

June 2022, Issue 6, Volume 84

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Cover photo credits:

1. Top Left: This month's speaker, Judy Giordan – Shelia Yeh
2. Middle Left: Trudy Lionel – Alex Madonik
3. Bottom Right: Bricks from the dismantling of the chimney of the brick factory – Donald MacLean

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Errata for May The Vortex

Newsletter Editor Donald MacLean

The May issue of The Vortex was published using the first draft Word doc. This was not meant to be the final circulated copy. Items came in late that were not in the first draft. These late items were incorporated into the final draft, PDF ed, and provided for posting. Mid month, I received notices that something was not right without enough detail. When putting the June The Vortex together I went back to see what was created. A volunteer took the first draft, PDF ed it, and posted it was a mistake.

Two topics that were missing is the initial May posting are May 15th Zoom for George C. Pimentel Centenary, and the reflection on Trudy Lionel.

I also asked to have the Final May 2022 The Vortex version replace the first draft version.





Please join us for a virtual presentation by Dr. Judy Giordan, 2022 President-Elect of the American Chemical Society:

Chemistry, ACS and YOU: The value of getting involved

When: June 21, 2022, 5:00 to 6:00 pm, PDT
Where: Online Zoom event, [RSVP Here](#)
Cost: FREE!
Contact: [Despina Strong](#), Puget Sound Local Section



Dr. Judy Giordan
2022 ACS President-Elect
www.ecosvc.com
www.jgiordan.com

Our Distinguished Speaker:

Judy Giordan is Managing Director of ecosVC, Inc., a co-founder of the Chemical Angels Network, an entrepreneur and former Fortune 100 executive. Judy serves as board member, co-founder, advisor and investor in seed and early-stage start-ups and is 2022 President-elect of the American Chemical Society.

Her previous executive positions include Corporate VP and Global Director of R&D at International Flavors and Fragrances, Inc.; Vice-President Worldwide Research and Development for the Pepsi-Cola Company, PepsiCo, Inc.; Vice President R&D, Henkel Corporation, the North American operating unit of the Henkel Group. She has also served with the National Science Foundation as Program Director for the IGERT Program.

Judy has a BS in Environmental Science and VoTech Ag from Rutgers University, PhD in Chemistry from the University of Maryland and was Alexander von Humboldt post-doctoral fellow at the University of Frankfurt, Germany.

Abstract:

Judy will tell us about her priorities for her term as ACS President and how she chose those priorities. She will also discuss what she sees as the most important nationwide role for ACS. We've asked her to identify the top challenges, both internal and external, for ACS, as well as the best internal and external opportunities that she sees. Finally, Judy will address getting involved with ACS-- both the value of involvement and ideas for involvement. After her presentation, Judy will welcome questions from attendees. If you would like to submit a question ahead of the event, [please use this email link](#).

Presentation of the 2020 Walter Petersen Award to Gary Martin

By Paul Vartanian

In 2020 the California Section, ACS, selected Gary Martin for its Walter Petersen Award. Gary is the financial advisor to the Section's Board of Trustees. He was at one time a Trustee also. Although Gary resides in Nevada he travels to and hosts the Trustees meetings at the offices of Merrill Lynch in Walnut Creek. The bulk of the Section's trust funds are in a ML account.

Gary has long provided the Trustees with sound analysis of the various ways they can invest the funds under their care to increase them in value over the long term while providing income for the Section's current needs. The Section currently has a healthy portfolio that has maintained its basic value over the recent gyrations in the markets.



With the onset of the covid-19 pandemic in early 2020 we were not able to have an in person meeting of any sort in the California Section. This spring, however, the Trustees met together on Walnut Creek and the Petersen Award was finally presented to Gary.

Congratulations to Gary for his fine work assisting the California Section!

Picture: Paul Vartanian, Treasurer, presenting the 2020 Walter Petersen Award to Gary Martin. Photo by Larry Wiebe.

2022 Shirley B. Radding Award to Dr. Marinda Li Wu

By SVACS Section Newsletter*



Marinda Wu has been selected as the recipient for the 2022 SVACS (Silicon Valley – formerly known as the Santa Clara Valley section) Radding Service Award. The criteria to

be selected for the Radding Award are:

- Member of the American Chemical Society for more than 20 years.
- Demonstrated dedicated and unselfish service to ACS members over a sustained period of time.
- Provided leadership through elected and appointed ACS positions at local, regional and national levels.
- Made significant contributions to industrial, applied or academic chemistry.

Marinda Li Wu has over 45 years of experience in the chemical industry. She worked many years in research for Dow Chemical R&D where she earned 7 U.S. patents in advanced batteries and membrane separations, and as a business leader for Dow Plastics Marketing where she created partnerships between industry, education, government, and community leaders. These partnerships resulted in the nation's first municipal curbside plastics recycling program for all mixed plastics and in national model recycling programs for schools and industry. Dr. Wu subsequently held management roles

at several smaller chemical companies. A strong advocate of STEM education, she founded "Science is Fun!" to interest young students in science and enhance public support for science education.

As an ACS member for over 50 years, Dr. Wu has served in many national and regional leadership roles. These include being elected as the first Asian American ACS President (2013), Board of Directors (2006-2014), Councilor (1996-present), and Chair of the Committee on Economic and Professional Affairs (CEPA) (2003-2005) where she created a Globalization Task Force that brought out the importance of globalization to jobs and careers of ACS members and students.

Dr. Wu has also served on numerous other national ACS committees including Local Section Activities Committee (LSAC), Committee on Chemistry and Public Affairs (CCPA), Committee on Public Relations and Communications (CPRC), Petroleum Research Funds (PRF), and Budget & Finance (B&F) as well as the ACS Board Committees on Professional & Member Relations (P&MR), Public Affairs and Public Relations (PA&PR) and Grants and Awards (G&A). Dr. Wu has also helped countless students and professionals at all career stages as a certified ACS career consultant for almost 30 years. Dr. Wu was Chair of the Women Chemists Symposium at the Western Regional Meeting in 2006.

At her local ACS California Section level, Dr. Wu was Chair during its Centennial Celebration year in 2001, Chair of the Women Chemists Committee four times, Chair of the

Government Affairs Committee, and Chair or member of over half a dozen other committees. She continues to serve on the Executive Committee, actively participating at their monthly meetings. She pioneered the Family Science Night in 1997, introduced the popular Science Cafe programs to support public education and outreach, and co-founded the monthly Career Assistance and Transition Group meetings, providing mentoring and resume reviews to job-seeking chemists for many years.

Dr. Wu served on the Council of Scientific Society Presidents (2012-2015), the International Advisory Board for 45th IUPAC World Chemistry Congress, and has also been named an honorary member of the Romanian and Polish Chemical Societies. She is a longtime member of the University of Illinois Chemistry Alumni Advisory Board and the Chinese American Chemical Society Board of Directors (Chair, 2019-2022). She has authored over 70 journal articles, internal Dow research papers, and book chapters, co-edited three ACS Symposium Books, and was invited as plenary speaker for the Federation of Asian Chemical Societies as well as many other international and domestic conferences.

Dr. Wu was elected ACS Fellow in 2015. She received her Ph.D. in inorganic chemistry from the University of Illinois in Urbana-Champaign and a B.S. cum laude with Distinction in Chemistry from The Ohio State University.

The award will be presented at ACS Silicon Valley Annual Picnic and Awards Ceremony Sponsored by the ACS Silicon Valley Section on July 16, 4-7pm, Cuesta Park, Mountain View, CA. Further information is locate at [ACS Silicon Valley Annual Picnic and Awards Ceremony – SVACS \(siliconvalleyacs.org\)](https://siliconvalleyacs.org).

Marinda hopes to donate the Radding Award's \$1000 honorarium evenly between ACS Project SEED in CA, ACS Scholars, and the Chemistry Departments of The Ohio State University and the University of Illinois at Urbana-Champaign, her two alma maters.

*From and modified from SVACS newsletter at [news2206.pdf \(siliconvalleyacs.org\)](https://siliconvalleyacs.org/news2206.pdf)

6 Participants Receive Honors and High Honors for the 2022 National Chemistry Olympiad Exam

By Eileen Nottoli

We hosted the National Olympiad on April 30 at Las Positas College; ACS released the scores of the Part 1 last week. We (the California Section) had two High Honors and four Honors, alas no one qualified for Study Camp (The top 20 national participants are chosen for a 2-week month long Study Camp, of which 4 are selected to represent the USA at the International Chemistry Olympiad in July under remote exam conditions):

High Honors

Venkat Ranjan, Dougherty Valley High School, San Ramon
Annie Xu, Mission San Jose, Fremont

Honors

Sahand Adibnia, Dublin High School, Dublin
Chris Ge, Mission San Jose, Fremont
Anirudh Tenneti, Dougherty Valley High School, San Ramon
Hansen Yang, Abraham Lincoln High School, San Francisco

We hope to continue the tutoring with Cal Chem and ChemE majors next year.

As we finished with the 2022 Olympiad, Julie has already received inquiries about next year's Olympiad.

Editor's Note for Trudy Lionel May Posting

By Donald MacLean, editor



I have reposted this as May's The Vortex draft version was posted instead of the final version. The reflection came in after the first draft.

Picture showing Trudy in the yellow jacket.

Trudy Lionel, former WCC Co-Chair

1952 – 2022

It is with great sadness that we report the recent passing away of Dr. Trudy Lionel.

Trudy had been a long-time, active member of ACS and of our California Section. She was a strong supporter of our California Section's WCC (Women Chemist Committee) and organized many lively programs that connected chemists, particularly women chemists, especially in her three-year role as WCC Co-chair. Trudy had a gift for organizing these events with great ease. She also participated at numerous public outreach events of our Section, like Expanding Your Horizons, and easily engaged the public for chemistry activities with her friendly, joyous manner. As a weekly docent at the California Academy of Sciences, she knew scientists from the Academy in specialty areas such as coral reef research. Trudy was the contact that made that WCC meeting possible. Trudy loved group activities, even extending to non-ACS activities, such as hiking and singing in a church choir. She was an excellent hiker, and her WCC Co-Chair and she discussed chemistry, the world, and family as they explored the Bay Area trails. Some of us were privileged to hear the choral group, as they sang at the Unitarian Universalist Church in Kensington. She forged strong, lasting friendships with, especially, her WCC colleagues.

Trudy Lionel was born in Nanaimo, Vancouver Island, BC. After obtaining her Ph.D. in chemistry from Vanderbilt University, Dr. Lionel worked as a quality control chemist for several years at the original HP Company.

Then she took significant time off to raise her children, but always kept in touch with her local California Section, eventually becoming co-Chair of the WCC.

With connections stemming from our local ACS Section, she successfully re-entered the workforce as a full-time quality control scientist for Genentech and then Bayer. It was during her time at Bayer that Trudy helped another WCC member with her job search, along with other team members. This was somewhat difficult as the job applicant was trying to enter a different part of the chemical workplace than any of the group were familiar with. (Eventually, she was successful.) Trudy ended her working career at Amyris. After her retirement she actively continued her involvement with our outreach activities. She led a breakout room networking discussion at the recent February 12 WCC meeting.

Trudy courageously fought cancer in her last years, bravely following the science, and specifically the chemistry of her treatments, with detailed interest. We all miss her dedicated, joyful presence in our ACS Section.

- Elaine Yamaguchi and Margareta Sequin

Note this is a repost due to it being omitted in the May 2022 The Vortex website The Vortex copy.

The Irony of Iron

Part 6

by
Bill Motzer



In Part 5 (May 2022 Vortex), I noted that two terrestrial planet crusts (Mars and Earth) contain soluble hydrous ferrous [Fe(II)] oxides mobilized from their metallic iron-nickel cores through their respective mantles. This largely occurred via mantle plumes (see Fig. 1 in the May 2022 Vortex) but also from subducting oceanic plates that recycle weathered Fe(II) crust back into the mantle (**Figure 1**). However, this process only occurs on Earth because there's no evidence for plate tectonics having ever occurred on Mars. A stationary Martian mantle plume most likely resulted in the largest shield volcano in the Solar System: Olympus Mons (elevation: 21.9 km). Additionally, Mars once had oceans but because it lacked a dynamo magnetic field, it's believed that most of its early atmosphere and water leaked

into space. Therefore, Fe(II) precipitated out in and on Martian surface rocks and regolith, never to be recycled. Earth's thicker atmosphere and protective magnetic field allowed atmospheric and oceanic retention. As a result, Earth's crust, and subsequently its oceans, were enriched in Fe(II) oxides, the sources of which were from plumes erupting as volcanos, oceanic hydrothermal vents, and some crustal rock weathering. Over time, Earth's oceans became saturated with Fe(II) oxides, which eventually precipitated either chemically, biologically, or a

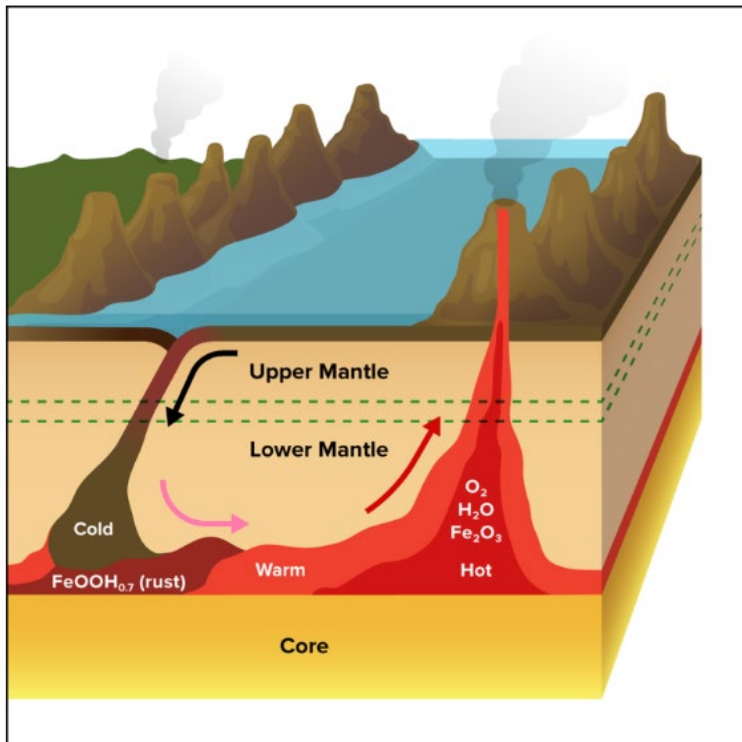


Figure 1: Schematic/cartoon model suggesting that core “rust” (as FeOOH_{0.7}) could form when a relatively cold subducting slab carrying hydrous minerals meets the outer core. Driven by mantle convection, core rust deposits from this cold region could then migrate along the core-mantle boundary to a hotter region at the root of a mantle plume, where it could become unstable and decompose into hematite (Fe₂O₃), water (H₂O), and oxygen (O₂). Source: Chen and Esdaille (2022) with credit to Mary Heinrichs / American Geophysical Union.

combination of both. And it's this and subsequent Fe(II) precipitation events that helped in stabilizing and forming an environment conducive to complex life.

In the geological record this is apparent in the worldwide occurrence of banded iron formations (BIFs) (**Figure 2**), of which deposition is believed to have occurred from Fe(II) oxidation in seawater either from oxygenic photosynthesis or iron-dependent anoxygenic photosynthesis (aka photoferrotrophy). As an analog, modern aerobic Fe(II) oxidation occurs from acidophilic oxidizing bacteria use O₂ as an oxidant as a terminal electron acceptor:

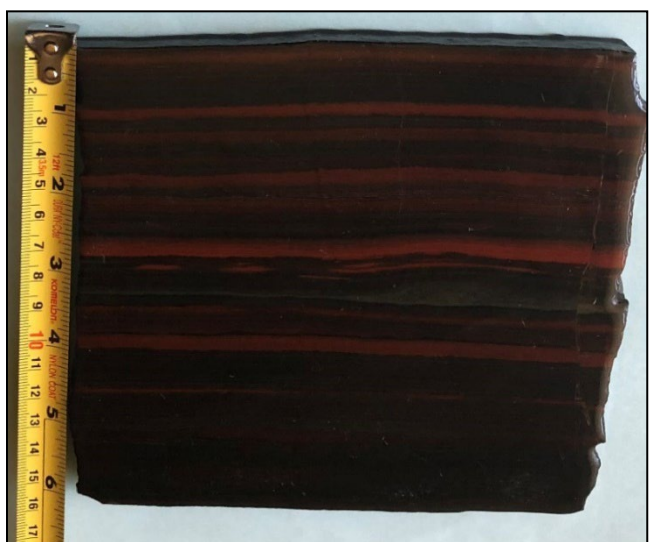
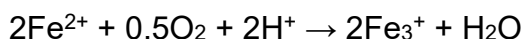
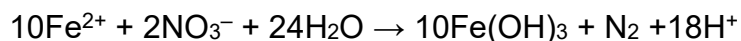


Figure 2: Polished specimen of a banded iron formation (BIF) with repeated thin layers of iron oxides and chert. Scale on left in both inches (large numbers) and cm (small numbers). Sample location typical of the Mitten Mine, northern Michigan. A typical BIF consists of these repeated, thin layers (a few mm to a few cm in thickness) of light gray/silver hematite (Fe₂O₃), and black magnetite (Fe₃O₄) alternating with bands of red iron-poor chert. BIFs may range in thickness from tens to several hundred meters extending laterally for several hundred km. BIF deposits are responsible for much of the mined iron ore; they occur in Russia, Australia, Brazil, Russia, Canada, and the U.S. (northern Michigan, Minnesota, and Wisconsin). Sample shown is from author's collection.

Most BIFs were deposited in Precambrian [early Archean to late Paleoproterozoic ~3.8 to 1.8 billion or giga years ago (Ga)] oceans. However, BIF deposition remains somewhat controversial because possible photosynthetic biomasses produced during iron oxidation are absent. Additionally, early Earth's surface environment (atmosphere and oceans) is believed to have been largely anerobic or anoxic as was early bacterial (microbial) life – perhaps appearing as early as 3.3 Ga, that used hydrogen, nitrogen, and perhaps even sulfur as electron acceptors, e.g.:



Archean sedimentary rocks and fossils also indicate the presence of liquid water on the Earth's surface. The dominant atmospheric Archean gases were most likely carbon dioxide (CO₂) and nitrogen (N₂) with perhaps traces of methane (CH₄). Additionally, the rock record suggests an absence of atmospheric oxygen (O₂) (**Figure 3**), although O₂ may have started increasing in shallow seas as early as 3.5 Ga produced by cyanobacteria in stromatolites. However, it's the greenhouse gases that probably allowed above freezing surface and oceanic temperatures even though the warming mechanism effectiveness during the Archean are still not well understood.

BIF deposition by photoferrotrophs may have also contributed to CH₄ atmospheric fluxes, thereby aiding in stabilizing Earth's climate under a dim early Sun (Solar luminosity is estimated to have been 77-79% of its present value at 3.2-3.5 Ga) (**Figure 4**). The absence of significant O₂ in the Archean atmosphere is also indicated by unoxidized detrital sulfides (e.g., pyrite or FeS₂) and uraninite (UO₂) contained in Archean fluvial sediments and by sulfur isotopes in sedimentary rocks that were fractionated independent of mass by ultraviolet photolysis of SO₂ in an anoxic atmosphere.

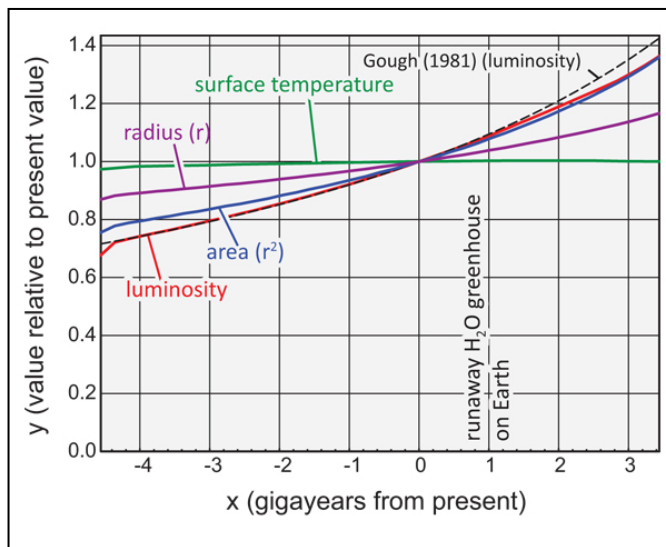


Figure 4: Evolution of solar properties. A simple approximation of solar-luminosity evolution is shown as the solid red line paralleling equation 1 of Gough (1981) is also shown. See Spencer (2019) for reference.

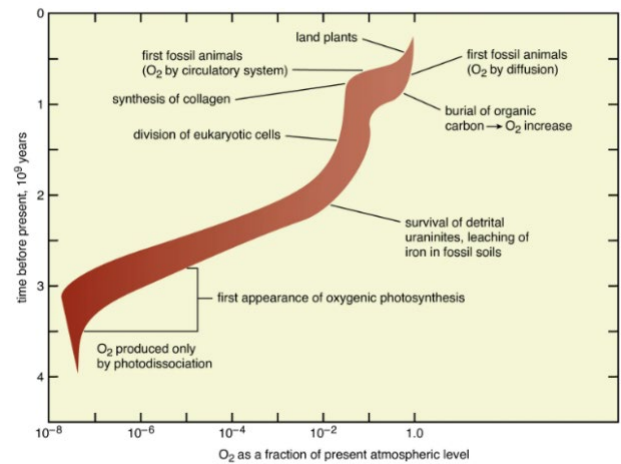


Figure 3: An estimated reconstruction of O₂ in Earth's atmosphere as a function of time. The O₂ abundance axis is logarithmic. Source: Hayes and Rafferty (2020).

But not all mantle plumes are created equal and there's at least one that may have been responsible for wiping out nearly 95% of land and ocean species. And we'll discuss this in my next article.

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1. Chen, J. and Esdaille, S.S., 2022, *Is the Earth's Core Rusting?:* EOS, v. 103, <https://doi.org/10.1029/2022EO220201>. Published on 25 April 2022.
2. Hayes, J.M. and Rafferty, J.P. (editor), 2020, *Evolution of the Atmosphere:* Encyclopedia of Britannica: <https://www.britannica.com/topic/evolution-of-the-atmosphere-1703862>.
3. Spencer, J., 2019, *The Faint Young Sun Revisited:* GSA Today, v. 29, pp. 4-10.

Miller / Knox – Brickyard Cove Brick Kiln– Point Richmond (Contra Costa County)

By Donald MacLean



Lagoon with heron.



Swing arm railway crossing signal.

South of the Richmond - San Rafael Bridge is Miller / Knox Region Shoreline. The small shoreline contains an abandon rail line that runs along the shoreline out to the abandoned Ferry Point dock, 2 tunnels to Point Richmond, is across from the Golden State Model Railway Museum, and is close to an old brickyard that has some history. By far the place is most notable for an auto tunnel that connects Point Richmond to the shoreline area, or for the chemist the Chevron refinery.

Point Richmond is the former terminus to the Santa Fe railroad. Today Pt Richmond is a quaint enclave of Richmond known for the tunnel, a unique railroad swinging crossing arm, and an indoor pool. The area is under utilized which is why I am giving this a recommendation.



Rocks along the shore have a variety of things going on.

The shoreline has erosion protective rocks that seem to come from everywhere dumped in collections that create an interesting contemplation of where they came from. I have been to a lot of places, and the rubble is normally the same



That is a lot of belts.

type. The old rail line passes through its own tunnel on the way to Ferry Point and a degraded railroad loading pier.

If you don't mind doing a bit of walking / biking, further along the shore will lead to boat docks and condos with a tall chimney in front, well before May that is. The chimney has been partially dismantled in May due to safety with its ultimate fate unknown. The red bricks are made from local clay, some of which have "Richmond" as an identifying name. Upon further investigation two brick (of the original 6) "beehive" houses are still there, but modern strap belts have been added to keep the round shape. This is the kiln that give the cove its name.

Going the other direction towards the bridge is a small beach and at low tide the area smells of ocean with green eel grass. Of course, the shore birds come by looking for easy crab. Further up the beach front homes look at the bay and the bridge with Chevron Oil refinery near by.

The shoreline surroundings are a bit of mishmash with a lagoon and the surrounding trees showing a hard life just to be there. Wildlife is attracted to the area due to the pond and the proximity to the bay.



Hard life tree.

If you like model trains there is a model train museum across the street with a California route theme that is actually pretty good.

Address: 900
Dornan Dr.,
Richmond, CA 94801
Parking – free and plenty
Fee - Free



Information Sign.

Reference: <https://richmondstandard.com/richmond/2021/07/15/effort-underway-to-save-brickyard-coves-historic-kilns-and-chimney/>

More on Leavening agents

By Donald MacLean

In the April 25, 2022 issue of CEN, Page 18 there is "Periodic Graphics: Baking Soda Versus Baking Powder". The common theme is the word baking and both are chemical reactions. However, yeast is another familiar leavening agent. Further expansion of leavening agents follows.

BAKING SODA VERSUS BAKING POWDER

Baking soda and baking powder are two common ingredients in baked goods. Here we take a look at what these leavening agents are made of and how they help your cookies, muffins, and cakes rise.

WHAT ARE RAISING AGENTS?

Carbon dioxide makes doughs and batters rise during baking. The gas can be produced by yeast, other microorganisms, or chemical raising agents.

BAKING SODA

Sodium bicarbonate
 NaHCO_3

Heat or acidity breaks down sodium bicarbonate to release carbon dioxide. If a dough or batter is acidic enough, no acid needs to be added with the baking soda.

$$\text{NaHCO}_3 + \text{HX} \rightarrow \text{CO}_2 + \text{NaX} + \text{H}_2\text{O}$$

(acid) (neutral salt)

$$2\text{NaHCO}_3 \xrightarrow{\text{heat}} \text{CO}_2 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$$

Baking soda is alkaline—too much causes bitter flavors in baked products.

Potassium bicarbonate Used to reduce sodium content of baked goods.

Ammonium bicarbonate Produces carbon dioxide and ammonia gases. Used in crisp cookies and crackers.

BAKING POWDER

Sodium bicarbonate
Acid or acidic salt

Most baking powders are double acting, releasing gas during both mixing and baking.

During mixing

A soluble acid reacts with the baking soda.

During baking

A less soluble acid reacts with the baking soda.

Different acid ingredients affect gas production differently.

BAKING POWDER ACIDS

Cream of tartar (potassium bitartrate) is a soluble acid and reacts during mixing.

Potassium bitartrate

$$\text{HOOC-CH(OH)-CH(OH)-COO}^-\text{K}^+$$

Double-acting baking powders often combine monocalcium phosphate, which reacts with baking soda during mixing, with sodium aluminum sulfate, which reacts during baking. Some other baking powders use pyrophosphate salts, whose different granulations can vary their reaction times.

Monocalcium phosphate

$$\text{HO-P(=O)(OH)-O}^-\text{Ca}^{2+}$$

Sodium aluminum sulfate

$$\left[\text{O-S(=O)}_2\text{-O} \right]_2 \text{Na}^+ \text{Al}^{3+}$$

© C&EN 2022 Created by Andy Brunning for Chemical & Engineering News
Cupcake image © Shutterstock

Figure 1. Snip and clip image of the Baking Soda Versus Baking Powder Periodic Graphics

A leavening agent is a substance that causes dough to expand by releasing gas once mixed with liquid, acid or heat. Table 1 shows 5 types of leavening agents.

Single- and double-acting baking powders

As the graphic indicates, the use of two acidic components is the basis of the term "double acting". The acid in a baking powder can be a fast-acting acid where the reaction occurs in a wet mixture (during mixing) with baking soda at room temperature, or a slow-acting acid which does not react until heated (during baking). When the chemical reactions in baking powders involve both fast- and slow-acting acids, they are known as "double-acting"; those that contain only one acid are "single-acting".

By providing a second rise in the oven, double-acting baking powders increase the reliability of baked goods by rendering the time elapsed between mixing and baking less critical. This is the type of baking powder most widely available to consumers today. Double-acting baking powders work in two phases; once when cold, and once when hot.²

For example, Rumford Baking Powder is a double-acting product that contains only monocalcium phosphate as a leavening acid. With this acid, about two-thirds of the available

gas is released within about two minutes of mixing at room temperature. It then becomes dormant because an intermediate species, dicalcium phosphate, is generated during the initial mixing. A further release of gas requires the batter to be heated above 140 °F (60 °C).²

Common low-temperature acid salts include cream of tartar and monocalcium phosphate (also called calcium acid phosphate). High-temperature acid salts include sodium aluminum sulfate, sodium aluminum phosphate, and sodium acid pyrophosphate.²

The filler (starch or calcium carbonate) stabilizes the product by keeping the baking soda and leavening acid separate and standardizes it to the desired strength.

Table 1. Leavening agents		
Type	Mechanism	Product in addition to carbon dioxide that can cause volume expansion
Baking Soda	Chemical	sodium bicarbonate – water potassium bicarbonate – water ammonium bicarbonate – ammonia, water
Baking Powder	Chemical	NaHCO ₃ + acid or acidic salt – water NaHCO ₃ + KC ₄ H ₅ O ₆ - water NaHCO ₃ + Na ₂ H ₂ P ₂ O ₇ – water NaHCO ₃ + CaPO ₄ H - water NaHCO ₃ + NaAl(SO ₄) ₂ - water
Yeast	Biological breakdown	alcohol
Whipping (egg white), folding, kneading	Physical	Whipping - No CO ₂ , protein unfolds which allows trapped air Kneading - entrapping air, break down starch – yeast breaks down starch to CO ₂ .
Heat - Steam	Phase conversion	No CO ₂ , water and Trapped air

References:

1. Periodic Graphics, Chemistry and Engineering News, 100 (14): 18
2. https://en.wikipedia.org/wiki/Baking_powder#Alum-based_baking_powers
3. https://www.lallemmand.com/BakerYeastNA/eng/PDFs/LBU%20PDF%20FILES/1_12CHEM.PDF

Radionuclides are Back in Vogue

By Donald MacLean

In the April 18, 2022 Chemistry and Engineering News (CEN)¹ issue there is an article titled “Old tool, New tricks”. This article is about radionuclide rebirth in medicine emphasizing prostrate cancer treatment. The article mentions Bayer’s 2013 FDA approved Ra-223 dichloride drug (Xofigo) as the first in class treatment then goes into Novartis’ Lu-177 based Lutathera / Pluvicto. The article also shows the use of Ac-225 radioconjugate. The interesting part is not so much the radionuclides, but how each delivers the radioisotope to the target.

The use of radionuclides is not new, ergo the article title. There are various radionuclides used for diagnostic and treatment uses. Diagnostics use emitted gamma rays for detection, preferably in the 150 to 300 keV range (1 keV = 1.602×10^{-16} Joules). One the most commonly used diagnostic radioisotope is Tc-99m, which emits a 140 keV gamma. That said MRI (magnetic resonance imaging) has become so common that the use of diagnostic radionuclides has not gotten the public attention that it once had. Therapeutics use emitted particles due to the greater linear energy transfer (LET - the amount of energy that an ionizing particle transfers to the material traversed per unit distance). Treatments have concentrated on particle emission, alpha and beta particles. One exception is the gamma knife where beams of gammas are focused into a volume in the brain.

LET and Emax

The CEN article states the range for alpha particles is 80 μm (2 cell diameter), beta 2 mm or 75 cell diameters. This is generic statement as decay energy is also going to determine the particle range, but the relative penetration difference is what is key to why one would use an alpha emitter or beta emitter.

Emax – maximum particle energy. Lu-177 decays to Hf-177 emitting a beta particle and antineutrino. The three-way particle conservation of energy means that the more energy given to the other two particles, the less given to the beta particle. The beta particle can have any energy up to the Emax (it is a continuum not discrete energy like seen with X-rays).

Focus on 3 radioisotopes, Ra-223, Ac-225, and Lu-177.

Xofigo (radium Ra 223 dichloride) is radium chloride that is not conjugated or labeled onto a larger entity. The harmful effect of radium is well known by the radium dial painters’ story in which the dial painters used their lips to get that pointed brush tip, which resulted in short time jaw cancer. Radium is a bone seeker as Radium-223 is a “calcium mimetic that can preferentially bind to areas of hydroxyapatite deposition, such as bone metastases in prostate cancer. Xofigo is administered IV. Ra-223 is an alpha emitter.

Ac-225 is also an alpha emitter. In the article example it is complexed, not given as the salt as in the Xofigo case, nor attached to a site directed monoclonal antibody. The advantage with Ac-225 is the short half-lives of the daughter / grand daughters (decendents) means it is an alpha generator (4 successive emissions in short time). There is no FDA market approved drug with AC-225 that I am aware of. Figure 1 shows an example of Ac-225-PSMA-617 binding to the PSMA (prostate specific membrane antigen, a protein found on the prostrate cancer cell surface).

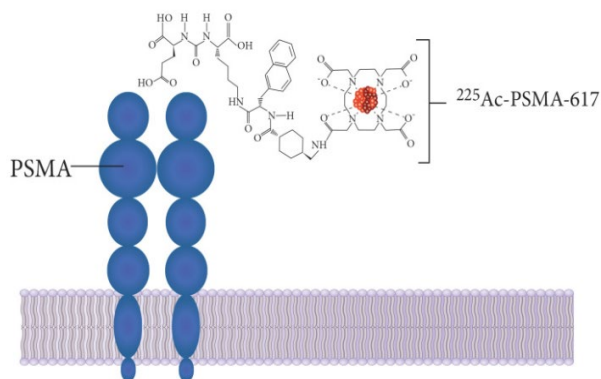


Figure 1. Ac-225 bind to PSMA receptor. From Annals of Annals of Oncology.

Pluvicto (lutetium Lu 177 vipivotide tetraxetan) uses Lu-177 complexed to (2S)-2-[[[(1S)-1-carboxy-5-[[[(2S)-3-naphthalen-2-yl-2-[[4-[[[2-[4,7,10-tris(carboxymethyl)-1,4,7,10-

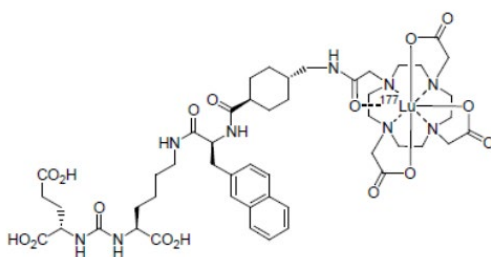


Figure 2, Structure of lutetium Lu 177 vipivotide tetraxetan. Image from Patient Insert.

tetrazacyclododec-1-yl]acetyl]amino]methyl]cyclohexanecarbonyl]amino]propanoyl]amino]pentyl]carbamoylamino]pentanedioic acid. Lu-177 is a beta emitter. Lutetium Lu 177 vipivotide tetraxetan is a PSMA-binding ligand bound to a DOTA chelator radiolabeled with lutetium-177. It binds to PSMA, a transmembrane protein that is expressed in prostate cancer.

Lutathera (lutetium Lu 177 dotatate) also uses Lu-177. Lutetium Lu 177 dotatate is a radiolabeled somatostatin analog. The drug substance lutetium Lu 177 dotatate is a cyclic peptide linked with the covalently bound chelator 1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid to a radionuclide.

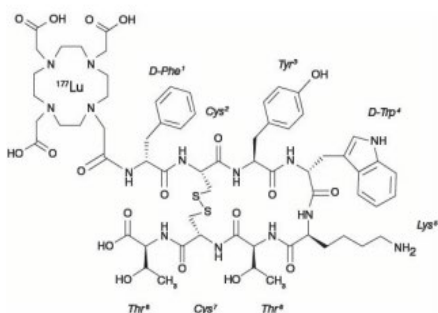


Figure 3. Structure of lutetium Lu 177 dotatate. Image from Patient Insert.

Isotope Production

Ra-223 is a part of the U-235 decay chain. Isolating Ra-223 can be a source of this material. However, neutron activation of Ra-226 to produce Ra-227 which then decays to Ra-223 is the method commercial production. Another production method is to use Ac-227 created during Ac-225 cyclotron production, then allow for decay to Ra-223.

Ac-225 is part of the Np-237 decay chain. Isolating Ra-225 or Ac-225 can be a source of this material. However, cyclotron using proton beam onto a Ra-226 target yields Ac-225 and 2 neutrons in a knock out reaction.

Lu-177 is produced through neutron activation (neutron in, gamma out) of Lu-176 or Yb-176. ^{177}Lu emits β^- particles with an $E_{\beta(\text{max})}$ of 497 keV (78.6 %), 384 keV (9.1 %) and 176 keV (12.2 %) and low-energy gamma photons [$E_\gamma = 113$ keV (6.6 %), 208 keV (11 %)]. For information Lu $K_{\alpha 2}$ X-ray is 53.0 keV and $K_{\alpha 1}$ X-ray is 54.1 keV the low energy photons are gamma not X-rays.

From Wikimedia Commons, the free media repository

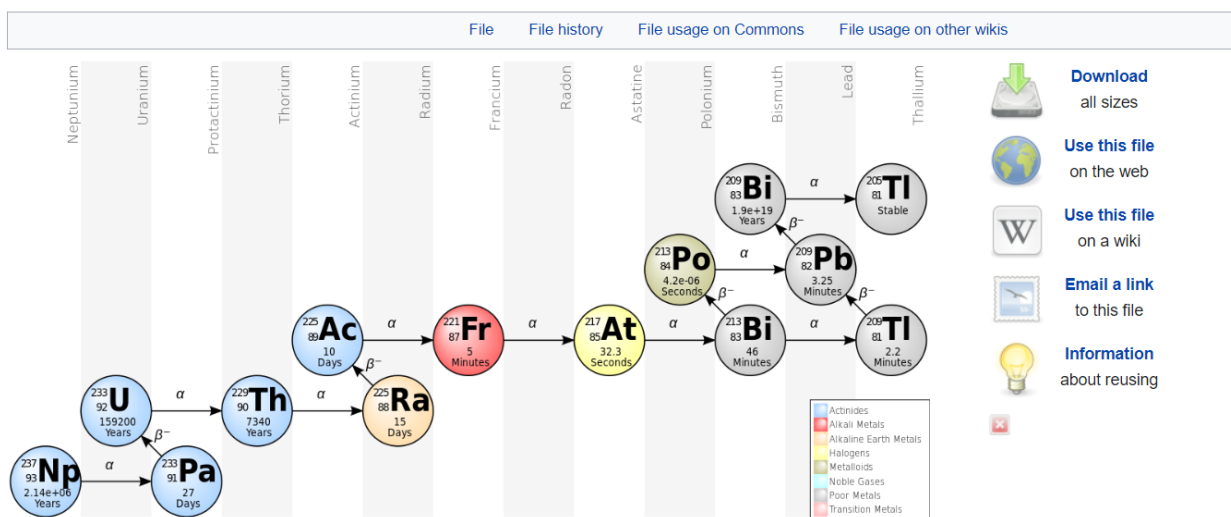


Figure. Ac-225 Decay Chain is part of the Np-237 Decay Chain. However, production is from neutron activation of Ra-226. The decay of Ac-225 yields a beta particle then 4 alpha particles in a short time after the beta decay. Source figure is [Creative Commons — Attribution 3.0 Unported — CC BY 3.0](#).

Table 1. Half-lives of the Four Alpha Emitting Radioisotopes.			
Isotope	Half-life	Alpha (MeV)	Beta (MeV)
Ac-225	9.9 days	5.94	NA
Fr-221	4.9 minutes	6.4 (99.9%)	(0.1%)
At-217	32.3 msec	7.20	NA
Bi-213	45.6 minutes	5.98 (2.09%)	1.42 (97.91%)

Potential Article Error Note:

On page 33 of the CEN article there is a picture of the Ac-225 in a vial that is blue with the statement the blue is from air ionization. I think the blue light is from Cherenkov radiation. In water medium beta particle must be ≥ 0.26 MeV, proton $\sim \geq 320$ MeV, while the alpha particle has to have ≥ 1926 MeV⁶. The minimum energy would be higher in air, 20 MeV for beta particles, which is many times the Emax. Since it appears the solution is blue, it could be the container or more likely from water not the air. Table 1 shows the alpha energy and beta Emax for Ac-225 and its decedents.



Credit: Andrew R Burgoyne, Oak Ridge National Laboratory
Actinium-225 nitrate in a vial glows blue because of the ionization of air by α particles.

Ac-225 Induced Blue Solution. Figure from CEN Article.¹

References:

1. Leigh Krietsch Boerner, Targeted radioactive drugs raise hopes for treating cancer, Chemistry and Engineering News, 100 (13): 28-33.
2. XOFIGO Prescribing Information (Patient Insert)
3. LUVICTO Prescribing Information (Patient Insert)
4. LUTATHERA Prescribing Information (Patient Insert)

5. De Vincentis, et al., Advances in targeted alpha therapy for prostate cancer, *Annals of Oncology*, 2019, 30 (11): 1728-1739. DOI:<https://doi.org/10.1093/annonc/mdz270>
 6. NL Ackerman and EE Graves, The potential for Cerenkov luminescence imaging of alpha-emitting radionuclides, *Phys Med Biol.*, 2012; 57(3): 771–783.
DOI: 10.1088/0031-9155/57/3/771
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WCC meeting held on 5/21/22: How to Thrive (Not Just Survive) as a Woman in Today's World

By E. S. Yamaguchi

Introduction

For our May meeting, let me introduce you to our WCC co-chair from Canada, Dr. Mina Mozafari¹, who organized this talk. Our co-chair informed me of Keda Edwards Pierre who currently works in several different spheres, including inspirational speaker. About Mina first, she is a post-doctoral fellow at UC Irvine, and her journey to Irvine took some time, as she was detained in Canada, solving visa issues. She found our WCC group and wanted to volunteer! At last, she is working in-person with her UCI group on analyzing NMR spectra of complex biological compounds. She has also contributed to the Section's programming by organizing a technical talk on this subject earlier this year.

Keda's background

Keda's talk addressed a completely different subject area. It is Keda's background with her own personal trauma, policing for 27 years in Toronto, and acting/movies, that allowed her to develop the system she advocates. (Interestingly, the CA Section, WCC has independently practiced some of her teachings, which were all non-technical, such as the strong networking session we have that precedes all the formal talks.) She herself commented on the warmth she experienced as she listened to comments while participating in the networking session. Previous WCC leaders (Mary Singleton, Marinda Wu, Greti Sequin, and the late Trudy Lionel) held in-person networking sessions even before 'network' was recognized as a verb. Keda was raised by a single parent, with a Grenadian immigrant origin. Thus, it is unlikely her life path would find her as the founder and leader of true2soul.com and inspirational speaker. Early on in her policing career, she realized that social justice was her passion, and she has worked in that subject area ever since with influence from "Sankofa", a West African word that tells people of African descent to return and learn from the past to move forward.

The essence of Keda's talk:

1. it is up to each of us to remember our own personal trauma (most people have experienced some);
2. to analyze critically our professional experiences-- in STEM fields, we cannot generally "fake it till we make it";
3. and to develop a mentality whereby we exchange ideas and support one another—not divide and conquer, so that we can increase innovation both in the non-technical and technical spheres of life.

In fact, Keda does not see a real separation between them, and does not ascribe to the work/life balance that many women have sought in modern times. A clear philosophy of passion, integrity, authenticity, social consciousness, and emphasis on quality and services drives each person's journey to the development of his/her inclusive space, allowing for fruitful interaction

with trusted others. This results in an elevated action level, and one can accomplish more of our cherished goals. The process requires an acute awareness of communication skills, while caring for oneself via professional development, as an example, and honing creative skills by being flexible and innovative. Despite Keda's non-technical underpinnings, her lessons are valuable for anyone who wants to lead, no matter which type of project. Chemists are used to forging new technical pathways, and this talk focused on the non-technical side and offered concrete suggestions. Get to work!

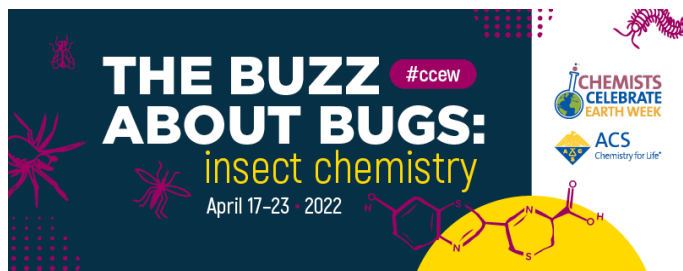
WCC members also have fun, and at this meeting, six attendees answered questions based on Keda's talk correctly, earning them ACS-themed prizes. All members are invited to join us for future fun!

Notes:

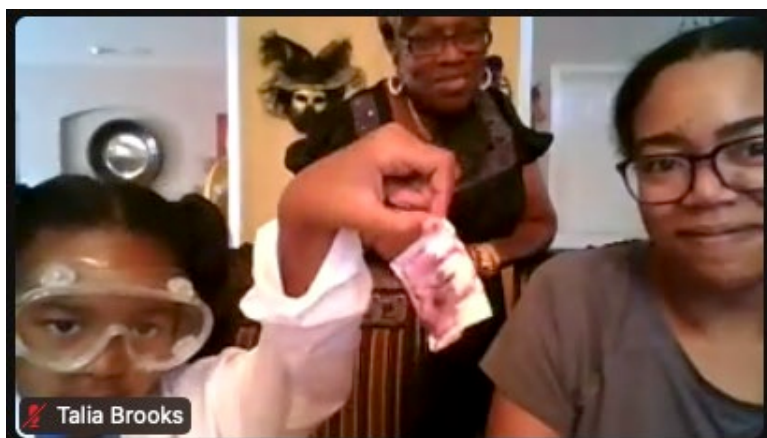
¹ the new co-chair of WCC who ran the meeting

Earth Week Continues

By Alex Madonik



This year's Earth Week theme, "The Buzz About Bugs," included excellent hands-on chemistry activities that [Cal ACS presented online on April 23rd](#). In preparation for this event, we assembled activity kits that could be shared with schools and families. Anyone who signed up for the Zoom presentation received a free kit, and some were able to show us their results in real time as we explored "Bugs to Dye For:"



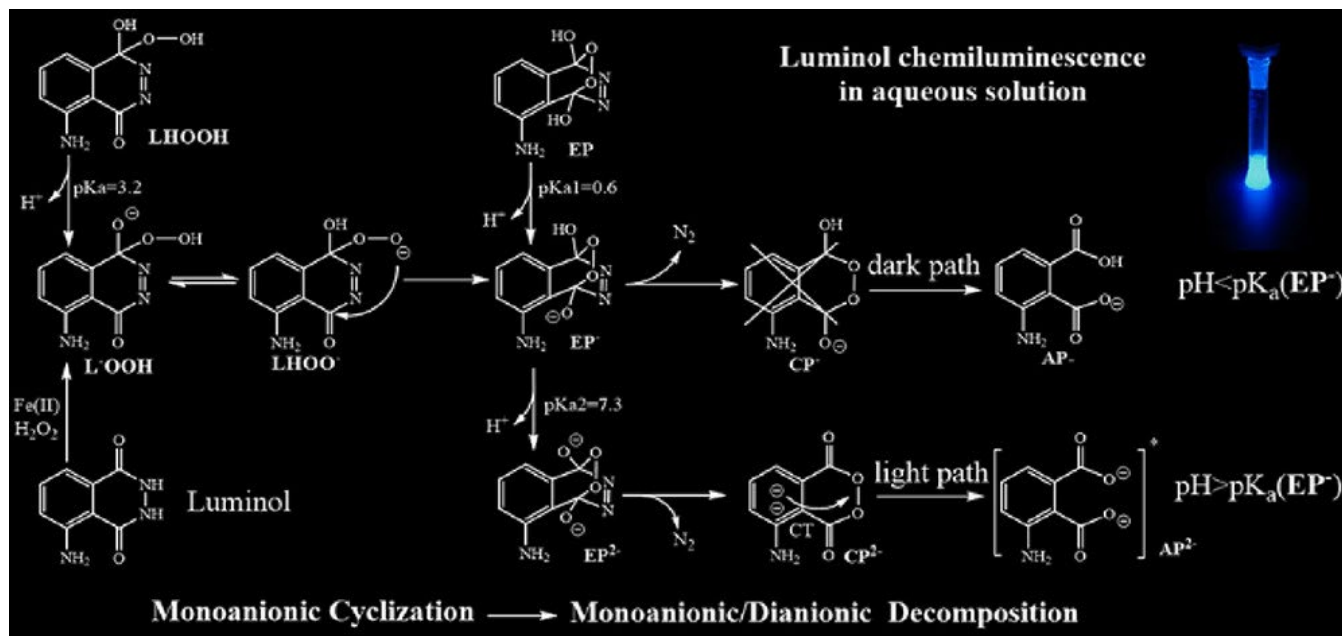
A young chemist shows her results with cochineal dye.

Eileen Nottoli, who presented this activity, reached out to local libraries in Kensington and El Cerrito, and they offered to help us distribute a total of sixty kits with materials for two activities, "Bugs to Dye For" and "Cool Blue Light Experiment – Luminol:"

Bugs to Dye For – Cochineal Dye



Cool Blue Light Experiment - Luminol



Luminol is an example of chemiluminescence, the chemical production of light without the generation of heat. It's the process that allows fireflies to glow (as well as many undersea creatures). The Buzz About Bugs banner incorporates the chemical structure of luciferin, the substances in fireflies that emits light when it reacts with oxygen:



The Buzz About Bugs Activity Kit – Cal ACS

We hope these kits get some young scientists started exploring the world of chemistry. We had another opportunity to meet the public at North Bay Science Discovery Day in at the Sonoma County Fairgrounds in Santa Rosa on Sunday, May 15th. Jerry Taylor and I presented activities that didn't require any wet chemistry (or safety glasses): UV Color-Changing Beads and the Chemistry of Insects



Formic acid is named for ants (formica in Latin) who protect themselves with this acid.

and Plants (with molecular models and illustrations of key scent compounds). Kids of all ages love making a bracelet that changes color in sunlight, and plenty of future of scientists were willing to try building molecular models:



We distributed several activity kits to visitors and Jerry took more back to Petaluma for teachers and students there. Please let us know if you're still looking for a kit! – Alex

Jerry Taylor with the Cal ACS booth at North Bay Science Discovery Day – 15 May 2022