2-oxo-L-threo-hexono-1,4-lactone-2,3-enediol

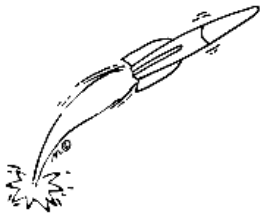
or

Why We Need to Stop Worrying and Love Amateur Science

In an age when man-kind can access information and communicate almost instantaneously using handheld computers, when space travel is no longer solely in the domain of government agencies, and when researchers have paved the way to incredible medical advances through the mapping of the human genome, none of the wondrous technological conveniences enjoyed today would have been possible without the unparalleled scientific advances of the past few hundred years. Today the majority of scientific research and discovery is done by trained professionals working in academia or in conjunction with research laboratories supported by government grants or private enterprise, but this does not exclude the importance of amateurs who work independently purely out of personal interest or love of the subject. There exist numerous individuals within the United States, and, in fact, around the world, who enjoy the practice of self discovery, and through which gain an understanding and appreciation of science greatly exceeding those who merely see the subject as abstract concepts in a text book.

Sadly, however, a few individuals misuse their scientific knowledge and the technology at their disposal in order to manufacture illegal narcotics or produce homemade explosive devices. These individuals, in turn, harm others with their poor choices and misrepresent the activities of legitimate amateur scientists to the public. In response to concerns over the manufacture of illicit drugs and improvised explosives, particularly methamphetamine and homemade fireworks, both state and federal governments have implemented a series of laws which attempt to resolve the problem indirectly by restricting the precursor materials used in such activities. Unfortunately, not only do the laws restrict many of the common chemicals and equipment used by those who wish to break the law, but the laws also restrict access from those who have legitimate reasons to posses the same materials, namely the amateur scientists. Many versatile materials once utilized in amateur science are now on lists which track, restrict, or even outright prohibit their sale to individuals without proper government permits or licenses. Without access to the once common and inexpensive chemical sources and their actions under greater scrutiny than ever before, amateur scientists face immense difficulty pursuing their pastime while those who wish to break the law continue to adapt in ways the hobbyist cannot. Government regulations on the use of certain chemicals and equipment in an attempt to eliminate the actions of only a few misguided individuals who engage in illegal activities unjustly impede many legitimate scientific pursuits and negatively impact society as a whole.

There are many legitimate ways to practice amateur science as a fulfilling hobby and, in the process, gain valuable scientific skills which one can apply to real-life situations. In years past, amateur rocketry and small scale pyrotechnics allowed many young people to experience the thrill of launching their own, homemade, model rockets into sky. For many, their experiences in amateur rocketry or other sciences led them into careers in related fields; such was the case with Homer Hickam. Hickam describes in his book, Rocket Boys (later a movie, October Sky), the adventures he and his friends had in their endeavors to build and launch numerous rockets during the 1950s and '60s, at the dawn of the space race[1]. With his experience in rocketry, Hickam went on to win first prize in the National Science Fair, and later worked as an aerospace engineer for the U.S Army and NASA for 27 years[2].



The cofounder of Intel Corporation, Dr. Gordon Moore, remembers experimenting with a neighbor's chemistry set in a shed converted into a home lab which Moore kept stocked with various mail-ordered chemicals to supply his experiments[3]. Today, many know Moore for his contributions to the world of microprocessors and for the 'law' of computing named after him which describes the doubling of computer processing power every two years. Science need not be limited to merely the realms of chemistry either. Cofounders of Apple Computer, Steve Jobs and Steve Wozniak, first got their start hand-making hundreds of their company's first computers in Jobs' garage after Wozniak began designing computers as a hobby.

Not only does amateur science hold great potential in terms of acting as a stepping stone to numerous fulfilling and profitable careers, but amateur scientific activities also provide direct benefits to society. A prime example of the benefits resulting from the home-experimentation is the story of Charles Martin Hall who, at the age of 22 and just 8 months after graduating from college, developed a way to inexpensively refine Aluminum ore. Encouraged by his chemistry professor and after several years of working in the woodshed behind his house, Hall achieved his high school goal of a process to produce Aluminum metal so cheaply as to allow widespread use and application of the material[4]. Before Hall's breakthrough, Aluminum was considered a precious/semi-precious metal on par with Silver due to the difficulty and expense of the refining process.

Crushed Aluminum soda cans, made possible using the Hall refining process.

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[1] Hickam, Homer. Rocket Boys. New York City: Delacorte Press, 1998.

[2] "About Homer - Biography." Homer Hickam Online. 4 Nov. 2006 <http://www.homerhickam.com/about/bio.shtml>.

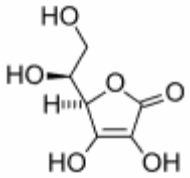
[3] Silberman, Steve. "Don't Try This At Home." Wired June 2006: 192-200.

[4] Craig, Norman C. "Charles Martin Hall and the Electrolytic Process of Refining Aluminum." 1992. Oberlin Chemistry Department. 2 Nov. 2006 <http://www.oberlin.edu/chem/history/cmharticle.html>.

Today, Aluminum is an invaluable resource used extensively in aerospace engineering, materials packaging, transportation, and anywhere else where a cheap, lightweight, and strong material is needed.

An extremely pressing and valid concern with the practice of amateur science is that of safety, both for the individual performing the experiments as well as for the general public which may also be affected. Whether one is mixing vinegar and baking soda to make a volcano for a school science fair or preparing the highly unstable explosive nitroglycerin, there is always some element of danger no matter the activity. No one wants to allow irresponsible individuals to build bombs out in the woods in order to blow up government buildings, nor does anyone want would-be chemists synthesizing illegal drugs for personal consumption or distribution, quite the contrary in fact. The vast majority of amateur scientists are responsible individuals who practice the necessary safety precautions in order to protect themselves and others. When practicing any potentially dangerous activity the key is to recognize the danger and respond in an appropriate manner. Safety is important, a belief commonly shared by both responsible amateur scientists and the general public, but not at the expense of the activity itself. One must assess the danger and risk level associated with an activity, taking care not to exaggerate the problem or overreact when searching for solutions.

Unfortunately, some people do exaggerate and overreact to dangers, and what is even more unfortunate is that some of these people who overreact are also those who are in charge of governmental policy development. In past decades society considered amateur science a rewarding and wholesome hobby; however, in recent years, a growing negative stigma is often associated with home laboratories, chemical supplies, or even a general interest in science outside of the societal 'norm'. Although not a universally held view, there are those members of the general public who, for whatever reason, distrust, or even fear, the unknown in regard to the activities of amateur scientists and science in general. The apprehensive attitude many hold toward science stems from misconceptions of the associated dangers of science. For example, consider the connotation associated with the word "acid". Thoughts of "acid" invite horrible mental images of an incredibly dangerous liquid capable of dissolving anything it touches. However, in reality, there are many types of acids with many distinguishing properties, not all acids live up to the 'death in a bottle' notion held by some. In fact, acids of all sorts are in common use in many house holds across the country. One may commonly find acetic acid, citric acid, and carbonic acid in an average kitchen within products such as vinegar, orange juice, and soda respectively. Even the title of this essay ("2-oxo-L-threo-hexono-1,4-lactone-2,3-enediol") is merely the name of another acid, ascorbic acid, otherwise known as vitamin C. Despite the common place of science in our society, growing suspicion of the practices of amateur scientists is evident in laws which aim to prevent the illegal manufacture of drugs or explosives by individuals in their homes by cutting the practice off at the source with little or no regard to any possible legitimate activities.



Molecular Structure of Vitamin C

In the noble pursuit of promoting public safety, many state and federal agencies have imposed numerous laws and regulations on the sale, possession, and use of substances which they define as chemical precursors of illegal drugs and explosives. Over the past 10 years the federal government has passed increasingly aggressive measures to combat the rise in methamphetamine use within the United States, namely the Comprehensive Methamphetamine Control Act of 1996, the Methamphetamine Anti-Proliferation Act of 2000, and most recently the Combat Methamphetamine Epidemic Act of 2005. Under these acts, the federal government regulates the distribution of controlled substances and what it considers chemical precursors used in the manufacture of methamphetamine and other illegal drugs. One of the most well known chemicals atop the list of drug precursors used in meth labs is ephedrine and pseudoephedrine, a drug used in some cold and allergy medications such as Sudafed®. Under the recent Combat Meth Epidemic Act, federal law requires retail sellers of products containing pseudoephedrine or ephedrine to keep those items behind counters or inside locked cabinets in order to discourage theft, and additionally requires customers to show government-issued identification and sign log books which sellers must keep to detail all transactions. Sellers may no longer sell more than 3.6 grams of an ephedrine/pseudoephedrine containing product to an individual in a given day nor can an individual intentionally buy more than 9 grams in any 30 day time period[5]. The strict requirements on the sale of ephedrine based products puts a strain on retailers who were not previously required to take such protective measures with such a common product, as well as places a strain on the drug manufactures who worry about a potential loss in sales to legitimate customers. Pfizer, the maker of Sudafed® Nasal Decongestant, in collaboration with the government and law enforcement agencies, developed an alternative drug which does not contain pseudoephedrine and can be sold off the shelf[6]. Additionally, the Administrator of the Drug Enforcement Administration maintains lists of regulated chemicals used in the manufacture of methamphetamine and requires the registration of those chemicals by distributors[7]. Common chemicals which appear on the regulated lists include acetone (used in nail polish remover), toluene (used as a solvent in painting), Hydrochloric acid (sometimes known as “muriatic acid”, a common swimming pool supply), and Sulfuric acid (“battery acid” found in automotive batteries).

Sudafed product containing pseudoephedrine

Although on the state level laws can vary in scope and severity, many states have passed similar measures to the laws enacted by the federal government in order to prevent the manufacture of methamphetamine. One state known for its harsh chemical laws is Texas**,** which not only restricts chemical precursors, but also requires

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[5] United States. Office of National Drug Control Policy. Executive Office of the President. Synthetic Drug Control Strategy. Washington, D.C., 2006.

[6] "What a New Formula?" 2005. Pfizer. 4 Nov. 2006 <http://www.sudafed.com/formula.html>.

[7] "Code of Federal Regulations." U.S. Department of Justice. 4 Nov. 2006 <http://www.deadiversion.usdoj.gov/21cfr/cfr/1310/1310_02.htm>.

the registration of many common types of laboratory glassware with the state in order to prevent individuals from running meth labs. Texas law defines a 'Chemical laboratory apparatus' as "any item of equipment designed, made, or adapted to manufacture a controlled substance" and requires individuals to register these items with the state[8]. Included within a list of items which law makers consider a threat due to their possible role in manufacturing controlled substances are items such as Erlenmeyer, Florence, and round-bottom flasks, as well as condensers and other distilling apparatuses, all common sights in chemistry labs as well as extremely useful tools in home-chemistry. The founder of the Society for Amateur Scientists, Shawn Carlson, remarks on the overly broad nature of the laws, saying that, "The Mr. Coffee machine that every Texas legislator has near his desk has three violations of the law built into it: a filter funnel, a Pyrex beaker, and a heating element"[9]. Additionally, within a Texas law detailing penalties for those found in violation of drug policies, "intent to unlawfully manufacture the controlled substance methamphetamine is *presumed* [italics added]" if an individual possesses or transports a combination of 3 or more of such common chemicals as iodine, lye (commonly found in drain cleaner), alcohol, paint thinner, or table salt, or any one of other useful chemicals/materials in amateur science, including unregistered glassware[10].

Erlenmeyer flask

Sometimes law enforcement goes too far when prosecuting those found in violation of the laws. In North Carolina, district attorney, Jerry Wilson, attempted to try meth lab operators under the state's statutes against *weapons of mass destruction*, claiming that the chemicals and conditions associated with such labs pose an inherent danger to the public[11]. A superior court judge ruled against Wilson's charges, but the incident nevertheless exemplifies the over-zealous and fearful attitudes of some in an effort to curtail drug manufacture.

In order to ensure continued scientific and technological developments in the future, children must be encouraged to take an interest in the sciences in hopes that one day they will enter the field and contribute to society. The youth of today will soon become the scientists and engineers of tomorrow. However, if the scientific spark inside today's children is extinguished before they have a chance to learn and become interested in the sciences, then those trained, knowledgeable, individuals necessary for continued growth in science and technology might one day be a rare and valuable

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[8] Texas. Texas Legislature. Texas Controlled Substances Act. 2 Nov. 2006 <http://tlo2.tlc.state.tx.us/statutes/docs/HS/content/pdf/hs.006.00.000481.00.pdf>.

[9] Silberman

[10] Texas

[11] Sena, Jerry. "Meth Growth Prompts Sudafed Changes." Watauga Democrat 4 Jan. 2005. 3 Nov. 2006 <http://www.wataugademocrat.com/topic.php?tid=25&sid=5123>.

commodity only found in foreign nations. Safety is important, however if society always sees science as being too dangerous for anyone other than the already trained individuals wearing layers of protective clothing operating in high-tech laboratories, then science quickly becomes a practice which is inaccessible for anyone other than an elite group. Once science is elevated out of the reach of ordinary people in society's mindset then it becomes all too easy to disregard the importance of the home experimenter or the necessity of engaging children to help teach and motivate them into scientific careers. Lawmakers too readily dismiss the effects on amateur science as an unfortunate consequence of the war on drugs and terrorism, but what they do not realize is that their restrictive laws hold ill consequences for the future. Bill Nye ('the science guy'), the host of a popular children's, educational, TV show and qualified engineer in his own right, once said, "People who want to make meth will find ways to do it that don't require an Erlenmeyer flask. But raising a generation of people who are technically incompetent is a recipe for disaster"[12]. Those who truly wish to break the law and manufacture illegal drugs will always exist to a degree, even without easy access to glassware or precursor materials; however each additional obstacle placed on the path of amateur science only further robs children of the opportunity to learn and experience the joys of discovery and self achievement.


Bill Nye ('The Science Guy")

Laws intended to prevent the actions of the proportionally few individuals engaging in illegal acts such as drug manufacture or homemade fireworks serve to infringe on the freedoms of the law abiding and well intentioned groups wishing to practice amateur science. The laws reflect a general uneasiness, suspicion, and overreaction to the fears associated with home experimentation and those who practice such activities. As well intentioned as policy makers may be, restrictions on the chemicals and supplies place unnecessary restrictions on ordinary citizens and merchants with no intention of building bombs of cooking drugs. Society will feel the frightful implications of these repressive laws one day if legislators do not take action to refocus the goal on the real criminals and less on the average individual amateur scientist.

11-15-06

[12] Silberman