American Chemical Society: I'm May Nyman here to answer your questions about the August 12 warehouse explosion in Tianjin, China, AMA!

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April 17, 2023

Abstract

Hello, May Nyman here, professor of chemistry at Oregon State University. A warehouse exploded in Tianjin, China last week that did the damage of 20 tons of dynamite, felt like an earthquake, looked like a nuclear explosion from space, but we don't know yet what caused it. Many different chemicals were stored in that warehouse, and scientists and other experts can only hypothesize what happened, and what will happen next. At Oregon State University, I run a research lab, training young scientists from all over the country and the world. We are inorganic synthetic chemists, and we make materials for energy and environmental applications. For example, we collaborate with other scientists in the Center for Sustainable Materials Chemistry developing low energy methods to make the materials you find inside your smartphone and computer. We also work with scientists in the Energy Frontier Research Center, Materials Science of Actinides to discover new ways to make nuclear energy more efficient and safer. For the Department of Energy, we figure out ways to make new materials with new properties. I have not always been a professor; for only three years in fact. I started my career at Sandia National Labs, studying nuclear wastes, and inventing ways to remove the radioactive elements and store them safely. I also figured out ways to make the water that we drink cleaner. But what I love most of all about chemistry is the beautiful and perfectly functional things in nature that are completely composed of the elements of the periodic table; including rocks and minerals, butterfly wings, leaves, and DNA! August 12, 2015 was a sad day for chemists when such a tragic accident happened that gives chemistry a bad name, and results in people fearing chemicals. The officials do not yet know what exactly happened, what caused the explosion, how it could've been prevented, and which chemicals stored in the warehouse might have been the source of explosion. We also do not know why the fish are dying and why 'soap suds' are observed everywhere after it rained in Tianjin. We do not know what the short-term or long-term impact of this accident will be, or if the people living near the accident site or sites like it are in danger of future explosions. We know of about a half dozen chemicals that were stored there including calcium carbide; ammonium potassium and sodium nitrate; sodium cyanide; toluene diisocyanate; and compressed gases. As scientists, we can form hypotheses of what chemical reactions could have occurred in Tianjin at the scene of this most unfortunate event. Update: strangely enough there was a second warehouse explosion a few hundred miles away, 10 days later in Shandong; the chemical mentioned here is adiponitrile I'll be back at 1:00pm ET to begin answering your questions. EDIT: 9:53 PT good day Reddit community, Thank you for all your questions. I am online now until 2:00 Eastern time. May Nyman EDIT: 11:10 PT. thank you for all the fantastic questions and comments, Reddit community. My official hour is up, and I need to take a break and work on my day job. I will come back at 3:00 PT to answer some more questions. May Nyman EDIT: 2:59 PT I am back to answer a few more of these many many questions. and I will be sure to address storage, as this question comes up in various forms. May Nyman EDIT: 3:49 PT. It has been fun talking with you, Reddit community. A good day to all. May Nyman

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REDDIT

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MAY_NYMAN R/SCIENCE

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WRITE A REVIEW

CORRESPONDENCE:

DATE RECEIVED:

It is my understanding that a cloud of cyanide has tainted the area with ~360 times the safe limit, but the chinese government have announced they have contained it to prevent it from spreading. How is that possible with a gas?

TheeMightyPineapple

thank you for this question, I will talk first about sodium cyanide and then answer the question in a

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second comment.

the sodium cyanide stored in the warehouse is creating the most fear in the citizens and local inhabitants of the area, understandably so. Sodium cyanide is another chemical that changes form when it reacts with water. see comment: https://www.reddit.com/r/science/comments/3ibnjb/american_chemical_society_im_may_nyman_here_to/cuf8ytz

sodium cyanide is a crystalline solid, which converts to hydrogen cyanide when exposed to water. hydrogen cyanide is a gas that is infamous for its use in gas chambers. So it is very toxic, and reports say the levels of hydrogen cyanide in the air are above normal

May Nyman

Given that there were so many chemicals stored in the facility are there legitimate concerns about this explosion butterflying into other serious safety/environmental concerns?

TheAquaFox
Yes, this is a very valid point. One thing can lead to another. For example, there is compressed gas stored there. This, in addition to the acetylene formed by the reaction of calcium carbide with water can provide fuel for the fire, and the explosion. compressed gases, especially flammable gases should not get hot! They become dangerous.

With respect to long term environmental concerns, we then need to think about what chemicals are fairly stable and can last a long time in the environment in some form, that might get into the ground water, stick to building material and other surfaces, get into the rivers.

May Nyman

Good morning, Professor. Could the physical attributes of the explosion (the magnitude, fireball temperature / spectral composition if detectable from the videos, damage pattern, fireball propagation, velocity of the shockwave, etc.) hold specific clues to the chemical(s) involved? Acetylene is often mentioned; could acetylene by itself create an explosion of that type?

On your research regarding nuclear waste: Are you as optimistic as some around the Internet about certain new technologies (FBRs, LFTRs, traveling wave reactors, neutron bombardment, etc.) and some of those technologies' potential to utilize more energy from what is now considered waste, while "burning up" some of the more dangerous isotopes? Is that even accurate? Also, do you think the long-term storage issue (besides onsite dry-cask storage) will eventually be properly addressed?

DesertTripper
This is very good thinking: When trying to understand what happened, anything observed or recorded can provide clues. For example to color of the fire. Remember chemistry lab where you used the flame test to identify substances? Or how your gas flame on your stove turns orange when you accidentally dump salt into it? so different metal salts like strontium, barium and sodium are used to give color to fireworks; so yes, the color of the fire after the explosion could give clues into what burned up in the explosion. May Nyman

Did the firefighters spraying water on the factories have anything to do with the second explosion?

devidentarch321
thank you for this question. I will begin the answer with a note that, many thousands of miles away, we can only make educated guesses, based on the little information that we have onhand. Calcium carbide, is indeed a very suspicious player. It reacts quite violently with water to produce a flammable gas, acetylene, which is an ingredient in oxygen acetylene torches used in welding! So yes indeed, spraying water on calcium carbide is not a good idea. May Nyman

What, if any, long term effects do you anticipate for the area?

osheabutter
This is a great question. The good news is, much of the chemicals present in the warehouse likely got destroyed in the two massive explosions. Anything organic converted to carbon dioxide, water and some form of nitrogen oxide. So large amounts of these gases, which are generally not harmful, could result in some changes in the local environment. For example, excess carbon dioxide could get into the water and make it acidic, but the ash could make the water basic (see https://www.reddit.com/r/science/comments/3ibnjb/american_chemical_society_im_may_nyman_here_to/cuf8mkb) so it is difficult to say the final result. Nitrogen oxide can be dangerous in numerous ways.

the other more long term effect could be the chemicals that did not get completely destroyed, but instead released, due to damage of the facilities or their containers. For example, toluene diisocyanate is reported to be stored in the warehouse. This would alter its form in water, but convert to molecules that could last a long time in the environment (something like benzene).

May Nyman

Could you elaborate a little more on the fish dying and the soap sud rain?

BongmasterGeneral420
Now about those fish. the pictures of many dead fish are pretty shocking. again, ash produces alkaline water, so perhaps it could be the alkalinity in the water went up (acidity went down), this is not the fish's usual environment, which resulted in massive death. And also, per a comment below, there are times of the year that water does not get so much oxygen, algae blooms, etc. which could result in pressure on the fish's environment and result in death. May Nyman

Could you elaborate a little more on the fish dying and the soap sud rain?

BongmasterGeneral420
thank you for this question. These phenomenon are indeed curious. If we think about such a large explosion, what results is lots and lots of ash. Ash is in fact the ingredient for making soap, the old-fashioned way. Ash is water makes lye (very alkaline water) which could react with road tar or oil, and you could get a very crude soapy material

I currently live in Shanghai. It has been rainy here and I've heard reports that the weather could be contaminated with smoke from the blast. Is there anything to worry about?

nobecauselogic
smoke from a huge fire like this can travel thousands of miles easily, and is controlled by weather patterns. However, at that point, smoke is smoke. Similar from a chemical fire or a forest fire. Especially if it has traveled such a long distance. So it could certainly contribute to making the air quality worse in Shanghai, but that should be only very temporary.

May Nyman

What is your hypothesis for an explanation of the explosion?

Edit: My first AMA question to be answered, AND reddit stuck up for me. Today was a good day.

...is it my cake day? No? Oh. Okay. Feels like it..

JabawaJackson
Thank you for using the word hypothesis, because that is indeed all we can do here. My biggest suspicion is the calcium carbide as a starting point, because it is so reactive with water. Water is everywhere--its in the air (i.e. relative humidity is a measure of how much water there is in the air). If the calcium carbide is accidentally exposed to water through a hot humid day in an uncontrolled

climate, a leak, a damaged container, it will start to react. acetylene is flammable and provides pressure, and could have been the source of the fuel for the fire.

That being said, it seems there should have been a spark that started the fire--human or instrument error: the same way forest fires start--a discarded cigarette or an electrical spark from a faulty wire or electrical cord.

May Nyman

Good morning professor.

On April 27, 2013 a fertilizer plant in West, Texas exploded when firefighters sprayed water onto a burning warehouse full of Ammoniom Nitrate. It killed my cousin, who was one of those firefighters. The Tianjin explosion seemed very similar to me. Were the same chemicals being stored in Tianjin, and did they cause this explosion? Did spraying water make it worse? Is this something that all firefighters should be aware of?

Mange-Tout
Another good question. ammonium nitrate was reported to be present in the warehouse. ammonium nitrate itself is not explosive nor reactive with water. But it is shock sensitive and can explode, when hit with a violent force like that of a powerful water stream, or some other chemical explosion nearby. It can also react with the some other released gas like the acetylene from the calcium carbide. It can also release ammonia which is dangerous.

May Nyman

Again, I emphasize, many chemicals combined, stored close together in a warehouse, is a recipe for disaster, and different reactions can trigger other reactions.

What's the risk of something like this happening in the US?

TeemL
I think after this explosion, all chemical warehouses in the U.S. and probably worldwide are having inspections, reviewing their storage rules, checking inventory, updating rules, etc. The good thing about such tragic and high profile events like this one is that it does cause society to stop and think and learn, to prevent such accidents happening in the future.

However, that being said, there was a chemical explosion at a warehouse in Shandong, only 10 days later, which we are yet to hear very much about.

May Nyman

Why would they have a large amount of cyanide there? Is cyanide or some version of it explosive?

hawkwings
cyanide is not really explosive by itself, and it can be neutralized (made harmless) with bleach. It is like used in mining: it bonds to all sorts of metals. see prior comment https://www.reddit.com/r/science/comments/3ibnjb/american_chemical_society_im_may_nyman_here_to/cufb7ad

it is also used to make other useful common chemicals such as polymers. I do not think it is stored for intentional use as a nerve gas.

May Nyman

Is it possible that Calcium Carbide granules in large quantities were near the fire and sprayed with water, creating acetylene gas?

If this was the case, would it have been able to produce the sheer volume of gas needed to

cause such a large explosion or was there a secondary reaction at work here?

I postulate that large amounts of Calcium carbide granules were superheated during the fire under pressure in their containers, and ruptured into the surrounding flood of water for fire suppression, causing hydrogen gas to be generated.

Something like this: Fire breaks out in non related chemicals, fire dept shows up to control fire. Fire suppression is inadequate, but floods the area with water trying to control flames. Sealed containers of calcium carbide are being heated by the flames. Those containers rupture into the surrounding area, possibly from the smaller primary explosion caused by acetylene production from water, this rips open the rest of the containers spilling superheated calcium carbide onto the flooded area immediately producing large volumes of hydrogen gas which detonates creating the larger second explosion.

Plausible?

AnalogHumanSentient
I agree entirely, that seems the most probable culprit, given what we know (and I always emphasize we do not know everything!)

see my other comment
https://www.reddit.com/r/science/comments/3ibnjb/american_chemical_society_im_may_nyman_here_to/cuf965i

May Nyman

Are there any measurements of sodium cyanide contamination that are concerning? What are the potential effects of a large release of sodium cyanide or any other form of cyanide into the environment?

MawcDrums
Yes, cyanide is causing great concern. The cyanide released in the explosion is likely destroyed. But we should consider the fact that cyanide loves to bind to metals that are present in building materials (calcium, aluminum and silicon in concrete) and in soils and rocks (iron, silicon, etc.). These substrates and media that are both natural and anthropogenic can retain the cyanide in the environment, and it can be remobilized with rain, humidity, physical disturbance, etc. So yes, this is something the officials should keep a close eye on.

May Nyman

Was it responsible to store such explosive chemicals so close to (if not in the middle of) a populated area? Or is it because stuff like this "never" happens? Could it happen in "western" countries, or are such storages more isolated for this exact reason (I know this might sound a bit off, and/or it might be outside your field of knowledge)?

JSDS999
It is absolutely not responsible for a populated area and large chemical warehouses to be in close proximity. In fact, of all the reports coming out of China, this seems to be the only confirmed violation, and it involved bribery of sorts. I refer you to this shocking report on NPR
http://www.npr.org/sections/parallels/2015/08/23/433495276/tianjin-tragedy-is-a-painful-reflection-of-how-china-works

May Nyman

If you, as a research professor in a Chemistry lab, was given authoirty to write the guidelines on how these chemicals are stored, what would you recommend to prevent something like this happening again?

Also, did the warehouse operators follow standard protocol when storaging these chemicals? If not, where did they go wrong?

Migmatite

Thank you for this question concerning storage. There is much that goes into regulations on storage; in particular, how much of the chemical you have and what reacts with what. In a research laboratory, we have much smaller amounts of chemicals than in a warehouse! but the general rules are the same. Here are a few. 1) everything should be stored in cool dry places with good ventilation so if volatile compounds get out, they escape the enclosure/building without contacting other chemicals. 2) chemicals that react together should be stored in separate cabinets, and the cabinets should be metal (non-flammable). Acids cannot be stored with bases. Oxidizers cannot be stored with flammable organics. 3) when possible, secondary containment is always recommended. meaning containers inside containers, so if a spill or leak happens it is still contained. 4) chemicals that react violently with water are some of the more serious. They should be stored with a dessicant that will absorb the atmospheric water.

what was violated? likely oxidizers stored with organics. The oxidizers are the nitrates: sodium, potassium, ammonium. the organics are the acetylene that is produced from the calcium carbide, probably some of the compressed gases, and other things like toluene diisocyanate.

Finally, even if rules are followed, accidents still can happen.

May Nyman

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Migmatite

In my opinion, cool and dry place is one of the most important operatives! Many accidents can be prevented just by observing these environmental conditions. It keeps volatile compounds from vaporizing, which prevents pressure buildup and accidental mixing of reactive chemicals. It keeps water away from chemicals that react with water. and furthermore, reaction rates are greatly slowed down by low temperatures. Enforcing this however, would be very expensive. It requires air-conditioning and humidity control of very large areas. It might require retrofitting old facilities. This cost would be reflected in the endproducts of the chemicals that are stored.

below more.... May Nyman

what goods will be affected by this break n the supply chain and when can non Chinese consumers expect to notice these effects?

gilfpound69

I suspect this will not be an issue. The chemical that we know of that were stored there are not specialty or rare. They are very common and there are many supplies and resources for these all over the world May Nyman

Please forgive me professor, but if *"but we don't know yet what caused it."* and *"what caused the explosion, how it could've been prevented, and which chemicals stored in the warehouse might have been the source of explosion. We also do not know why the fish are dying and why 'soap suds' are observed everywhere after it rained in Tianjin. We do not know what the short-term or long-term impact of this accident will be, or if the people living near the accident site or sites like it are in danger of future explosions"*

Then how can this be an "ask me anything" post about the August 12th explosion in Tianjin?

I am being serious, what kind of AMA in science is valid if you have no answers to any questions? Would not every answer you give be your own personal speculation at this point?

I have no qualms about theorizing or speculating, but this is an "AMA" from an expert not simply a post about the explosion, so there should be real answers. Am I wrong?

lostintransactions
Dear 'lostintransactions' Of course the entire puzzle of this explosion will take years to put together, maybe it will never be entirely explained if the Chinese officials are not forthcoming. So yes, much of this is educated guesses (hypotheses). I will offer you two explanations of my cautionary approach, which is prudent in a situation such as this. 1) this 'experiment' has never been done before. These chemicals (and more that we don't know about) have never been combined in these quantities and set on fire. Nor will it be replicated to understand. As a chemist with years of experience working with all types of chemicals, I put together reasonable assessments and predictions. That's what science is; even with all the control experiments in done, the data analyzed by multiple techniques, and experiments done in replicate, we can never say definitively and absolutely 'this is exactly what happened'. If we knew exactly, then we wouldn't need to do science any more.

May Nyman EDIT: 9:31 PT and I never put a #2...but I think #1 will suffice! May Nyman

What were the chemicals stored at that warehouse being used to make?

atlas_puppy
toluene diisocyanate is used to make polyurathane. calcium carbide is used in steel making and also to produce acetylene both calcium carbide and ammonium nitrate is used for fertilizer manufacturing the potassium and sodium nitrate are used in fireworks, rocket propellent, and also fertilizer. sodium cyanide is used extensive in mining and other applications that involve leaching or separation of metals. May Nyman

What preliminary results reported have baffled you when the explosion happened?

Yourponydied
what baffles me more than this incident is that an explosion happened in Shandong only 10 days later, also in a chemical warehouse!! Very little information is released about this, and it will be interesting to see how this story develops. Is there a link between the two events, or is it just coincidence?

May Nyman

Given your background in nuclear waste and water treatment - I would be interested to hear your assessment of the continually growing amount of waste water accumulating at the Fukushima Daiichi Nuclear Plant in Japan.

Specifically what can we do with all that waste water? Can it be used for fuel? Could it be filtered or treated to the point that it was safe?

Also regarding incidences such as Fukushima and Tianjin what you propose as a remedy or further measures to limit these types of industrial accidents in the future?

Thank you for your time. My brother goes to OSU - I will definitely be sharing this AMA with him!

RIPKingSteelo
I do love this question, and could provide answers, but that is off topic. But please know that there are many scientists and engineers working on this problem, and they are making great progress on the cleanup. go Beavers!

May Nyman