

A Brief History of Prime - Part 2

AN ABBREVIATED HISTORY OF
DECHLORINATORS AND DETOXIFIERS
AND THEIR EVOLUTION



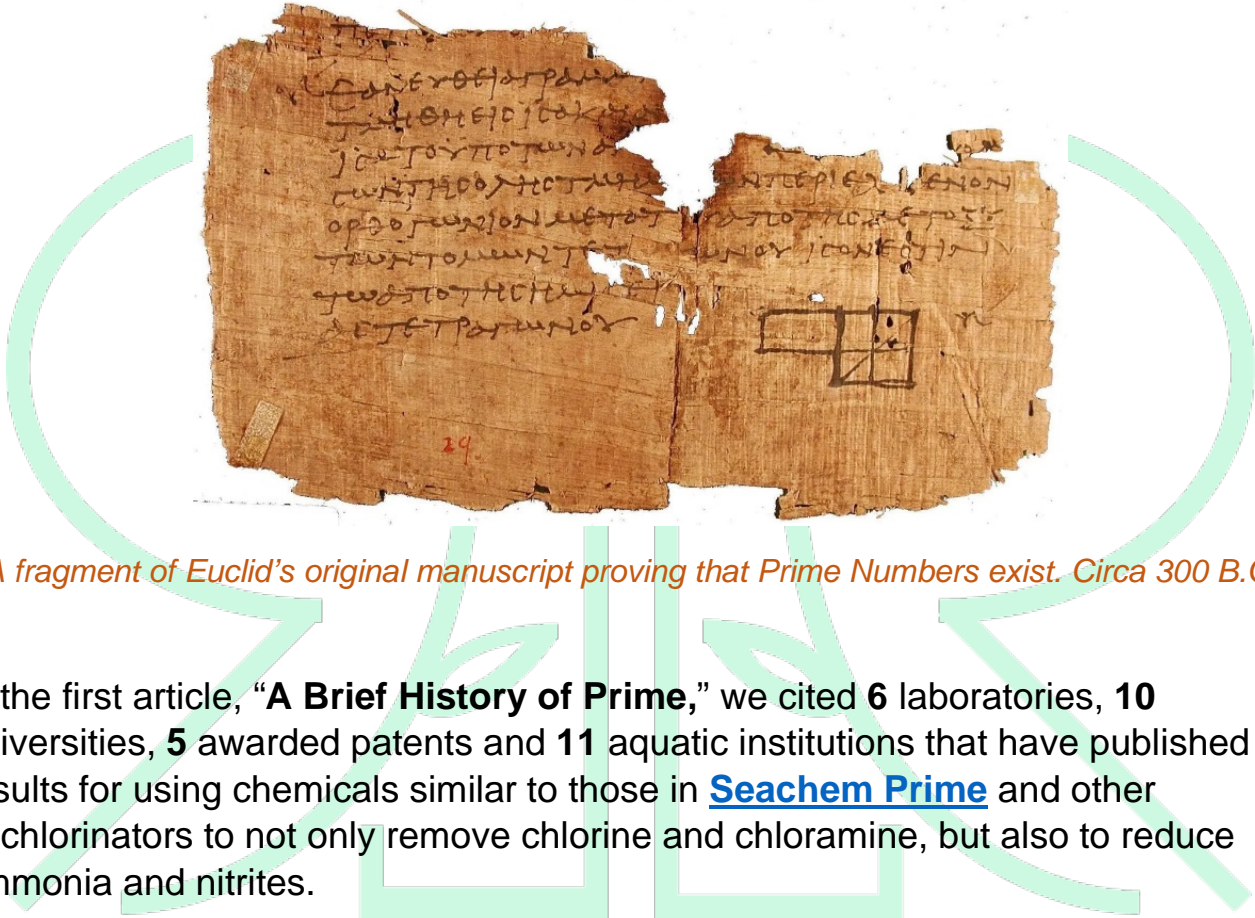
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A Brief History of Prime - Part 2

Proving Prime

(The Movie)

Go Directly to Video: [Proving Prime \(15-minute video\)](#)



A fragment of Euclid's original manuscript proving that Prime Numbers exist. Circa 300 B.C.

In the first article, “**A Brief History of Prime**,” we cited **6** laboratories, **10** universities, **5** awarded patents and **11** aquatic institutions that have published results for using chemicals similar to those in [Seachem Prime](#) and other dechlorinators to not only remove chlorine and chloramine, but also to reduce ammonia and nitrites.

The amount of 3rd party evidence for these chemicals' efficacy is simply overwhelming. Despite the volumes of citations in the article, we barely scratched the surface of citing reputable institutions from around the world who have published reports or studies on using these chemicals for detoxification. As they tested it, we added little commentary and simply allowed their reputations to speak for themselves.

In fact, my sole contribution was to perform a few informal tests for some reinforcement of conclusions on what proposed chemicals may likely be present

in Prime. But we asserted nothing about the efficacy it has on reducing ammonia or nitrite as there were too many unknowns. We left that to the cited institutions.

PRIME-L Screams



There are few topics in aquatic social media that spark more vitriol than if dechlorinators and detoxifiers actually remove ammonia. I've seen volumes of *highly speculative* equations, deep corporate mistrust, patent fraud accusations and even assertions of ineptitude or corruption on the part of the chemists who reviewed the patents for Amquel, Tetra, Fritz and others.

I have also seen dozens of amateurish, equative 'proofs' to the contrary as well as some poorly executed, ill-performed amateur tests. A balanced equation may be mathematically correct, but this is no indicator that this reaction is not taking place. Nor is a failed test improperly executed.

Choosing to ignore literally millions of facilities using this technology for ammonia detoxification for over a century is nothing more than typical, conspiracy theory. Conspiracy theories are borne from attention seeking, uneducated speculation and pollute virtually all walks but serve no one and simply add to the volumes of misinformation.

The vitriol against these known chemical reactions taking place in fisheries, laboratories, universities and hundreds of thousands of government facilities for over a century is little more than that. But once again, the above-mentioned fisheries, laboratories, universities and government facilities DID document their results. So, in our not wanting to add to the speculation, we

elected to present the verified works of others and simply illustrate the vast history behind how we got here.

Not Ready for Prime Time

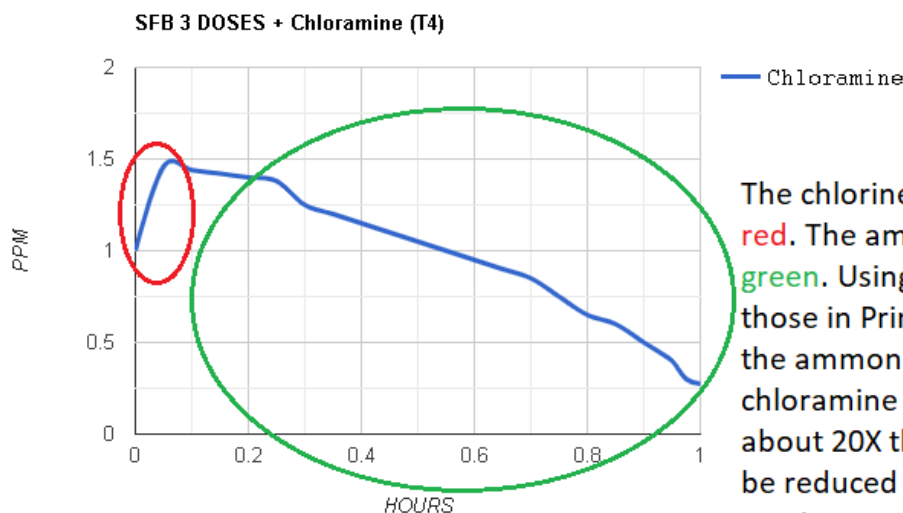


"The Not Ready for Prime Time Players" The original SNL cast in 1975

As we perused the forums to try to understand why people doubted this virtue with such intensity, perhaps this most common recurrent theme appeared:

"Testing for ammonia before and after adding Prime indicates no difference".

Considering the above quote and after seeing the chart below, we then realized that the problem is **TIME**:



This chart was created from data from the 1987 Kuhn patent awarded to Amquel.

The chlorine reaction is circled in red. The ammonia reaction in green. Using chemicals related to those in Prime, Kuhns found that the ammonia portion of chloramine reduction required about 20X the amount of time to be reduced as the chlorine portion.

In the J. Kuhns patent awarded jointly to the inventor and Amquel in 1987, there was a data table from which this interesting chart was created, displaying their findings on how Amquel in this case, affected chloramine.

Taking some semantic license for simplicity, chloramine may be somewhat inaccurately yet approximately described as *half chlorine and half ammonia*. In the chart above, Kuhns showed that Amquel reduced the *chlorine portion* of chloramine **far** more quickly than the *ammonia portion*.

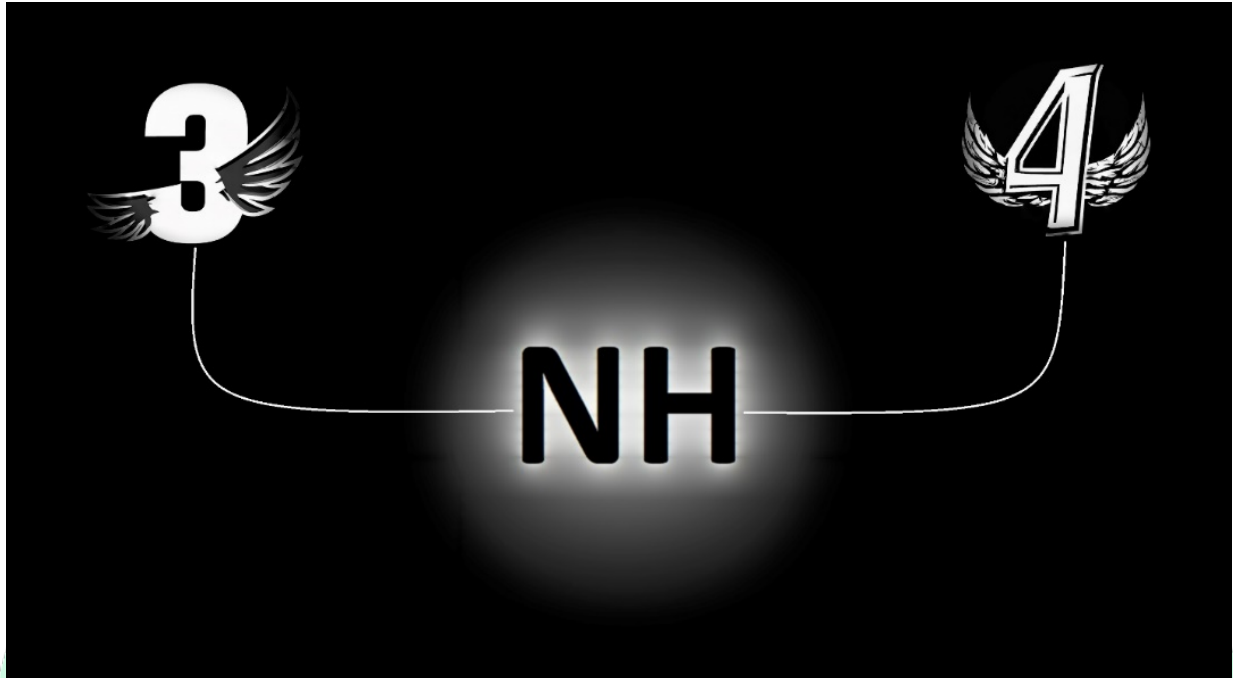
In fact, 20X more time was required for the latter.

Notice that when Amquel breaks down chloramine into chlorine and ammonia, the chlorine is reduced in about 3 minutes whereas the ammonia portion required over an hour to be reduced. The literal values of time here are unimportant as they are subject to the amounts used, the PPM of ammonia being reduced, the pH and the temperatures.

What is of value is *relative time*. As mentioned above, the ammonia portion of chloramine required 20X the amount of time as chlorine portion did for reduction.

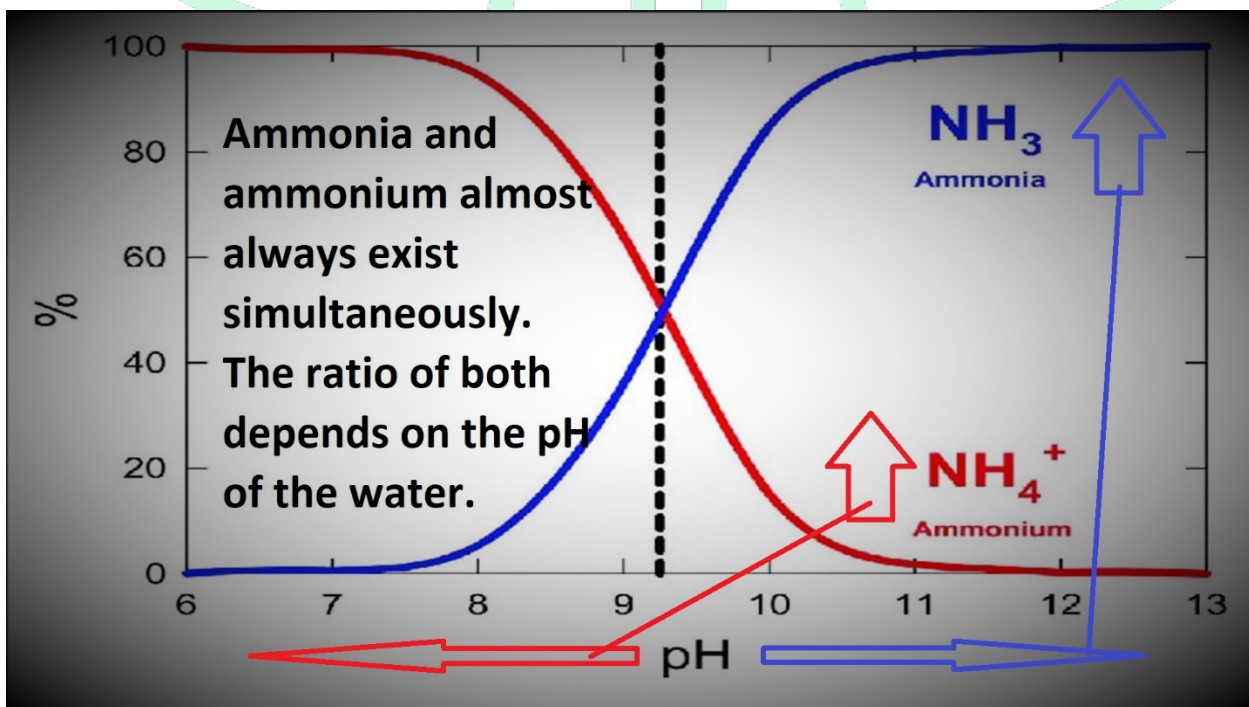
What follows is a prelude to a series of tests that were performed to demonstrate Prime removing ammonia. This is then followed by a series of tests to verify that the predicted byproducts created when Prime reduced ammonia are present AND tests for potential errors in the test themselves, also documented on video.

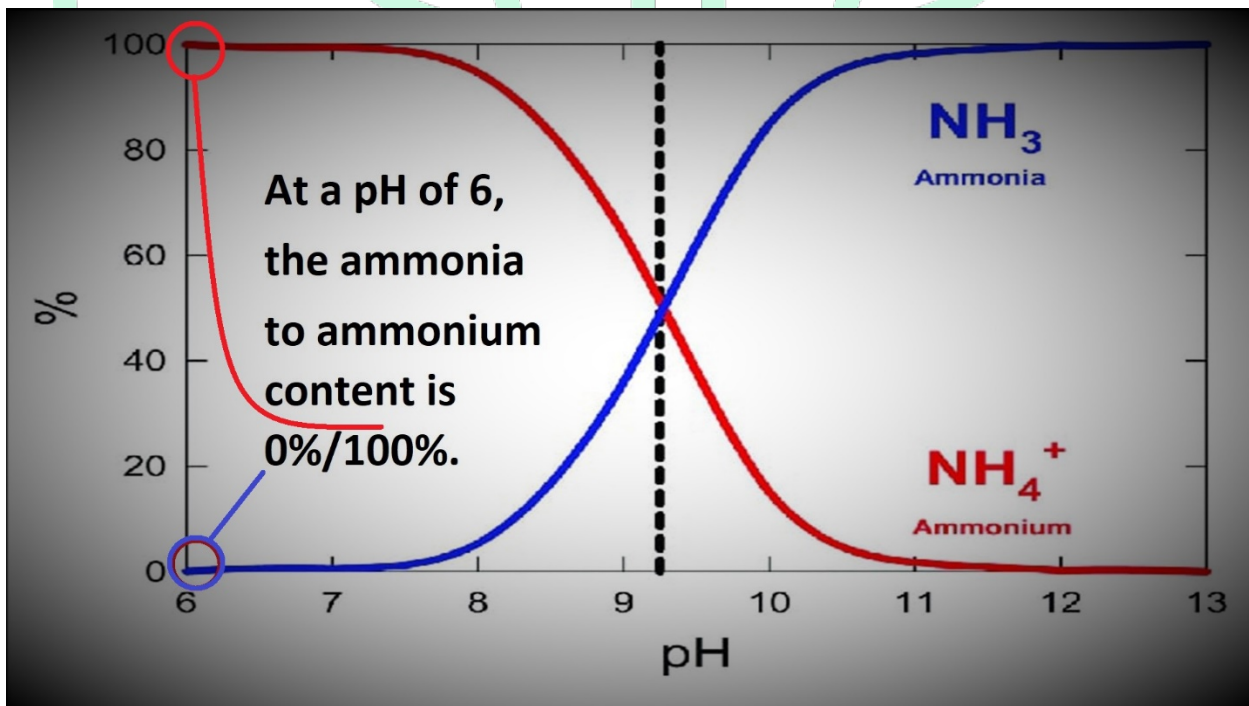
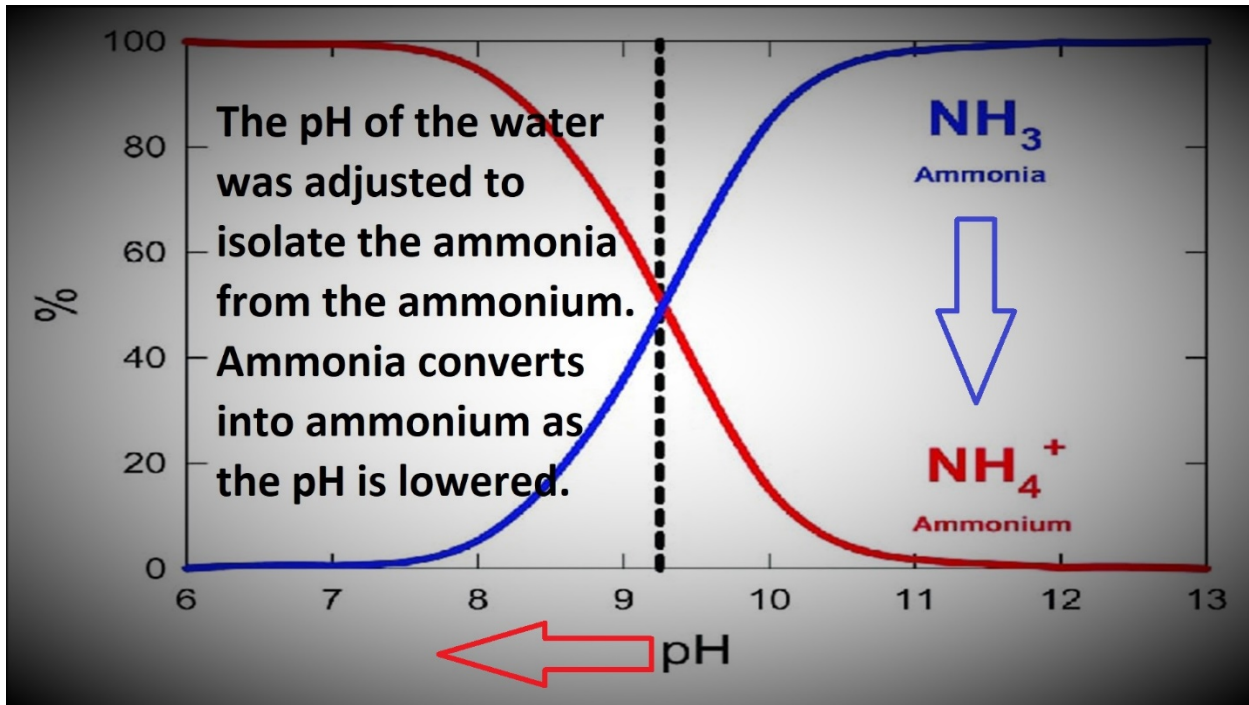
The complete reduction of the ammonia by Prime required 7-hours of footage to be shot. It includes explanatory slides to guide you through the metamorphosis and to highlight changes and errata. It was recorded in real time but was greatly accelerated to view the reaction in its entirety in only 15 minutes.

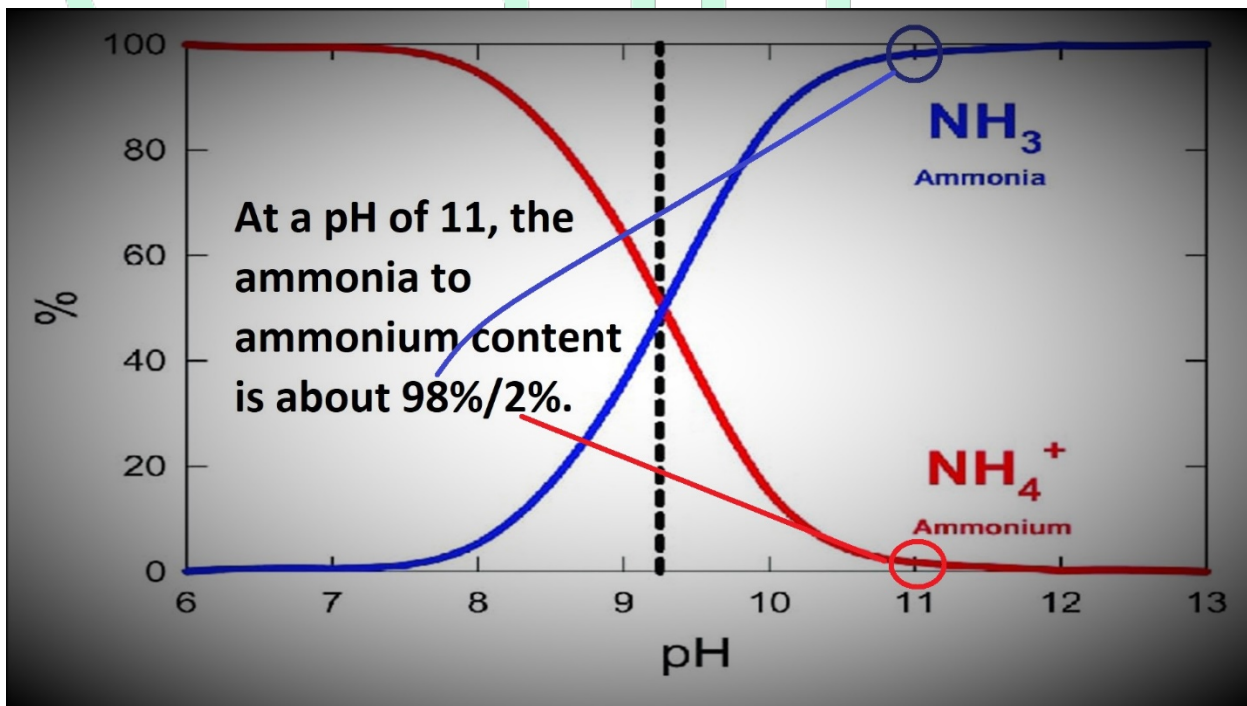
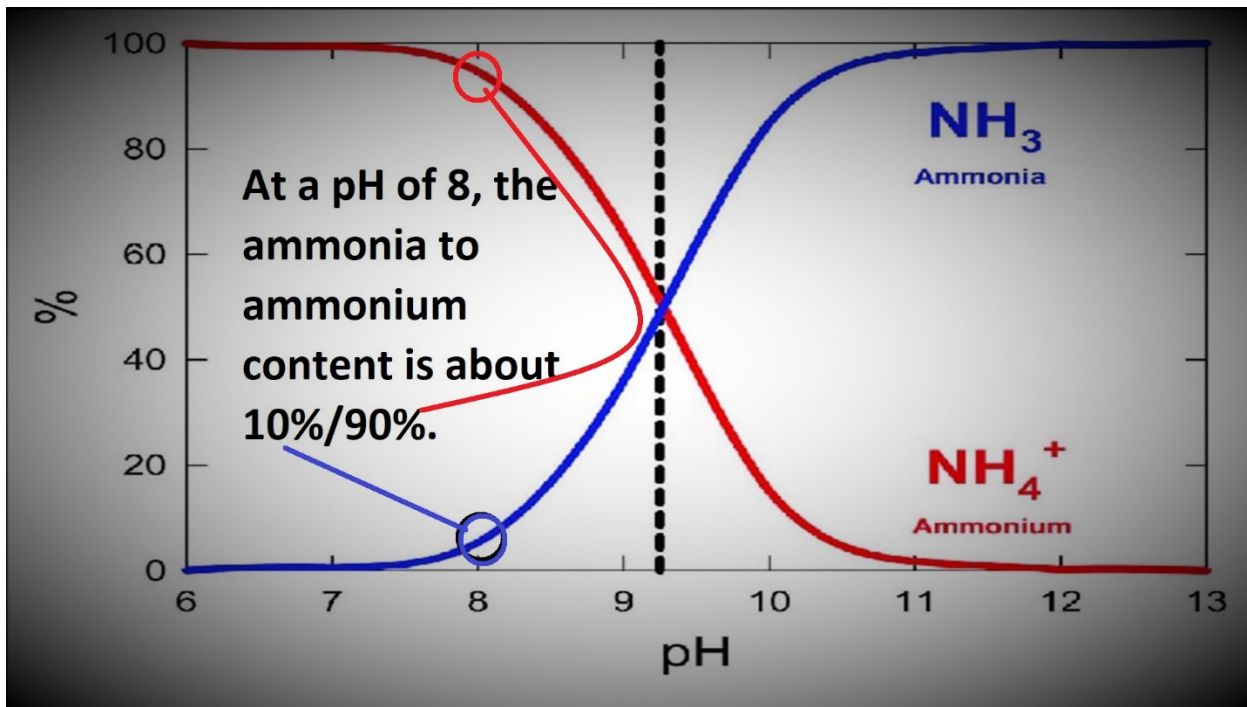


As ammonia and ammonium have vastly different effects on our fish, the first directive here was we needed to *isolate the ammonia from the ammonium*. Then we could see how Prime affects each individually in both degree and time.

This was achieved by creating three solutions of varying pH levels.

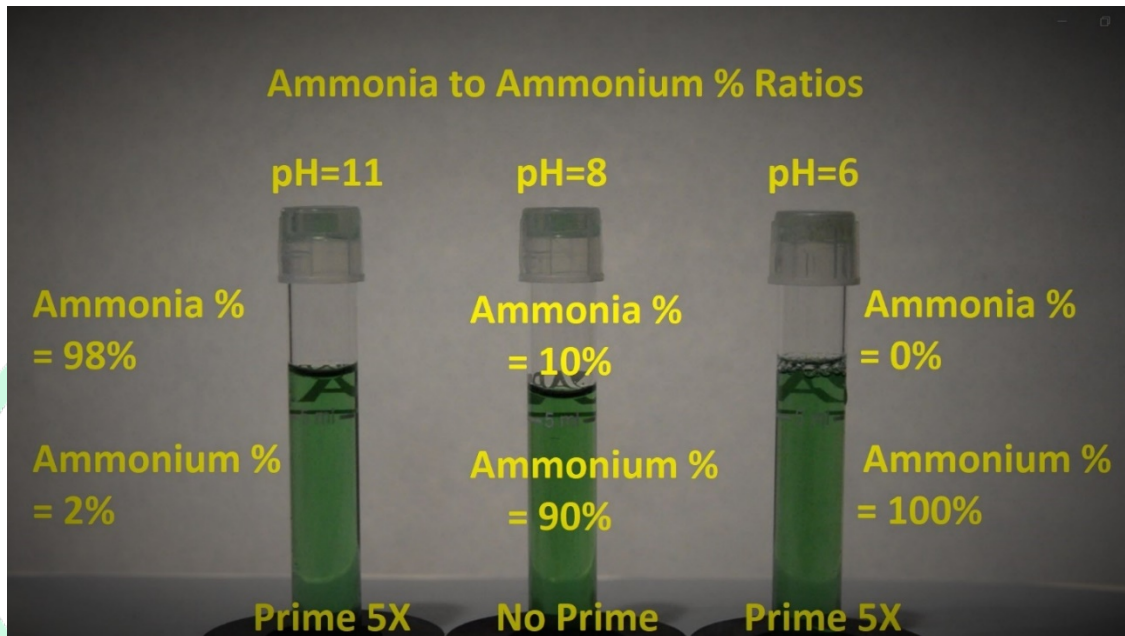






Three solutions were prepared; one at a pH of 6, another at the *default* pH of 8 (the natural pH of the water at this facility, used as aControl) and a third at a pH of 11.

Prime was administered to two of the three vials below. The vial at a pH of 8 (center) had none, the vials at a pH of 6 (right) and 11 (left) were treated with Prime's "Emergency Dose" (ED) of 5X the normal dose per 1PPM of desired reduction.



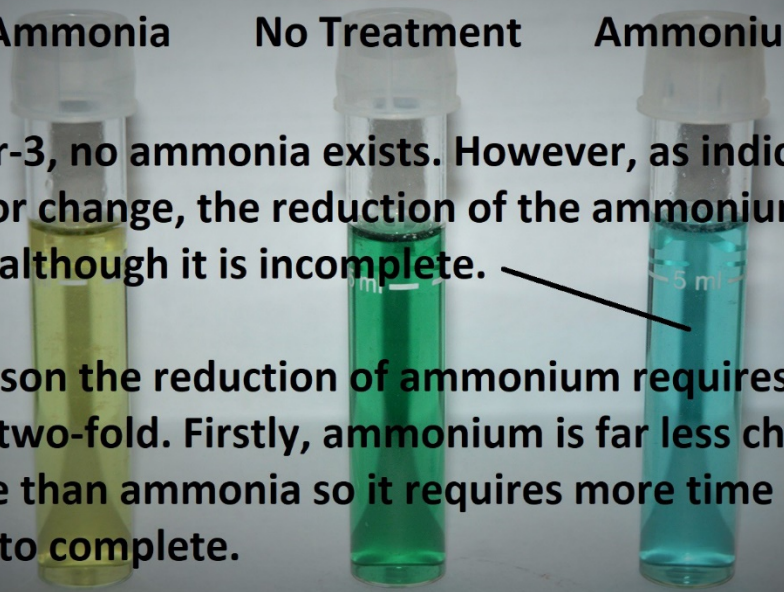
All three vials tested positive for 2PPM of ammonia. Prime 5X removed 100% of the *ammonia* in about 3 HOURS:



For the reason detailed below, however, Prime required 7 HOURS to remove the ammonium:

HOURL-3

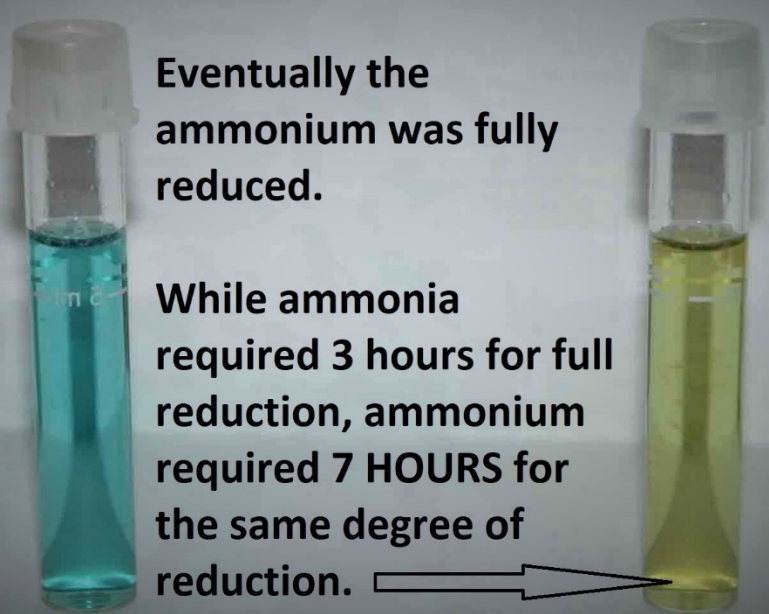
Ammonia No Treatment Ammonium



By Hour-3, no ammonia exists. However, as indicated by the color change, the reduction of the ammonium has begun, although it is incomplete.

The reason the reduction of ammonium requires more time is two-fold. Firstly, ammonium is far less chemically reactive than ammonia so it requires more time or energy to complete.

Ammonium Hour-3 Ammonium Hour-7



Eventually the ammonium was fully reduced.

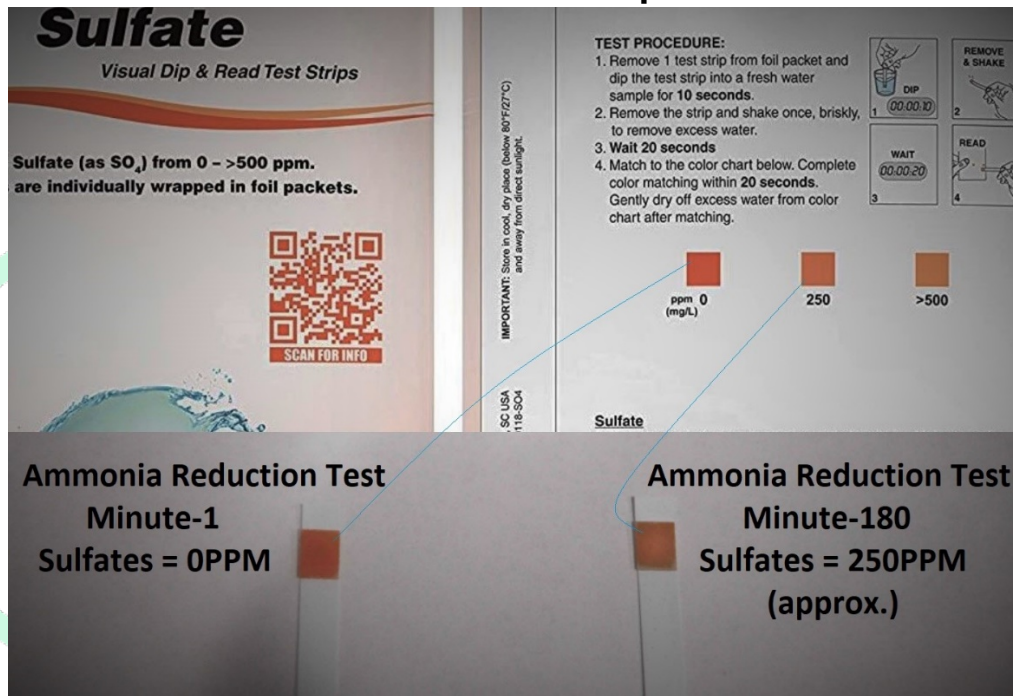
While ammonia required 3 hours for full reduction, ammonium required 7 HOURS for the same degree of reduction.

The difference in reduction time is that ammonium is less chemically active than ammonia and therefore requires more energy or time to reach the same level of reduction.

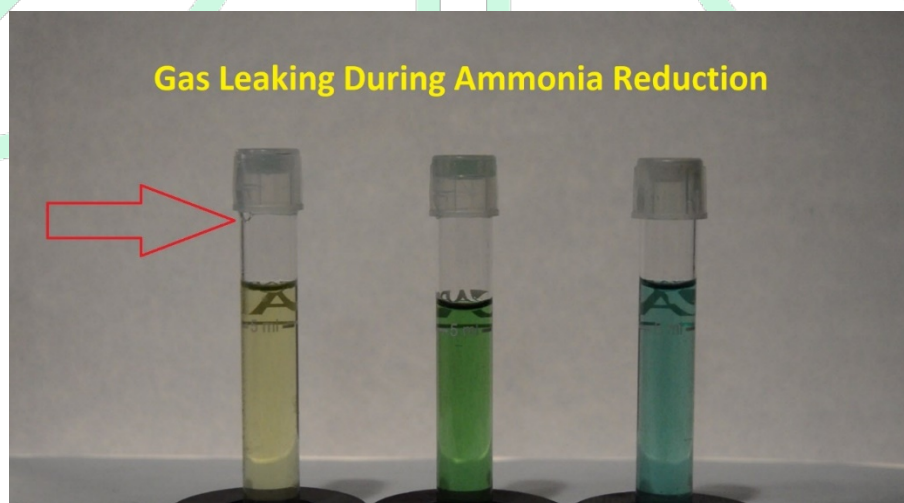
For either ammonia or ammonium to be reduced, it has to be converted to a more inert compound. As Prime *et al* are sulfur-based reducing agents, the ammonia and ammonium compounds should create sulfates.

In this case, the created sulfates are related to the Ammonium Sulfate *family*.

The vials treated with Prime now test positive for SULFATES:



During the three-hour reduction, we observed gas escaping, only from the Prime treated vials:



For the sake of simplicity, I'll take a bit more semantic license here. The reductive reaction taking place here results in the production of various gasses. Nitrogen,

Oxygen, Hydrogen and Sulfur Dioxide should be liberated in this process (it can take the form of nitrogen, hydrogen and oxygen *compounds in gaseous forms* as well but again for simplicity, I'll be referring to these as their parent elements and compound: N, O, H and SO₂).

It is not unexpected that ammonia or ammonium, being nitrogen/hydrogen compounds, would eventually break down into either *nitrogen* or hydrogen gasses or gaseous compounds composed of nitrogen and hydrogen. Oxygen may be liberated as well, either directly or in the form of water.

In “**A Brief History of Prime**”, we tested Prime for **sulfites**--the reason being, Seachem's only reference to their ingredients was “*Complexed Hydrosulfite Salts*.” We wanted to verify the presence of sulfites (along with sodium and formaldehyde) as these results very strongly suggested the same or similar chemicals were in use as we saw in the Amquel, Fritz and Tetra patents.



Wine makers need to test for sulfites during fermentation. However, the same test for sulfites will also detect sulfur dioxide gas (SO₂).

The gas escaping the vials above tell an important story. If the escaping gas contains sulfur dioxide (SO₂), it strongly suggests that a sulfate is decomposing.

To that end, by far the most the telling gas, *if present*, would be sulfur dioxide, as this directly indicates that Prime has reduced the ammonium sulfate salts *it previously tested positive for*, into escaping sulfur dioxide (SO₂) gasses.

The Prime treated vials now test positive for SO₂ gas:

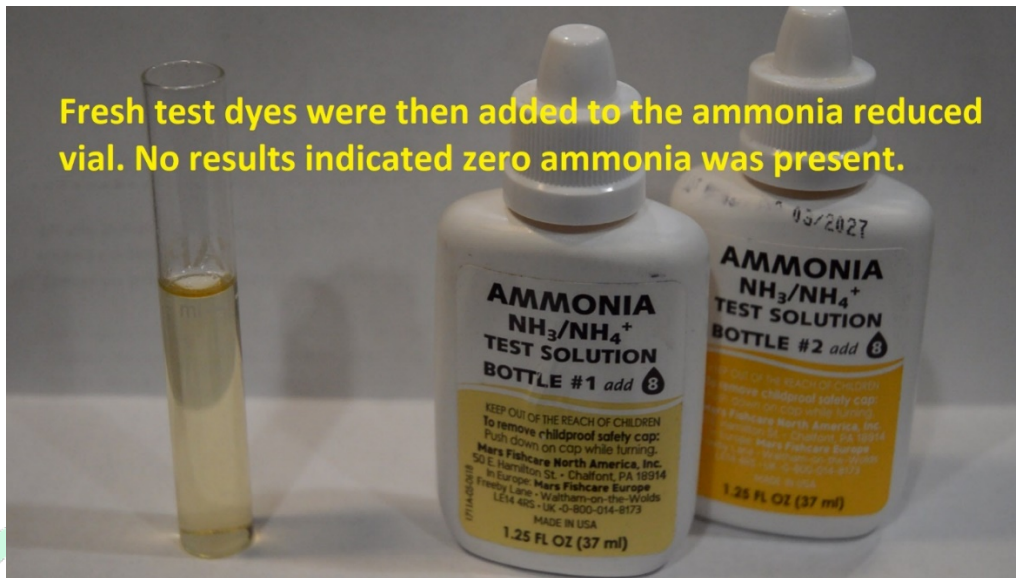


A wine maker's Sulfite Test will also detect Sulfur Dioxide (SO₂) gas.

With this final reaction in play, the ammonia, ammonium and sulfates are reduced to gasses which slowly escape the solution. The Prime treated vials now both test positive for sulfur dioxide gas.

Our next test for errors in the results was to verify that Prime did not reduce the tests dyes themselves, therefore giving us a false ammonia reduction reading. Here we reapplied the dyes to the ammonia vial to see if ANY ammonia is still present.

The results remained negative. No ammonia was present in the Prime reduced ammonia vial:



In an effort to be comprehensive, the now ammonia-free vial *with freshly added test dyes* was verified to be an active, viable ammonia test by simply adding fresh ammonia.



It almost immediately tested positive for ammonia:



T.A.N. Lines

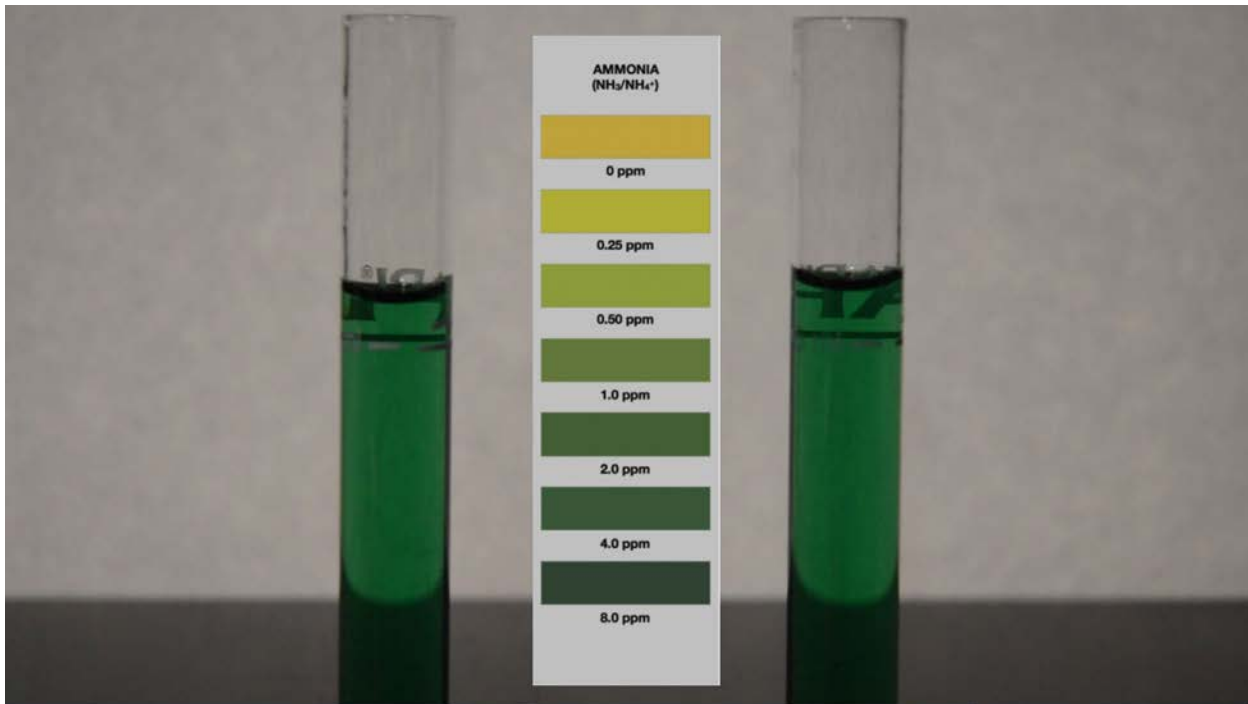
Our final verification test was to simply test Prime's reduction of the TOTAL ammonia and ammonium as is most commonly done in aquatic ammonia test kits. This is known as Total Ammonia Nitrogen or **T.A.N.**

This was performed to compare and illustrate if *the pH adjusted water samples* had any influence on the test results.

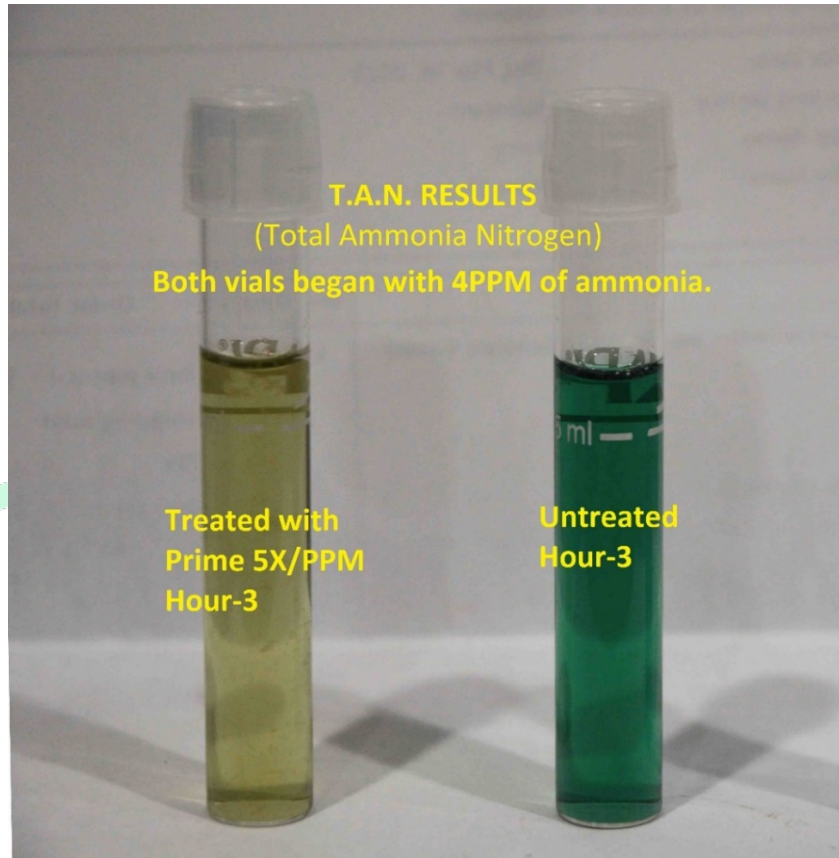
Below are identical vials with 4PPM of ammonia added. The left vial has been treated with Prime 5X (ED). The pH of both was 8.

No alteration of any kind to the water was done. The only difference here is the process was performed at +4°F higher than the others. This is because an

ammoniacal reduction time changes at a rate of about 20%/*F. In this case, this reduced the reduction time of the *ammonium* portion from 7 hours to 3 hours.



By Hour-3, 100% of the T.A.N. was reduced to zero:



P E R I O D I C T A B L E

In Summary...



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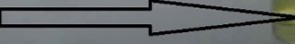
As a species, the sulfur-formaldehyde-based chemicals in common dechlorinators and detoxifiers like Prime are all closely related. Not surprisingly, the byproducts these create in the reduction process are also in the same family.



Ammonium Hour-3



Eventually the ammonium was fully reduced.

While ammonia required 3 hours for full reduction, ammonium required 7 HOURS for the same degree of reduction. 

Ammonium Hour-7



A PRIME VIDEO



[PROVING PRIME – THE VIDEO](#)

Above is live footage of the entire process of [Seachem Prime](#) eliminating all ammonia products from the water in real time.

You'll see ammonia and ammonium separately reduced *and* reduced together as T.A.N. (Total Ammonia Nitrogen), the latter being typical of what most water tests can present. In addition, after the main tests, you'll see verification footage as we confirm that Prime did not affect the test chemicals themselves but only the ammonia products.

A few of the charts in this article also appear in the video for consistency so there's some redundancy. A total of 7 HOURS of footage has been edited and accelerated so you may watch the experiment in its entirety in just 15 minutes.

It seems worth noting that not all the manufacturers' data was in concert with our findings. As it seems relevant, despite being of dubious importance, we added the following after this piece was written...

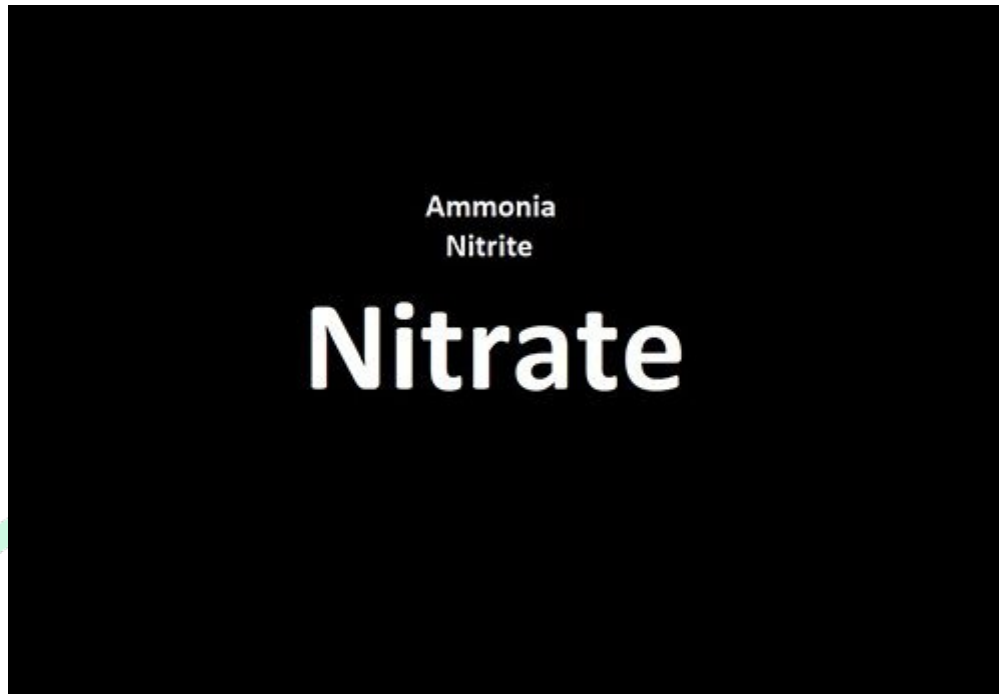
Just for Scale



Seachem claims that the normal dose of Prime will detoxify 1PPM of ammonia, nitrite and nitrate. It seems to be approximately linear such that the Emergency Dose (5X) applied to a 4PPM of ammonia sample if quadrupled, eventually tested at 0PPM of ammonia.

While we only tested for ammonia, the equations describing the reaction extrapolate to nitrite and nitrate at a similar rate. Said another way, it reduces ammonia, nitrite and nitrate as claimed at a rate of the Standard Dose; 1X per 1PPM.

As toxic levels of ammonia and nitrite begin at about 1PPM reaching up to very dangerous levels such as 4 or 5 PPM, the Prime ED dose or 5X Dose/PPM of reduction is highly significant.



Therefore, while a 5PPM reduction of ammonia and nitrite are effectively 100%, a 5PPM reduction of an 80PPM nitrate environment is a mere 6% improvement.

In other words, although it is true it reduces nitrates, it's relatively insignificant.

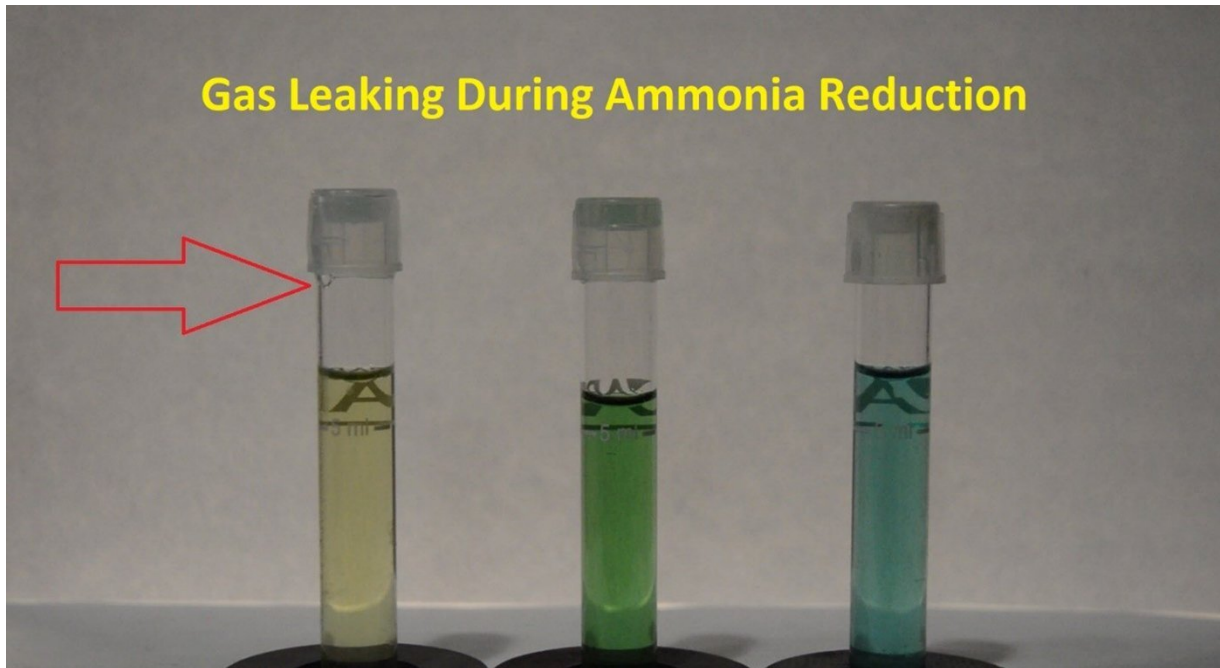
Doesn't Add Up



We found that with our testing and after reviewing the equations in the published patents, the manufacturers claims are not too distant from the real-world reality we measured.

The one glaring exception is the claim by Seachem that the detoxification treatment “reverts” in 48 hours.

Perhaps I’m missing something. To revisit a previous slide for a moment:



We observed gas leaking from the treated ammonia vials. Again, the equations suggest (as well as our samples testing positive for SO_2) this gas is predominantly SO_2 (sulfur dioxide) but it could also be any, or any combination of nitrogen, hydrogen, oxygen or gaseous compounds of those elements.

In fact, reversion should be impossible even if the gasses did not escape. The reduction process takes a high energy compound like NH_3 and reduces it to a lower energy compound like NH_4 . To 'revert, it would require addition energy to be applied.

I once tested this in an unsuccessful experiment with high power electrolysis. It was documented here in a somewhat whimsical article:

[Well, That Didn't Work...](#)

But it's much simpler than this. If these reactions cause ammonia, nitrates and nitrites to release gasses, they are GONE. The chemicals required to revert back to higher energy ammonia in this case have literally broken down and are no longer in the solution. Reversion should be impossible.

This was and remains the only glaring conflict in our findings with the manufacturer's claims. While it has little to no bearing on our use of it as intended, we thought we'd highlight the only conflicting data we found with Seachem's claims in order to be comprehensive.

"GoPro or Go Home" - Debunking Conspiracy Theories

As of 2022, according to the FDA, the CDC, the EPA and CISA, in the United States alone, 1,100,000 farms use Sodium Bisulfite to detoxify ammonia before it can enter into water tables.

Also in the US, about 200,000 wastewater treatment facilities treat their water with Sodium Bisulfite to detoxify ammonia before it enters into runoffs that could contaminate oceans, rivers, lakes and streams.

If the Kitty litter that you use advertises that it "controls ammonia odor", chances are it uses Sodium Bisulfite to accomplish this.

This science is far from new. Since its introduction by BASF in 1904, Sodium Bisulfite and its related compounds have been used to detoxify ammonia to protect livestock and aquatic wildlife. Farms, wastewater plants, fish hatcheries, trout raceways, aquatic trade shows and more use this chemical or its chemical family for ammonia detoxification. You can read some of this data through many of the links in the previous section.

Addenda

[1] *Sodium Dithionite reduces stable iron to an unstable form. The unstable form is water soluble. It is also bioavailable for plants. This suggests a dose of Prime® will temporarily convert all of the iron in the water volume to bioavailable iron.*

From a Hach Industries US Patent:

Stain and rust removing composition.

US3183191A

United States

Inventor Clifford C Hach Current Assignee Hach Co

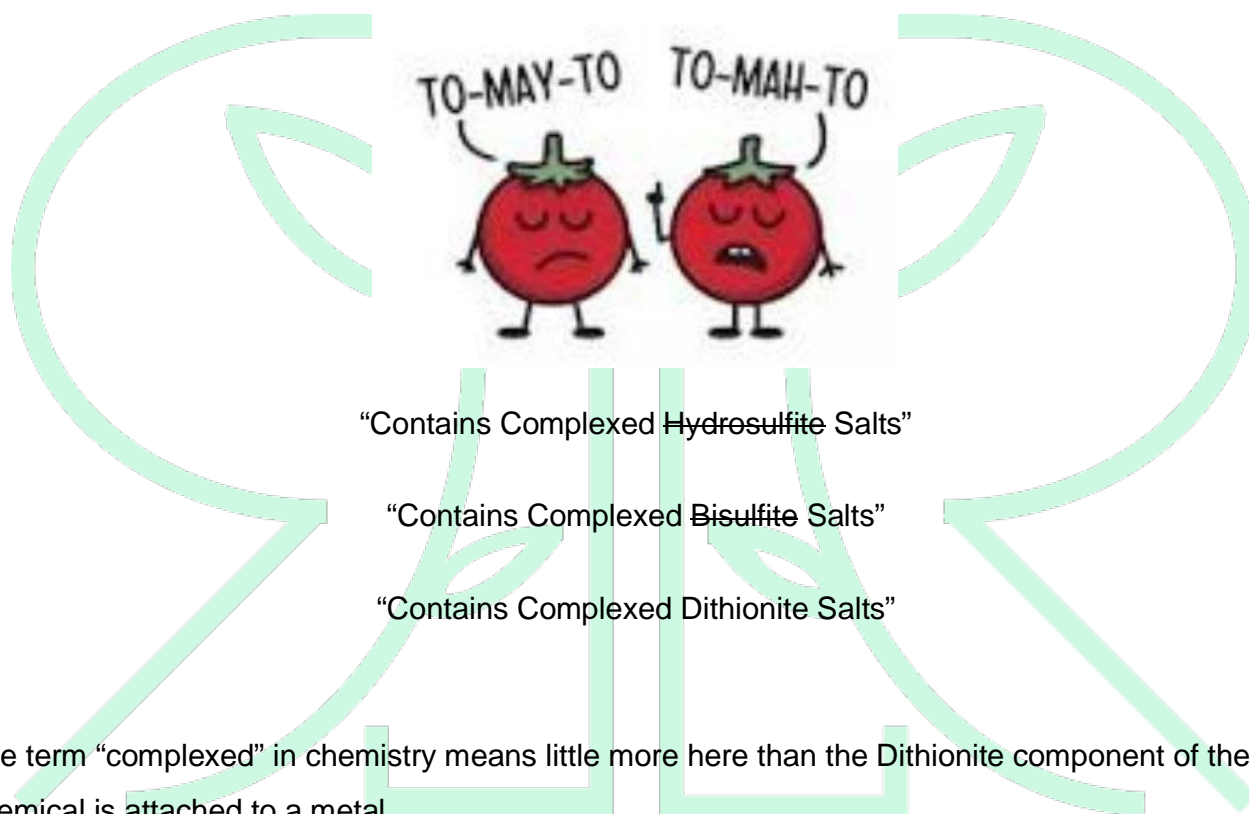
"...the reaction the sodium hydrosulfite is effective to reduce the insoluble rust (ferric iron oxide) to a lower iron oxide which then reacts with the bisulfite and is changed to the more soluble form of ferrous sulfite. The metabisulfites are similar in action to the bisulfites and have

been regarded as the hydrate of bisulfites, and the reaction given above would be the same when a metabisulfite is employed."

Download PDF Here: [Stain and rust removing composition](#) - Hach Chemical Co, 1965

*A chronology of human understanding of the nitrogen cycle†

James N. Galloway Allison M. Leach Albert Bleeker and Jan Willem Erisman, Published: 05 July 2013 <https://doi.org/10.1098/rstb.2013.0120>



The term “complexed” in chemistry means little more here than the Dithionite component of the chemical is attached to a metal.

In this case, that metal is Sodium.

TABLE 1. Chemical Required to Remove 1.5 mg/l Total Chlorine Residual in 10 mgd Flow

Chemical	Form	Purity %	Application Factor	Chemical Dosage lb/d/mgd	Chemical Required lb/d
Sulfur dioxide	gas/liquid	100.0	1.000	12.51	125.1
Sodium metabisulfite	anhydrous	95.0	1.340	17.65	176.5
Sodium sulfite	crystal	96.5	1.775	23.01	230.1
Sodium thiosulfate	pentahydrate	98.0	3.493	44.59	445.9
Sodium metabisulfite	38% solution	34.7	1.340	48.31	483.1
Sodium sulfite	15% solution	15.0	1.775	148.04	1,480.4
Sodium thiosulfate	30% solution	30.0	2.225	92.78	927.8

As mentioned above, Sodium Dithionite was designed by BASF to remove rust stains (iron oxide) from paper.



This common rust remover has both Sodium Dithionite and Sodium Metabisulfite being a slight variant when Sodium Dithionite is dissolved in water, yet both will exist simultaneously in water (aqueous). Both also reduce iron.

The product above is just one of many that employ Sodium Dithionite and/or Sodium Metabisulfite. Sodium Metabisulfite being a slight variant when Sodium

Dithionite is dissolved in water, yet both will exist simultaneously in water (aqueous). Both also reduce iron.

However, this ability is not exclusive to iron. The ability to dissolve (reduce) rust suggests that Sodium Dithionite should also reduce other metals in the water so long as they are less reactive than Sodium...and almost all metals are.



In fact, the EPA lists the following heavy metals as reduced to “non-toxic or less toxic compounds” in wastewater by Sodium Dithionite where concentrations of heavy metals can be at highly toxic levels. Being a far milder case, it would not be an unreasonable extrapolation to conclude the same would be reduced in the aquarium environment:

Element	Primary Oxidation States in the Environment	Potential In Situ Precipitates ¹
Antimony	+3, +5	Sulfide
Arsenic	+3, +5	Typically requires co-precipitation ²
Barium	+2	Sulfate
Boron	+3	Typically requires co-precipitation
Cadmium	+2	Carbonate, phosphate, sulfide
Chromium	+3, +6	Hydroxide
Copper	+1, +2	Hydroxide, phosphate, sulfide
Iron	+2, +3	Hydroxide, carbonate, sulfide

Lead	+2	Carbonate, phosphate, sulfide
Manganese	+2, +3, +4	Oxide, carbonate, sulfide
Mercury	0, +1, +2	Sulfide
Molybdenum	+4, +5, +6	Sulfide
Nickel	+2	Hydroxide, sulfide
Plutonium	+4, +6	Oxide, phosphate
Selenium	-2, 0, +4, +6	Elemental, mixed iron-Se
Thallium	+1, +3	Hydroxide, carbonate, sulfide
Uranium	+4, +6	Oxide, phosphate
Vanadium	+3, +4, +5	Typically requires co-precipitation
Zinc	+2	Hydroxide, carbonate, sulfide

Table 1. Major events in the history of nitrogen.

Year	Event	
10 000–8000 BC	Domestication of plants and animals began	28
1563	Bernard Palissy advocated for the use of fertilizers	
1675	John Evelyn noted that rainwater contained 'celestial nitre'	
1699	John Woodward proved that what is dissolved in water is essential for plant growth	
1772	Daniel Rutherford discovered nitrogen; he receives credit because he published first	
1772	Carl Scheele, Henry Cavendish, Joseph Priestley, and others concurrently and independently discovered nitrogen	
1774	Joseph Priestley discovered nitrous oxide and ammonia	
1785	C. L. Berthollet determined that ammonia is made up of nitrogen and hydrogen	
1785	Henry Cavendish discovered HNO ₃	
1787	William Austin was one of the first to try to synthesize ammonia	
1790	Jean Antoine Claude Chaptal officially named nitrogen	
1823	Johann Wolfgang Döbereiner produced ammonia using a platinum catalyst	
1824	Joseph Fourier was one of the first to describe the greenhouse effect	
1836	Jean-Baptiste Boussingault identified nitrogen as a nutrient for plants	
1838	Jean-Baptiste Boussingault determined legumes could fix their own nitrogen, but he did not know how	
1840	Justus von Liebig advocated the addition of certain nutrients to the soil for plant growth, making him the founder of the artificial fertilizer industry	
1843	John Bennet Lawes and Joseph Henry Gilbert confirmed that nitrogen helps plants grow and that nitrogen comes from sources other than precipitation	
1845	M. Ducros determined that hail contained nitric acid, and called it 'pluie acide' or acid rain	
1852	Robert Angus Smith connected the presence of acid rain with human activities	
1856	Jules Reiset recognized that decaying matter releases nitrogen, providing the basis for the nitrogen cycle	
1877	Theophile Schloesing and Achille Müntz discover the process of nitrification	
1880	Herman Hellriegel and Hermann Wilfarth discovered the process of biological nitrogen fixation	
1886	Ulysse Gayon and Gabriel Dupetit discovered the process of denitrification	
1896	The greenhouse effect was more fully quantified by Svante Arrhenius	
1909	Fritz Haber synthesized ammonia from nitrogen and hydrogen gas	
1913	Carl Bosch performed Haber's ammonia synthesis on an industrial scale	
1947	It was reported that many lakes in the US and Europe were undergoing eutrophication	

1950s	Through the mid-1950s, N additions to coastal ecosystems were incorrectly considered a benefit to productivity
1950s	Concern about coastal eutrophication was first noted in Moriches Bay, New York
1953	Haagen-Smit <i>et al.</i> were some of the first to document ground-level ozone formation and the role of NO _x in its formation
1960s	There existed 9 reported 'dead zones' in coastal areas
1968	Svante Oden was the first to link NO _x emissions from one country (the UK) to freshwater acidification in another country (Sweden)
1970s	On a global scale, the rate of N _r creation by the Haber-Bosch process surpassed natural N fixation
1970	Paul Crutzen quantified the role of nitrogen oxides in ozone depletion
1972	Sweden made a presentation to the UN Conference on the Human Environment, which started efforts to better understand acidification
1972	Likens <i>et al.</i> demonstrated that nitric acid formed from fossil fuel combustion leads to acid rain
1985	The greenhouse effect was further quantified by Ramanathan <i>et al.</i> , including the contributions of N ₂ O
1985	Stratospheric ozone depletion was discovered by scientists from the British Antarctic Survey
1986	Anammox (anaerobic ammonium oxidation) was first observed in a Dutch wastewater treatment facility
1989	John Aber <i>et al.</i> demonstrated that excess N deposition to forests not only causes damage to the forest, but it can also make forests a net source of N
2003	The concept of the nitrogen cascade was proposed
2009	Ravishankara <i>et al.</i> discovered that N ₂ O emissions are currently the most important ozone-depleting substance
2011	there are 540 reported dead zones on a global basis
	The European Nitrogen Assessment provides the first integrated and comprehensive look at N use in Europe