: Pete Myers, CEO and chief scientist of Environmental Health Sciences, was a co-author on the paper. He is also the founder of EHN, though the publication is editorially independent.) "This is an underestimate of an underestimate of an underestimate," Dr. Leonardo Trasande, a researcher at New York University, author of the book, *Sicker, Fatter, Poorer*, and an author on both studies, told EHN. Trasande noted his initial hope that Clarity would result in "progress toward a consensus" on methods to evaluate BPA. But the FDA, he said, "has taken the approach that its science and its mindset are superior to that which has been published in peer-reviewed scientific literature." Maurice Whelan, head of the Chemical Safety and Alternative Methods Unit of the Directorate for Health, Consumers and Reference Materials of the European Commission's Joint Research Centre, shared similar thoughts while sitting next Doerge on the panel in Italy. Clarity was "institutionally biased," he said, with "the science strategy dictated" and a "very clear mindset about how to go about this."

### Recipe for a poison

Core to the discord is a historical assumption about toxic chemicals. Nearly 500 years ago, Swiss physician and chemist Paracelsus coined an adage that would become a basic principle of toxicology: "The dose makes the poison." In other words, the higher the concentration of a toxic chemical, the more toxic it is. The FDA generally assumes this increasing-dose-increasing-harm relationship in its evaluation of chemicals that come

## Curiosities

### CHEMWATCH

into contact with food, whether directly or indirectly through production, processing, packaging and distribution. A dose-response curve should therefore always be monotonic, according to the agency, meaning it will never change direction from positive to negative, or vice versa. As a result, when the agency deems a dose of a chemical safe, their investigation has not necessarily tested health effects at that dose — or at any lower doses. Rather, industry and government scientists typically follow an efficient, seemingly common-sense method. They start by exposing lab animals to extremely high doses of the chemical, incrementally drop the doses until they no longer detect obvious harm, then cut that last number down by a margin of safety to create a conservatively “safe” exposure limit. Endocrinologists, on the other hand, expect craziness in their data. At least for hormone-mimicking chemicals, a relatively high dose might prove innocuous while a far lower dose wreaks havoc on the body. And they’ve observed that different doses can cause different effects. Such a non-monotonic dose-response curve might take the shape of a “U” or a bell. Take, for example, a 1997 paper co-authored by vom Saal. At 200 nanograms of DES per gram of body weight per day, the prostates of the mice in his study were significantly smaller than prostates in the control mice and prostates in mice receiving other doses. At a mid-range of 20 nanograms of DES, no effect was seen. And that, under traditional toxicology, is where regulators would stop testing. But drop the dose further, to 2.0, 0.2 and 0.02 nanograms, and vom Saal found prostates were significantly larger than prostates in all of the other animals. The resulting dose-response relationship resembled a bell. “What we’ve learned from literally tens of thousands of papers, is that endocrine activity is stimulated by very tiny quantities of endocrine hormones,” said Collins, the green chemist. “If you raise the concentrations, you turn the effect off.” His guess as to why: “Nature has decided it doesn’t want to have an overreaction to an endocrine hormone.” Birnbaum compared the phenomenon to the body’s response to vitamins and minerals, where “too little is a problem and too much is a problem.” And scientists have identified potential biological mechanisms for non-monotonic dose-responses, such as opposing effects from multiple hormone receptors. Still, others push back on the notion of non-monotonicity. “It’s illogical. It flies in the face of every mechanism we know in science,” Patrick McKnight, a measurement scientist at George Mason University in Fairfax, Virginia, told EHN. “In toxicology you really have to demonstrate that there’s an effect of some sort, and I think a lot of these investigators are searching for these effects.” (McKnight is on the advisory board at Sense About Science USA, formerly the Statistical Assessment Service, which has industry ties and a record of downplaying the dangers of products.) Steven G. Hentges,

## Curiosities

### CHEMWATCH

senior director of the Polycarbonate/BPA Global Group at the American Chemistry Council, an industry trade group, stated that “experimental evidence” to support non-monotonic dose-response has been “limited.” He pointed to a recent European review that supported that view. Of 179 datasets evaluated in the paper, the authors concluded that only 10 met criteria for a non-monotonic dose response. They acknowledged difficulty in identifying relevant studies and applied strict rules for inclusion in the review, including a requirement that studies include at least five dose groups. This is rare. Even guidelines for traditional regulatory toxicology studies recommend just three dose groups. The FDA, meanwhile, has stuck to its guns, repeatedly dismissing data on low-dose effects or non-monotonicity. Marianna Naum, an FDA spokesperson, told EHN in an email that the FDA and other federal agencies have determined that non-monotonicity “is not often found in toxicology of the endocrine system,” and that “current regulatory testing methods are sufficient” to pick it up. (EHN tried for months through multiple emails and phone calls to arrange a phone interview with someone at the FDA. The agency repeatedly ignored and denied those requests.) The agency also has a history of brushing off study results because they did not fit its strict study criteria adopted in the 1980s to calculate doses of chemicals that are expected to be safe for humans. These traditional “guideline” studies, as they are called, follow validated “good laboratory practice” (or GLP) protocols. Together, the rigorous study guidelines and lab rules dictate the number and type of animal used, levels of exposure to the chemical of interest, the outcomes to evaluate and record-keeping methods, among other details. And these studies remain the evidence preferred by the FDA, because they “provide risk assessors and risk managers with reproducible results upon which science-based decisions and policy may be based,” Naum stated in the email.

Jennifer Sass, a senior scientist with the Natural Resources Defence Council, said that the guidelines are “a good starting point to see if there’s evidence of harm,” and “allow regulators from Japan to Sweden to North Africa to look at data the same way.” However, she added, these guidelines “should not be used to eliminate evidence of harm.” Such standardised studies can also be pricey to conduct, often beyond the budgets of academics. And the FDA’s traditional targets for tests, such as weighing organs and looking for other overt signs of toxicity, generally do not consider the unique effects of endocrine-disrupting chemicals — some of which can be subtle such as behavioural changes or infertility years down the road. “You can’t weigh a brain to find out what is going on in there,” Soto said. In 2001, the NTP appeared to agree. They concluded

## Curiosities

### CHEMWATCH

in a report that published studies had provided evidence for the effects of BPA exposure at or below the safety standard set by the FDA. And they recommended a reconsideration of the current testing paradigm. The plastics industry pushed back, funding the Harvard Centre for Risk Analysis, a group that had received financial support from chemical companies in the past, to do a separate review of the literature on BPA. That assessment determined that only two large studies—both funded by industry—were relevant and reliable enough to consider. Both studies would go on to make regular appearances in subsequent FDA reports. Doerge was a co-author on FDA's most recent safety assessment of BPA, released in 2014, which reaffirmed its position that the chemical is safe at levels of exposure from food contact uses. "No new information was identified to suggest revision of the existing safety assessment level," wrote the authors. The report was an update of the agency's 2008 assessment, for which the FDA relied heavily on the same two industry-funded guideline studies considered in the Harvard group's analysis and discarded hundreds of non-GLP studies published by academics that nonetheless found low-dose effects of BPA. An external FDA committee had even reviewed the 2008 report and disagreed with the agency's decision to exclude those other peer-reviewed papers. "The draft FDA report does not articulate reasonable and appropriate scientific support for the criteria applied to select data for use in the assessment," they wrote. "Specifically, the Subcommittee does not agree that the large number of non-GLP studies should be excluded from use in the safety assessment." Of note: A 2006 analysis found that 11 out of 11 industry-funded studies found BPA had no significant action, while 109 of 119 studies that had no industry funding did find effects of BPA. Yet those industry-funded studies tend to use more expensive GLP protocols and qualify as guideline studies. "The non-guideline studies are basically ignored. To me, that's like wearing blinders," said Birnbaum. "Science has continued to advance, and I think there are questions that we really didn't know about 30, 40, 50 years back that people are asking today." "If you don't ask the question, you're not going to get the answer," she added.

Jerry Heindel, the health scientist administrator at the National Institute for Environmental Health Sciences (NIEHS) when Clarity was initiated, agreed. "Maybe these guideline studies aren't as gold standard and terrific as people have thought," he told EHN. "Problem is, the endpoints are so simplistic and old-fashioned."

But he and other scientists also acknowledge that the FDA has an extremely high bar to justify adoption of new approaches, let alone bans

## Curiosities

### CHEMWATCH

on a chemical. Regulatory agencies are in a tight spot and have to first ensure they can't be sued, added Heindel, who retired from NIEHS in 2016 and founded Commonwealth's Healthy Environment and Endocrine Disruptor Strategy (HEEDS), a hub for scientists working on endocrine disruptors. "If they come out and say a chemical is toxic and we need to ban it," he said, "then they have to feel confident they have the data that will stand up in the court of law."

#### Deepened divide

On 23 February 2018, upon completion of the draft version of the government's Clarity Core Study, the FDA released a public statement, suggesting that the findings supported its position that "currently authorised uses of BPA continue to be safe for consumers." The move stirred significant press, mostly reassurances to the public of the chemical's safety; FDA's collaborators were not pleased. Some suggested that the very agency responsible for ensuring our safety is actively working to avoid dealing with a massive experiment that is disrupting our hormones from birth. "I smell a big fat rat here," Gail Prins, a researcher at the University of Illinois at Chicago and Clarity investigator, wrote in an email to Nigel Walker of NIEHS after learning of the statement. "The FDA is not playing fair." Walker, a toxicologist who helped lead Clarity, responded by sending a scathing email to officials at the FDA. Members of that agency's upper management, he wrote, were "reneging on their own values in regulatory science," and "using the Clarity core study as a quasi-definitive human risk assessment document to affirm the current FDA policy on safety of BPA." In additional emails obtained by EHN, Walker went on over subsequent days to write of FDA officials' "shenanigans," calling their actions "disingenuous" and "disrespectful." He referred to himself as "peeved." He also made a point to state that he had no conflicts of interest himself: "I don't have a horse in this race," wrote Walker. The FDA declined to comment on the statement, or on the subsequent criticisms from collaborators. A culture clash of sorts continues between the FDA and NIEHS. Multiple scientists with the latter agency shared similar sentiments about the FDA's conduct in Clarity. Walker declined a phone interview but stated in an email to EHN that "there may from time to time be disagreements on various issues or topics." Birnbaum said that while she was not surprised by the FDA's conclusions from the government's portion of Clarity — it was, after all, consistent with their historic stance on the chemical's safety — she did not share their opinion. "I think we reserve the right to disagree, respectfully," she said. And Bucher of the NIEHS and NTP offered his take: "The FDA conclusions are the FDA's view of how they look at data from

## Curiosities

### CHEMWATCH

these kinds of studies... To us, it would be more valuable to try to integrate this information and then come up with statements as to interpretations." In September 2018, the government released the final version of its Core Study report. The FDA also advertised and hosted a webinar to detail their findings, which was pre-empted by outside academics who held their own webinar to present contrasting conclusions. The academic webinar was organised and moderated by Myers of Environmental Health Sciences. As expected, the government's report stated that exposing rodents to BPA resulted in some health effects at high doses but not at the low doses to which people are generally exposed. Hentges, of the ACC, praised the report. "The scope and magnitude of the FDA study are unprecedented for BPA, and the results clearly show that BPA has very little potential to cause health effects, even when people are exposed to it throughout their lives," he told EHN in an email. (The ACC declined multiple requests for a phone interview.) But that is not exactly what the government's data said, even if that sentiment was reflected in the FDA's early press release. "They have a bunch of data that says BPA is doing something. But they're ignoring that data," Patisaul, the North Carolina State University biologist and Clarity investigator, said. This March, Vandenberg co-authored an opinion paper with two other scientists also not involved in Clarity, to see what data the feds may be missing. After a close look at the government's Core Study results, they identified 41 endpoints with statistically significant effects. As with the academics' studies, the lowest doses were associated with the greatest number of effects, such as mammary gland cancer, kidney damage, increased body weight and altered gene expression in the brain. "There are a lot more effects at low doses than high doses. A lot more," Vandenberg said. "It's hard to ignore that and say everything is fine here. Even the FDA's own data suggests there is harm." During another session at last September's EFSA meeting in Italy, Barry Delclos, a biochemical toxicologist with the FDA, responded to a question from Patisaul regarding these low-dose results. He answered that his team had looked to see if "consistent responses" would explain the statistically significant results they had found. "We didn't feel that was the case," he said. Delclos also stated in the September 2018 webinar that his team questioned the biological significance of findings that didn't fit a consistent dose-response relationship. The frustrations of academics and health advocates, as well as of FDA scientists, is tangible. Patisaul argued that Delclos, Doerge and their colleagues are in their "own echo chamber," doing the "same thing they are accusing everyone else of doing," and unwilling to recognise that their science might be outdated. Doerge went on during the EFSA panel discussion: "You come to someone that has all the responsibility mandated by law to protect the public from this

## Curiosities

### CHEMWATCH

or that, and you're saying, 'Oh, these basic tenets that you've used to do your job for all these years is no longer valid. Dose-response doesn't exist any longer,'" he said. "This is a fundamentally unbreachable barrier, in my opinion." In the 1998 PBS interview, vom Saal detailed a "distinct pattern" that comes with any paradigm shift in science — especially one, he said, that could impact billions of dollars of profits for chemical companies. "The first thing is absolute denial," he said. "The second is a feeling that it may be true, but it's only true in very limited circumstances. The third is, it's true but the economic consequences are so great that we can't do anything about it." Lisette van Vliet, a senior policy coordinator with Breast Cancer Prevention Partners, a San Francisco-based non-profit, likened it to the times of Galileo. "A bunch of scientists were saying the Earth is the centre of the universe; other scientists were saying the sun is the centre," she told EHN. "They were using very different ways of ascertaining reality." "These paradigm fights tend to be long and protracted and don't always have a complete 'aha' moment," said van Vliet. "The Clarity study was as good of a stab as anyone could make... The integrated final version of the study is going to be a really important point in this discussion, but it is not going to be the end of the story. And, meanwhile, public health will suffer because of continued exposure to this harmful chemical."

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Antidepressants in Our Waters Really Are Affecting Fish in a Strange Way, Study Shows

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Immersed in a 'drug soup' of pharmaceutical pollutants, aquatic wildlife acts in ways that puts them at risk of becoming an easily meal for predators. A new study now suggests it could also affect how they themselves hunt for food. When researchers looked at the way eastern mosquitofish (*Gambusia holbrooki*) foraged in groups, they found antidepressants in our waste play havoc with the animals' social interactions in ways we'd never noticed in studies of individual fish. The new research conducted by scientists from Monash University in Australia highlights a potential flaw in previous studies that determine the impact of psychoactive waste on wildlife. "The results are significant because they suggest that behavioural tests in social isolation may not accurately predict the environmental risk of chemical pollutants for group-living species," says biologist Jake Martin. Evidence has been mounting over recent years that the drugs we take to deal with a litany of psychological

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## Curiosities

### CHEMWATCH

conditions are not only destined for our lakes and rivers, but potentially influencing the behaviours of the animals who live there. Fluoxetine is just one example. Better known by its commercial name Prozac, the drug blocks transport channels in neurons that would otherwise be soaking up a messenger chemical called serotonin. In humans, drugs that block serotonin reuptake channels can help stave off depression. But we're not the only animal with this neurological gateway. All vertebrates have it, leaving open the question of how the medication might be affecting their brains, too. The question isn't merely academic, either. Fluoxetine has been found in aquatic ecosystems at concentrations of up to several hundred nanograms per litre, making it a pollutant we ought to know more about. To put the drug to the test, researchers typically rely on watching solitary fish swim around in tanks. It's a practical solution that limits variables and makes for easier observation of behavioural changes in the animals. "However, few studies have considered how the response of exposed organisms might be mediated by social context," says Martin. To see if fish numbers made any difference, the team collected female mosquitofish from an uncontaminated site in the wild and placed them in large tanks either one by one, or in groups of three. Some fish were placed in low or high levels of fluoxetine for a month, while another group were left unexposed. All were then placed in tanks that allowed the researchers to watch how the fish hunted for their favourite meal, midge larvae. For solitary fish on the prowl, exposure to the antidepressant made no difference to their eagerness to tuck in. But this wasn't the case when the fish were hunting in groups; the differences came down to their weight, since competition within a group drives the need for predatory fish to gobble as much as they can. For animals that weren't exposed to any fluoxetine, it was a race among members - the greater the variation in their weights, the more aggressively each fish ate. Similarly, the lower the group's average weight, the more they foraged. But being exposed to relatively high doses of antidepressant seemed to have a chilling effect on this dynamic. "Fluoxetine exposure disrupted the relationship between the total number of prey consumed and standard deviation in group weight," says behavioural ecologist, Bob Wang. For the exposed fish, neither their average weight nor variation could predict the number of aggressive interactions they had while looking for food. The study stops short of showing how this change in aggression might influence survivability in the wild, but it's hard to imagine that anything that reduces the amount of food a fish might eat could be a good thing. Clearly, we've got a problem with how we manage our pharmaceutical waste. Medications like fluoxetine play a vital role in maintaining the health and wellbeing of millions, making it important we are careful with how we

## Curiosities

### CHEMWATCH

dispose of unused medication, and filter the waters we flush. As far as the research goes, future studies will need to consider not only how the mix of medications we're releasing into the environment might change individuals, but how it might affect entire groups of animals. "Our results suggest that social context may be an important, but underappreciated, factor influencing the ecological impacts of chemical pollutants on wildlife," says Martin. This research was published in *Biology Letters*.

Science Alert, 16 November 2019

<http://www.sciencedaily.com>

### **Steel and concrete are climate change's hard problem. Can we solve it?**

2019-11-21

"DANGER. No unauthorised entry. Hot rolling in progress." If anything, the sign beneath the dirty hunk of industrial machinery underplays things. When the 11-tonne slab of metal I've been watching emerges from the furnace, heated to 1300°C, it glows incandescent white. Then it zips along a conveyor belt, hissing and steaming as it is cooled by water jets, before a line of rolling cylinders press it into the final product: a sheet of gleaming steel. For all that we live in the digital age, we still rely on hot and dirty processes like this to construct our cities, homes and vehicles. Walking around the steelworks in Newport, UK, I get a sense of the immense energy required – and this is only the stage at which the steel is worked. Making it from raw iron ore is even more intensive. In fact, the production of steel and that other construction staple, concrete, accounts for as much as 16 per cent of humanity's annual carbon dioxide emissions. That is equivalent to the carbon footprint of the US. In the fight against climate change, heavy industries are the final frontier. Decarbonising transport and energy are the easy part. Steel and concrete are different beasts. It is much harder to produce them without releasing enormous amounts of CO<sub>2</sub> into the atmosphere. And yet if we want to reach net-zero carbon targets, we can no longer ignore them. Cleaning up concrete and steel is such an immense challenge that it can seem hopeless. But researchers and forward-thinking companies are pioneering clever ways to crack the problem – perhaps pointing the way to a crucial climate win. The need to act couldn't be clearer. If we don't keep global temperature rises below 1.5°C, droughts, floods and extreme heat are predicted to be much worse. Natural treasures such as corals, not to mention all manner of other life forms, may be annihilated. To avert disaster, we need to reduce carbon emissions to zero as soon as possible, and certainly no later than the

**Heavy industry produces more carbon dioxide than the entire US. Perfect the new technologies that could clean it up and we can score a crucial climate victory**

## Curiosities

### CHEMWATCH

middle of the century. In the parts of our economies that emit the most CO<sub>2</sub>, such as transport and energy, we have most of the technology we need to make that happen. Electricity generation can flip to low carbon sources such as wind and solar, cars can switch from combustion engines to battery power, and buildings can be insulated so that they use less energy. We just need to generate the will to implement these changes. Solutions are nowhere near as obvious for heavy industry. The world produced more than 1.8 billion tonnes of steel last year, for example. Concrete production is even higher, and demand for both is likely to grow for decades. Both industries seem to fly under the radar in the climate conversation, but make no mistake, they produce whopping amounts of carbon. "They are responsible for half of all industrial emissions," says Julian Allwood at the University of Cambridge, who was lead author on the problem of industry's carbon footprint for the most recent major report by the Intergovernmental Panel on Climate Change. Although efficiency drives have reduced the footprint from steel and concrete to a degree, they still have a long way to go to clean up their act.

#### Reuse and recycle

The problem for both materials is that their production processes seem almost unavoidably carbon intensive, and tried and tested, scaleable alternative processes have been conspicuous by their absence. Most steel is made using a combination of a blast furnace to extract iron from its ore and a basic oxygen furnace to convert this raw iron to steel. In essence, iron ore is heated by burning carbon-rich coking coal, creating CO<sub>2</sub> as a by-product. Hence, "the major thing would be to shift away from blast furnace operations", says Paul Fennell of Imperial College London. One alternative is to recycle more. It is a simple enough process: put scrap steel into an electric arc furnace, where electrodes produce current that melts the steel so it can be reworked. This can reduce carbon emissions by about two-thirds for each tonne of steel produced compared with that made from iron ore. The electricity can, in principle, come from renewable resources. That sounds like a win-win. Liberty Steel, the owner of the steel rolling mill I visited in Newport, certainly seems to think so, because it has plans to recycle a lot more steel. The mill isn't far from Uskmouth B power station, a 1950s coal-fired power plant that has been dormant since 2017. Now, Liberty's parent company GFG Alliance is spending £200 million on converting the power plant to a lower-carbon fuel: pellets made from non-recyclable plastic and other waste. It will send much of its electricity straight to the steelworks, where the firm hopes to build an electric arc furnace. The wrinkle at this stage is that some sectors, such

## Curiosities

### CHEMWATCH

as car manufacturers, still prefer to use virgin steel. One concern is that impurities like copper can build up and make recycled steel poorer quality, reducing its potential uses. "At the moment, we can make construction grade steel from recycling, but not automotive grade," says Allwood. Yet he adds that such impurities can be minimised by better sorting of materials before recycling them and by removing impurities from the molten steel. The other option is to make fresh steel using a greener process – and to that end there is a push in some quarters to convert iron ore not with coking coal but hydrogen. The idea is that the oxygen in the iron ore will combine with the hydrogen to produce water instead of CO<sub>2</sub>. SSAB, a steel-making company headquartered in Stockholm, Sweden, is among those exploring this strategy, which it has called HYBRIT. It has begun construction of a pilot plant in Sweden that could, the firm claims, produce steel with "virtually no carbon footprint". There is a caveat. For the moment, hydrogen is overwhelmingly made from fossil fuels, such as natural gas, and that means greenhouse gas emissions: the carbon footprint of global hydrogen production is on a par with the emissions of the UK and Indonesia combined. But it is possible to make hydrogen from water using an electrolyser powered by electricity from renewable sources. If we one day have enough excess wind power, we could potentially produce all the hydrogen we need for large-scale clean steel production via electrolysis – that is, if the economics somehow worked out. Promising. But part of the problem when it comes to decarbonising steel is the state of the industry. Unlike oil and gas, which continue to yield extravagant profits for producers, steel makers outside China are struggling to stay afloat. As a result, they don't have much leeway to cover the costs of new low-carbon technology. Nor have they enjoyed the support of governments in the same way as the renewable electricity sector, which has benefited from subsidies for over a decade.

SSAB says its hydrogen-produced steel could be 30 per cent more expensive than normal steel, meaning it would require governments to introduce some form of carbon levy on steel production to make it economically competitive. "Until you think there is going to be a significant and sustained carbon price, the commercial driver is just to produce iron and steel in the way you already produce it," says Fennell. Concrete suffers with many of the same problems, starting with the basic chemistry involved in its production: CO<sub>2</sub> emissions are inherent in making its component parts. Take cement, the "glue" that holds concrete together. To make it, you first grind and heat limestone in rotating kilns. The ensuing process of calcination decomposes the limestone's calcium carbonate into calcium oxide, releasing CO<sub>2</sub>. The next stage requires

## Curiosities

### CHEMWATCH

yet more energy to heat calcium oxide with other materials to make a substance called clinker. Add this to the soft mineral gypsum and you get cement. Many observers think the sector is almost impossible to clean up. Allwood puts it bluntly: "There are no options to decarbonise cement." But that hasn't stopped people from trying. One option is to use a different kind of cement. Almost all concrete is made using Portland cement, a 19th century formula that works well. But there are plausible alternatives. Some carbon savings are already made by using existing cement substitutes. One is fly ash, a fine powder produced as a by-product by coal power stations. Another is a by-product of iron-making called ground granulated blast-furnace slag. But we are trying to phase out coal plants for good reasons, and there is only so much of this slag. Elsewhere, researchers have started looking at using a calcium silicate slag that is a by-product of the steel industry as a substitute for cement. It is typically dumped in landfills. Carbicrete of Canada is one firm eyeing this route and promises great carbon savings, but it is unclear, commercially speaking, if it has made any inroads. All of these new formulations share two main problems. The first is a familiar one: they are more expensive than the current recipes. The second is a consequence of the first. No one is making them in volumes that would start to bring costs down. "There are alternative cements being developed in labs, but none at meaningful scale," says Allwood. A glimmer of hope can be found in Lixhe, Belgium, where researchers are experimenting with a different approach. Here, a plant owned by German company Heidelberg Cement has been retrofitted with a 13-storey tower designed to capture the carbon produced during cement-making before it gets into the atmosphere. The aim of the Low Emissions Intensity Lime And Cement (LEILAC) project, partly funded by the European Commission, is to test a new technology – one that separates the CO<sub>2</sub> released from other waste gases, to capture a pure stream of CO<sub>2</sub>.

#### Capture and convert

Fennell, who is involved in the project, believes it has promise in part because the CO<sub>2</sub> could be a commodity to sell to other industries, such as plastic manufacturing. "It's one of these rare processes that might have very little downside," he says. Scaling up could have an eye-watering price tag, though: LEILAC is a €21 million scheme, but will handle just 2 per cent of production at Lixhe, a typical-size cement plant. That hasn't stopped Heidelberg Cement pushing ahead with a report, based on a similar trial at a Norwegian cement plant, that will have a big say on whether it sinks funds into a full-scale project in Norway. In principle, carbon capture and storage technology could help mitigate the carbon footprint of both

## Curiosities

### CHEMWATCH

concrete and steel. It is often mooted as a potential solution in the energy sector, and Luke Warren of the UK Carbon Capture and Storage Association says attention is beginning to turn to its use in heavy industry. However, the truth is that the technology is still in its infancy. Despite its undoubted promise and years of efforts to make good on it, there are only 23 large-scale facilities in the world, capturing 40 million tonnes of CO<sub>2</sub> a year, chiefly in natural gas processing plants where it is easier to implement. That amounts to just 0.1 per cent of humanity's emissions. Ultimately, the quickest climate win for both concrete and steel may end up being the simplest: use less of it, and make what we do use last longer. In the book *Sustainable Materials: With both eyes open*, Allwood and his colleagues sketch out how we could cut the emissions from these two materials by 50 per cent by 2050 by designing buildings to use less of them. A case in point is the velodrome built for the 2012 Olympic Games in London, for which the choice of a lightweight roof made of steel cables meant using 27 per cent less steel than a conventional arch-based design would have required. Similar approaches are being explored for concrete. "Our mantra is use enough material and no more," says architectural researcher Paul Shepherd at the University of Bath, UK. In January, he started construction of an office building using concrete beams that can bear the loads needed but are shaped to require less material than usual. And in some cases, we could just use wood instead. Back at the steelworks in Newport, management are understandably hoping to ramp up the amount of metal they turn out. If things go to plan, output could double next year. And yet globally, the most credible and readily available route to a low-carbon future lies in the opposite direction. That is certainly how Kirsten Henson at KLH Sustainability, a construction consultancy that advised the London Olympics, thinks about steel and concrete: "We've got to use less of it," she says.

New Scientist, 13 November 2019

<http://www.newscientist.com/>

## Zero gravity made some astronauts' blood flow backwards

2019-11-21

Being in zero gravity can have strange effects on the body – now it's emerged that it can make people's blood flow backwards. The changes to circulation caused two astronauts to develop small blood clots, which could have been fatal – but fortunately the man and woman affected came to no harm. The blood changes happened in a vessel called the left

**Being in zero gravity can have strange effects on the body – now it's emerged that it can make people's blood flow backwards.**

## Curiosities

### CHEMWATCH

internal jugular vein, one of two that normally move blood out of the head when we are lying down. When we are upright, they mostly collapse to stop too much blood from draining out of the head, with our circulation taking a different route through veins with more resistance instead. On Earth, people have occasionally been spotted with backwards blood flow in the left internal jugular vein if there is a blockage lower down, such as from a tumour growing in the chest. Zero gravity is known to change people's blood flow, so Karina Marshall-Goebel of KBR in Houston and colleagues wondered if it would also affect this vein. They carried out measurements and ultrasound scans of this blood vessel in nine men and two women both before and after their missions on the International Space Station, as well as 50 and 150 days into their flights. In two of the astronauts, the blood flow was backwards – perhaps because the lack of gravity caused organs in the chest to shift around, pressing on the vein lower down, says Marshall-Goebel. She adds that this vein is predisposed to be blocked based on where it lies in the body. In another five members of the crew, blood in this vein was more or less stagnant, and in one of these, the scan revealed a clot blocking the vessel. "That was definitely alarming," says Marshall-Goebel. Blood clots can be fatal if they get carried to the lungs, so the person began taking blood-thinning medicines to break it down. Because of this surprise finding, the team asked a panel of experts to review all the previous scans and another small clot was spotted in one astronaut who had already returned to Earth. The team also had the participants test a device on the Space Station that encases their lower body in a chamber with lower air pressure for an hour to suck more blood into their legs. They found that this improved blood flow in ten of seventeen tests – but worsened it in two. Marshall-Goebel says the findings may cause female astronauts to reconsider taking the contraceptive pill to suppress their periods while on the Space Station, as this raises the risk of blood clots. The two astronauts in this study who had a clot included one man and one woman, although the team aren't giving any further details to protect their privacy.

New Scientist, 15 November 2019

<http://www.newscientist.com/>

## Researchers Find a Way to Treat Cyberchondria: Anxiety Over Googling Your Symptoms

2019-11-21

It's a busy day at the office and your left eye has been twitching uncontrollably. So, out of curiosity and irritation you Google it. Various

**It's a busy day at the office and your left eye has been twitching uncontrollably.**

## Curiosities

### CHEMWATCH

benign causes - stress, exhaustion, too much caffeine - put your mind at ease initially. But you don't stop there. Soon, you find out eye twitches could be a symptom of something more sinister, causing you to panic. You ruin the rest of the day trawling through web pages and forums, reading frightening stories convincing you you're seriously ill. For many of us, this cycle has become common. It can cause anxiety, unnecessary contact with health services, and at the extreme, impact our day-to-day functioning. But our recently published research, the first to evaluate online therapy for this type of excessive and distressing health-related Googling, shows what can help. I've heard of 'cyberchondria'. Do I have it? The term "cyberchondria" describes the anxiety we experience as a result of excessive web searches about symptoms or diseases. It's not an official diagnosis, but is an obvious play on the word "hypochondria", now known as health anxiety. It's obsessional worrying about health, online. Some argue cyberchondria is simply a modern form of health anxiety. But studies show even people who don't normally worry about their health can see their concerns spiral after conducting an initial web search.

Cyberchondria is when searching is:

- excessive: searching for too long, or too often
- difficult to control: you have difficulty controlling, stopping or preventing searching
- distressing: it causes a lot of distress, anxiety or fear
- impairing: it has an impact on your day-to-day life.

If this sounds like you, there's help. We tested whether an online treatment program helped reduce cyberchondria in 41 people with severe health anxiety. We compared how well it worked compared with a control group of 41 people who learned about general (not health-related) anxiety and stress management online. The online treatment is based on cognitive behaviour therapy (CBT), which involves learning more helpful ways of thinking and behaving. Participants completed six online CBT modules over 12 weeks, and had phone support from a psychologist. The treatment explained how excessive web searching can become a problem, how to search about health effectively, and practical tools to prevent and stop it. We found the online treatment was more effective at reducing cyberchondria than the control group. It helped reduce the frequency of online searches, how upsetting the searching was, and improved participants' ability to control their searching. Importantly, these behavioural changes were linked to improvements in health anxiety. Although we don't know whether the program simply reduced or completely eliminated cyberchondria, these findings show if you're feeling

## Curiosities

CHEMWATCH

anxious about your health, you can use our practical strategies to reduce anxiety-provoking and excessive online searching about health. So, what can I do?

Here are our top tips from the treatment program:

- be aware of your searching: don't just search on auto-pilot. Take note of when, where, how often, and what you are searching about. Keep track of this for several days so you can spot the warning signs and high-risk times for when you're more likely to get stuck in excessive searching. Then you can make a plan to do other things at those times
- understand how web searches work: web search algorithms are mysterious beasts. But top search results are not necessarily the most likely explanation for your symptoms. Top search results are often click-bait – the rare, but fascinating and horrific stories about illness we can't help clicking on (not the boring stuff)
- be smart about how you search: limit yourself to websites with reliable, high quality, balanced information such as government-run websites and/or those written by medical professionals. Stay away from blogs, forums, testimonials or social media
- challenge your thoughts by thinking of alternative explanations for your symptoms: for example, even though you think your eye twitch might be motor neuron disease, what about a much more likely explanation, such as staring at the computer screen too much
- use other strategies to cut down, and prevent you from searching: focus on scheduling these activities at your high-risk times. These can be absorbing activities that take your focus and can distract you; or you can use relaxation strategies to calm your mind and body
- surf the urge: rather than searching straight away when you feel the urge to search about your symptoms, put it off for a bit, and see how the urge to search reduces over time.

And if those don't help, consult a doctor or psychologist.

Author: Jill Newby, Associate Professor and MRFF/NHMRC Career Development Fellow, UNSW and Eoin McElroy, Lecturer in Psychology, Department of Neuroscience, Psychology and Behaviour, University of Leicester.

Science Alert, 16 November 2019

<http://www.sciencealert.com.au>

## Technical Notes

CHEMWATCH

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

### ENVIRONMENTAL RESEARCH

[Methylmercury Determination in Fish by Direct Mercury Analyser](#)

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## Technical Notes

CHEMWATCH

Differential Exposure to Job Stressors: A Comparative Analysis Between Migrant and Australia-Born Workers

### **PUBLIC HEALTH RESEARCH**

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Effect modifiers of lung function and daily air pollutant variability in a panel of schoolchildren

Exposure to heavy metals from point pollution sources and risk of incident type 2 diabetes among women: a prospective cohort analysis

Potential health effects of emerging environmental contaminants perfluoroalkyl compounds

Cigarette Smokers vs. Co-users of Cannabis and Cigarettes: Exposure to Toxicants