

The Science of Nitrogen Stabilizers and Additives

2019 South Dakota CCA Conference

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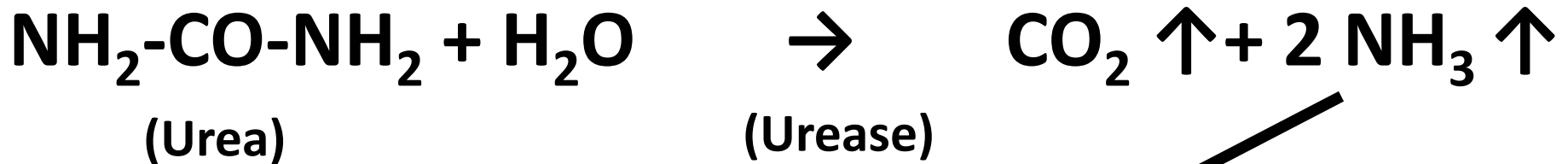
Nitrogen

Focus on two processes-

**Ammonia volatilization from urea
caused by the action of urease enzyme**

**Nitrification- bacterial oxidation of
ammonium to nitrate**

Urea is subject to ammonia volatilization if placed on or near the surface.



pH > 7 drives NH₃ towards gas

pH < 7 drives NH₃ to NH₄⁺

Yield for side-dressed no-till corn in Hardin County, KY. (From Schwab and Murdock, 2009)

Treatment	Yield, bushels per acre
Check (50 lb N/acre preplant N only)	117 d*
Urea	158 c
Urea + Agrotain	201 b
SuperU	201 b
UAN	150 c
UAN + Agrotain	179 bc
UAN + Agrotain Plus	175 bc
Ammonium nitrate	239 a

Ammonia volatilization from surface and incorporated urea at various depths-

Rochette et al., 2014, J. Env. Q.

Period-hours	Surface (% loss)	1 inch (% loss)	2 inch (% loss)	3 inch (% loss)
0-166	2.2	18.4	2.6	0.0
167-334	29.5	15.2	3.2	0.1
335-502	15.2	3.8	1.8	0.5
503-598	3.4	1.0	1.0	0.0
Total	50.3	38.4	8.6	0.4

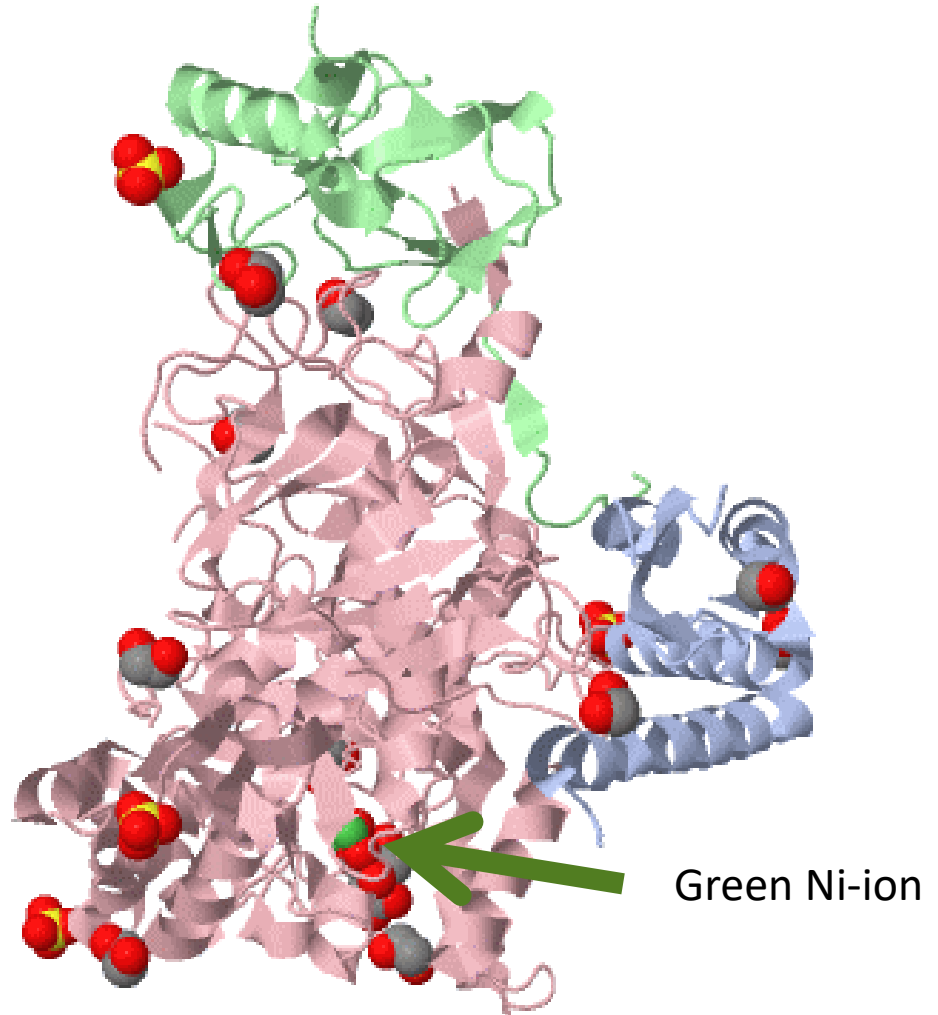
Slightly acid silt loam soil

Urease enzyme

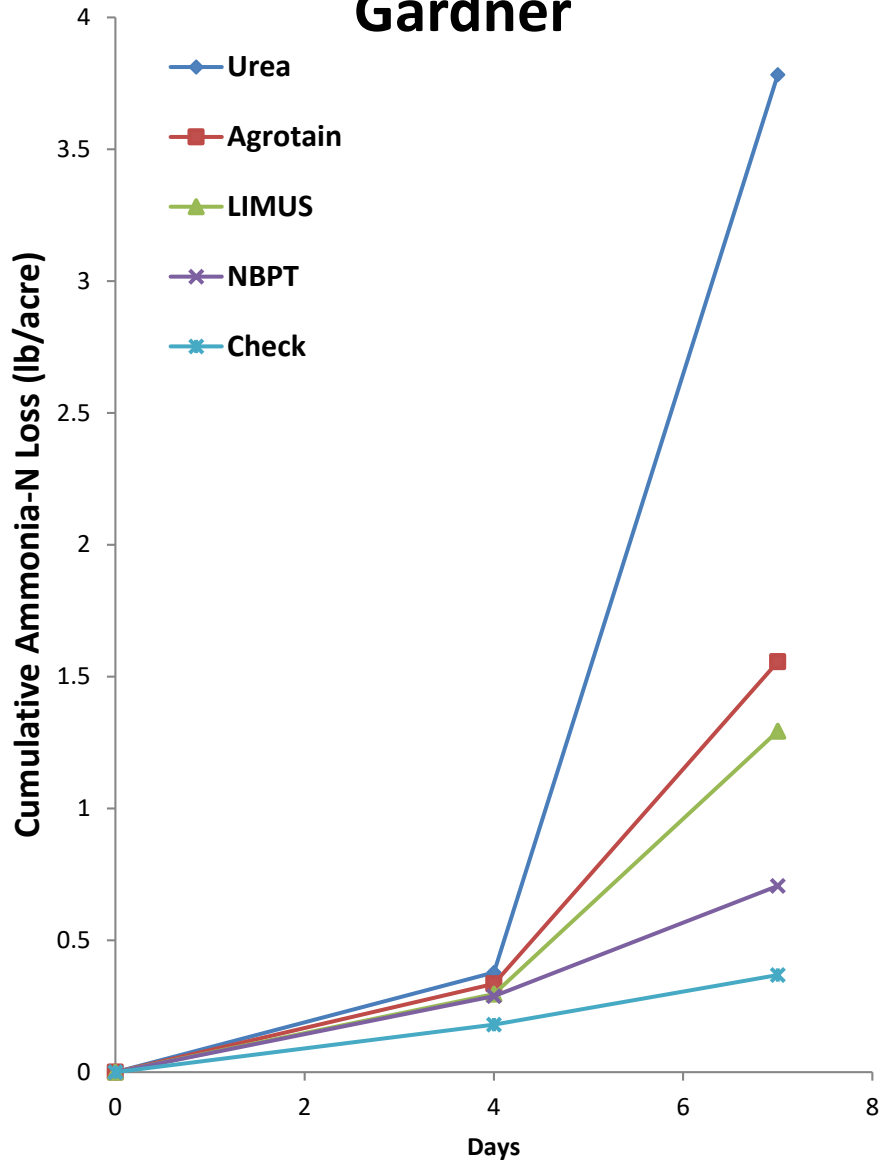
<http://www.proteopedia.org/wiki/index.php/Urease>

Urease is produced by plants, bacteria, fungi, invertebrates and is one of the last compounds to degrade after the organism dies.

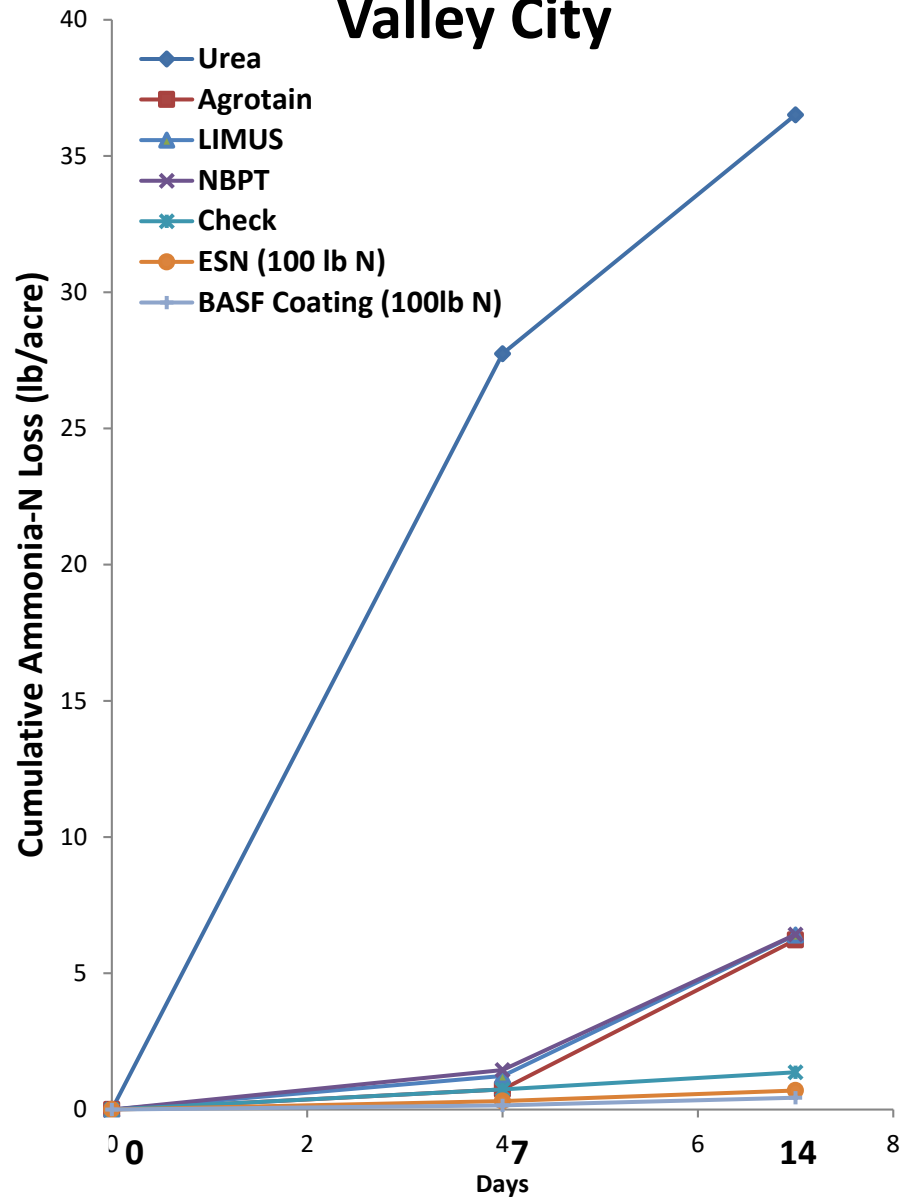
‘The Zombie Enzyme’



Gardner



Valley City

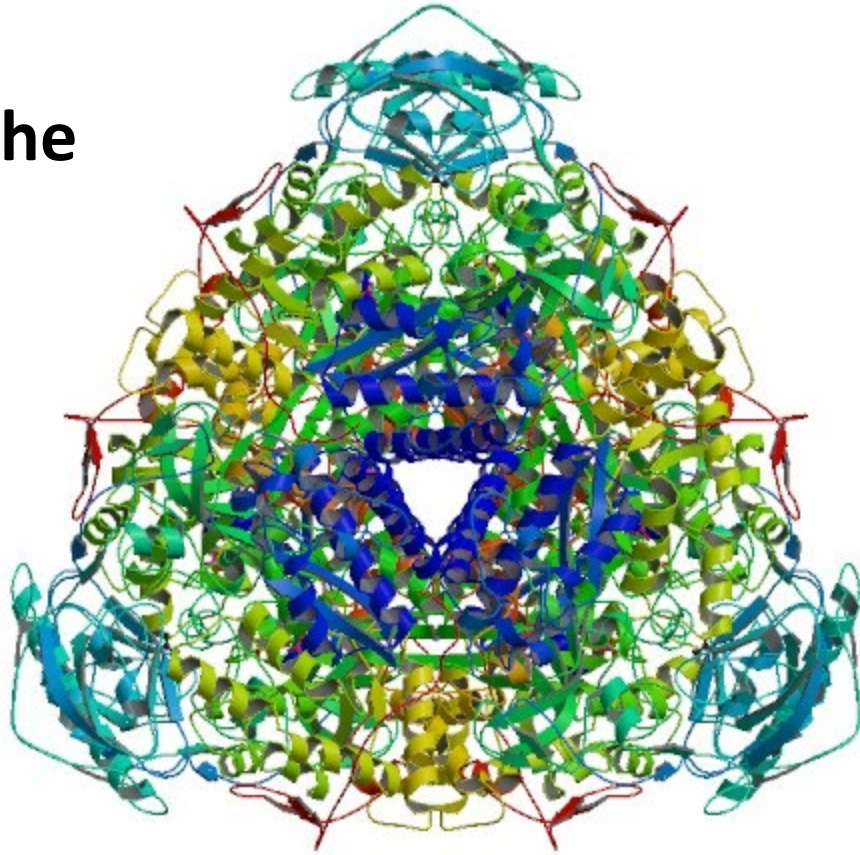
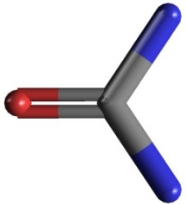


Ammonia volatility from surface/near surface application increases with

Residue

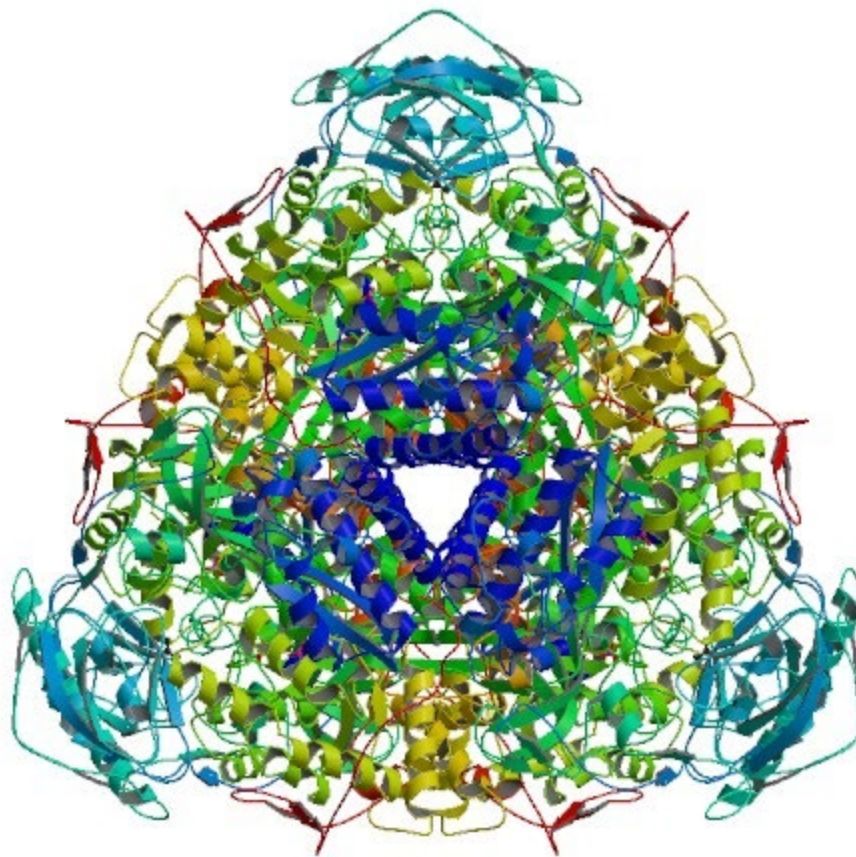
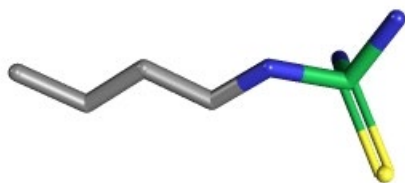
Soil pH

**Urea is acted on in the
'keyhole' structure of the
urease enzyme**



N-(N-Butyl)thiophosphoric triamide

Has same tri-atom configuration as urea



NPPT has same tri-atom structure, but tail has an additional C group.

NBPT (Agrotain and siblings)

and

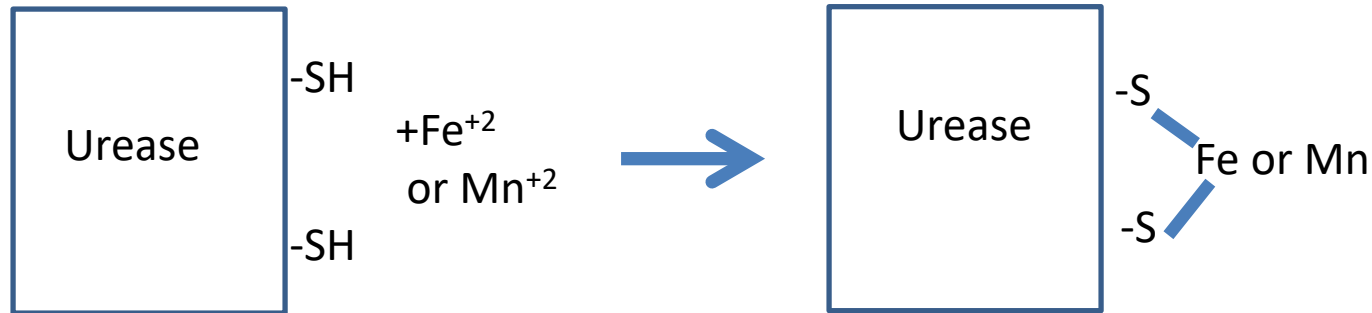
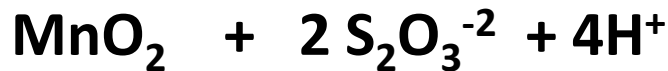
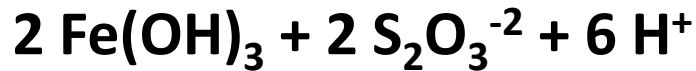
NPPT (Limus)

are the only chemistries known to inhibit urease activity for days (usually about 10) (Agrotain Ultra- 26.7% NBPT, use rate 3 qt/t of urea AU density is 8.9 lb/gal [6.7 lb NBPT/T])

Ammonium thiosulfate has measureable short-term activity, but NBPT is much better.

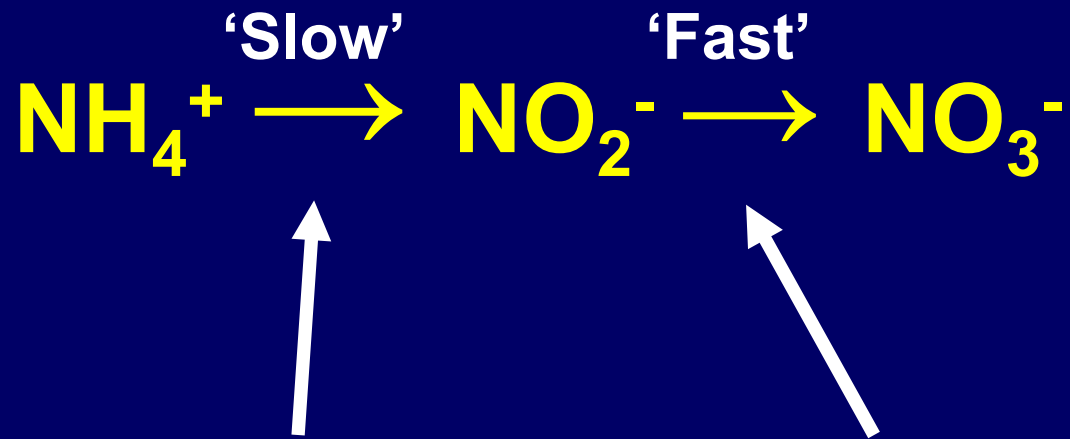
ATS does not directly affect the urease enzyme and is only indirectly inhibiting after interacting with soil-

Thiosulfate reacts rapidly and abiotically with soil, forming tetrathionate and liberating Fe²⁺ and Mn²⁺



Adapted from Goos, 1987, NC Ext. Ind. Soil Fertility Conf.

Nitrification-



Nitrosomonas spp

Nitrobacter spp

Factors influencing rate of transformation-

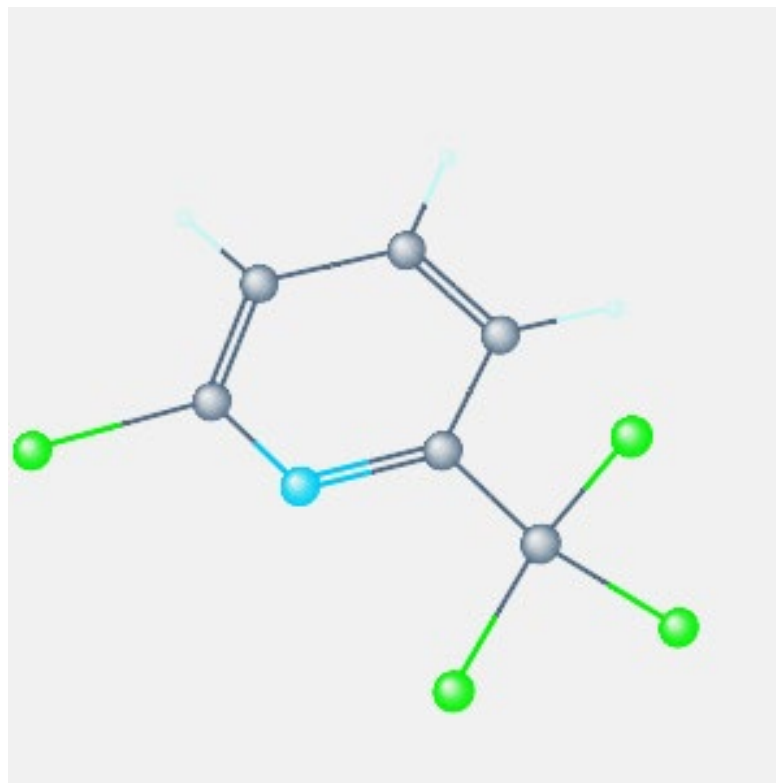
Moisture (moist, not saturated)

Temperature- max ~ 80F, min 32F

pH- favored by pH > 7 slowed by pH < 6

Nitrapyrin-

2-Chloro-6-(trichloromethyl)pyridine (N-Serve[®]/Instinct[®])



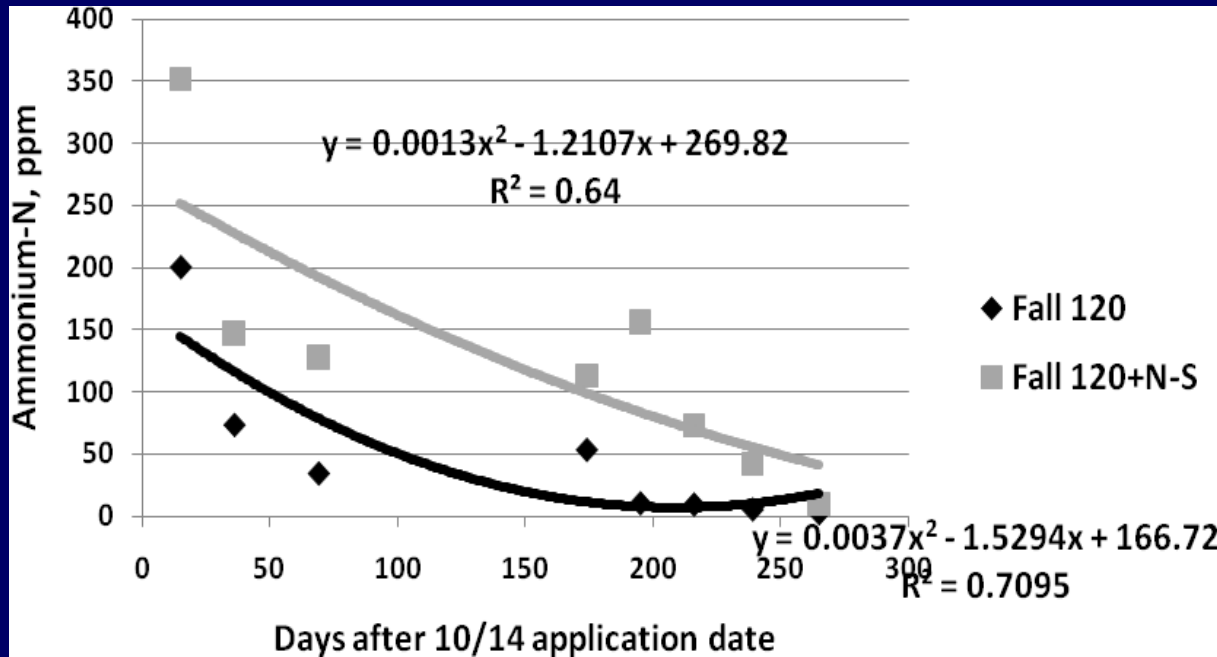
From PubChem

<https://pubchem.ncbi.nlm.nih.gov/compound/nitrapyrin#section=3D-Conformer>

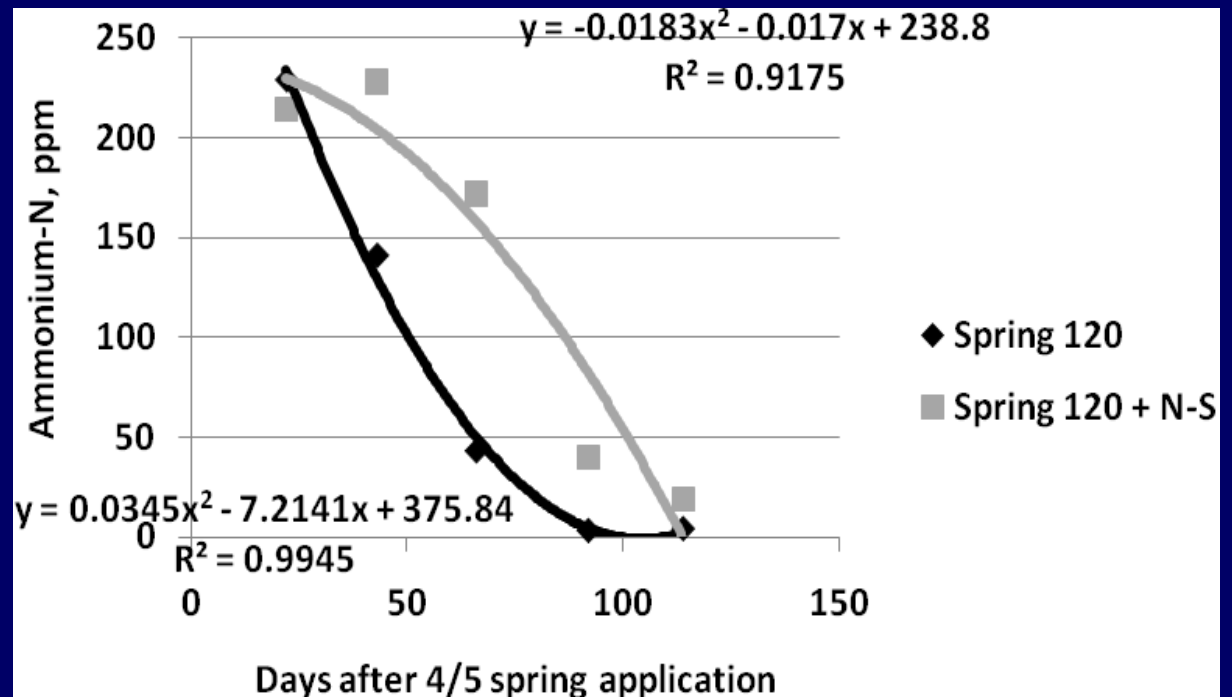
Nitrapyrin mode of action is as a bacteriocide or at least it greatly decreases bacteria ability to oxidize ammonium.

Active at concentrations as low as 1 ppm if the nitrapyrin is available all at once.

Fall N, Touchton et al., 1978
N-Serve 24, Illinois



Spring N, Touchton et al., 1978
N-Serve 24, Illinois



Some studies showed a yield increase with N-Serve, while others showed no yield increase. Yield increases were more a result of weather between application and N uptake rather than performance of the product.

Yield increases over the seven years in Minnesota were 15 bushels per acre more for fall anhydrous ammonia + N-Serve over fall anhydrous ammonia alone, and 27 bushels per acre more for spring anhydrous ammonia compared to fall anhydrous ammonia (Randall et al., 2008).

Inherent issues with N-Serve for ammonia

Corrosive-

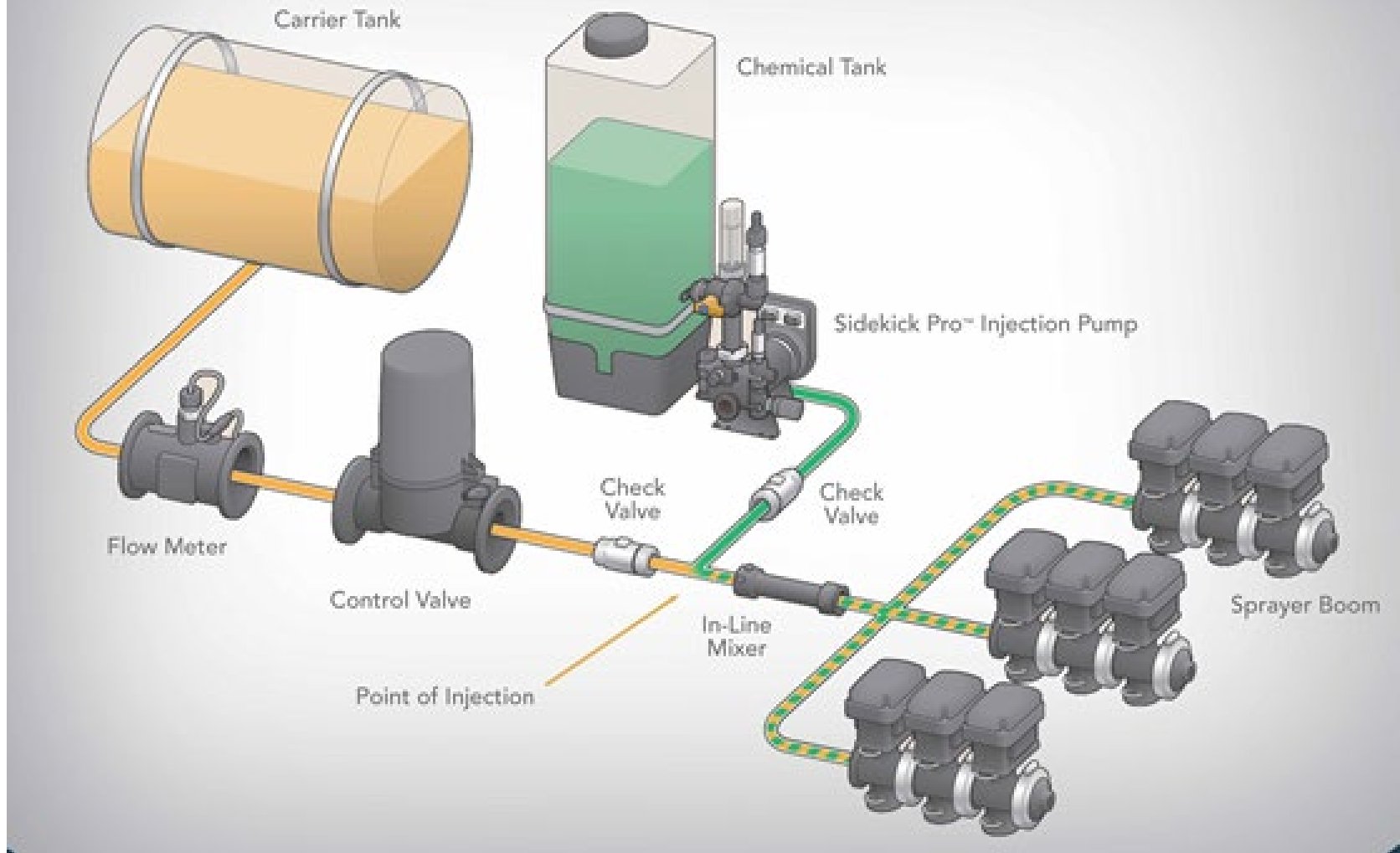
Replace aluminum float-gauges with stainless steel

Replace normal acme gaskets with BunaN gaskets/Teflon

First time use, be prepared to clean out screens frequently on first tank fill of each tank

Volatility- 2-3 times more than the most volatile incorporated herbicides

RAVEN DIRECT INJECTION SYSTEM



Direct injection system (not an endorsement)

Instinct II[®] is a new formulation of Nitrpyrin that can be mixed with ammonium fertilizers and can stay on the soil surface without incorporation.

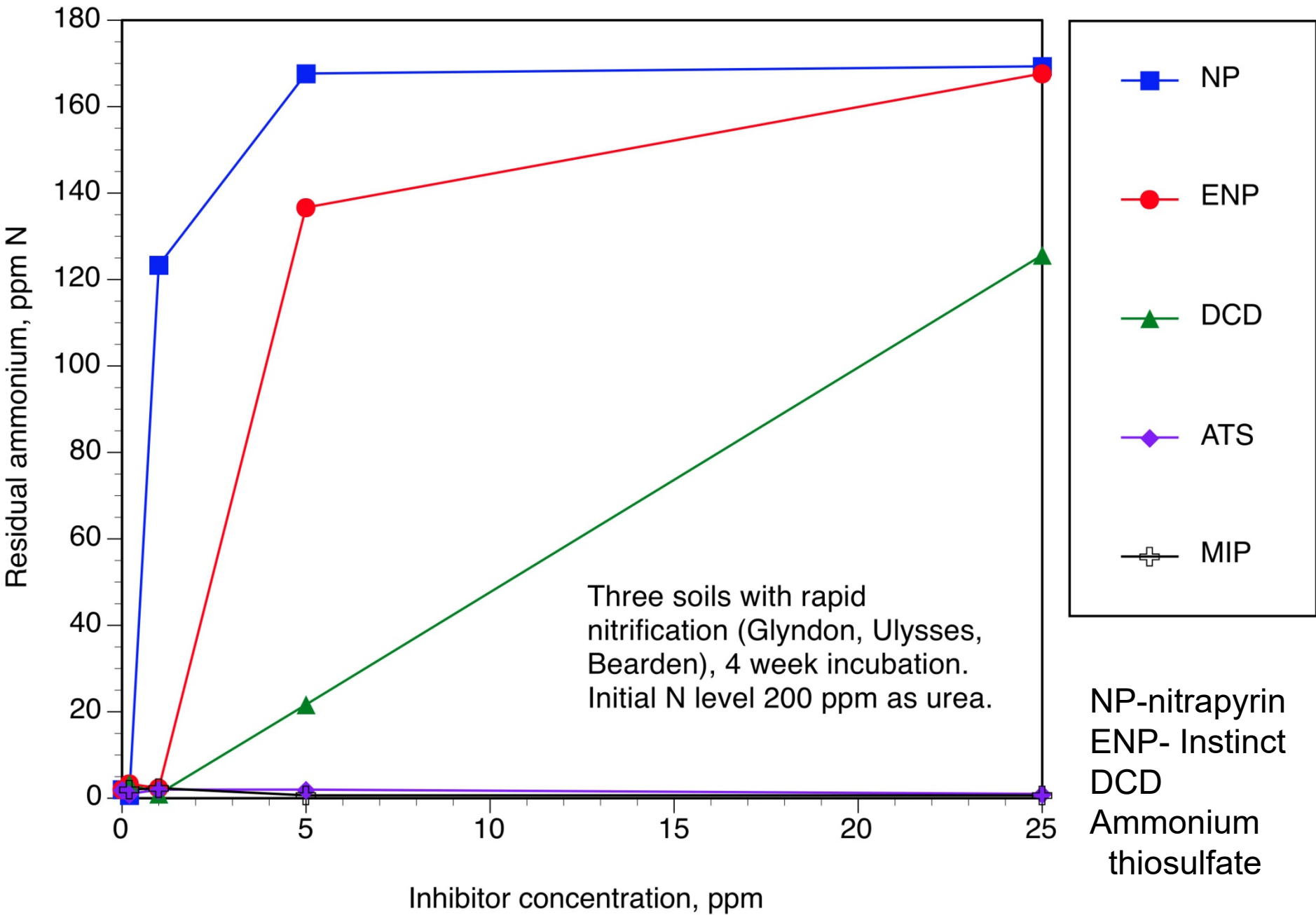
The formulation is microencapsulated nitrpyrin.

That means that nitrpyrin release is slow compared to nitrpyrin for ammonia.

Release rates of Instinct indicated a slow release through the encapsulation, with only 14% released in a 70 day incubation study.

(Menelas, 2014, PhD thesis, Purdue).

Speculated that use in the field might be better if soil pH/soil biology acted on the microencapsulation.



**Field study, Purdue
(Omonode and Vyn, 2013, AJ)**

**Instinct treated UAN had higher ammonium
and lower nitrate than untreated UAN.**

**Nitrification was significantly reduced.
Nitrous oxide emissions were reduced 44%.**

Wisconsin 2008-2012

Laboski and Andraski, 2013 Wis Fert and Lime

Soil ammonium levels were higher and soil nitrate levels lower with Instinct than without.

Yield increases documented, as well as sites with no yield differences.

DCD- Dicyandiamide

First developed as a fertilizer
(66.7-0-0)

Found that DCD was toxic
to plants when DCD was
used at rates equivalent to
use as a fertilizer

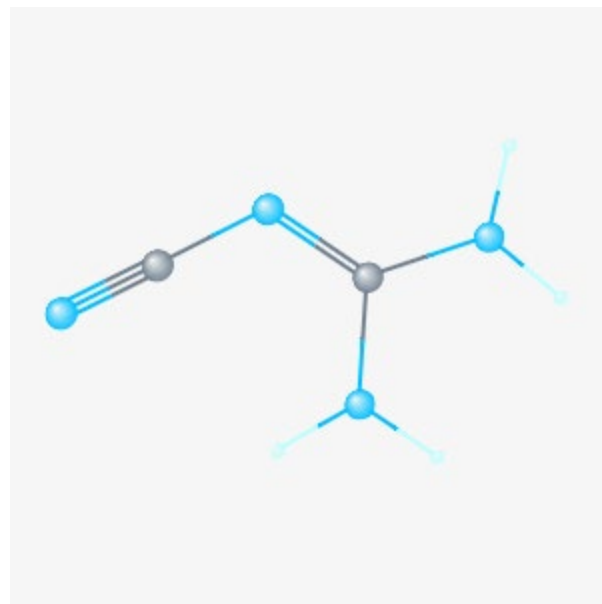
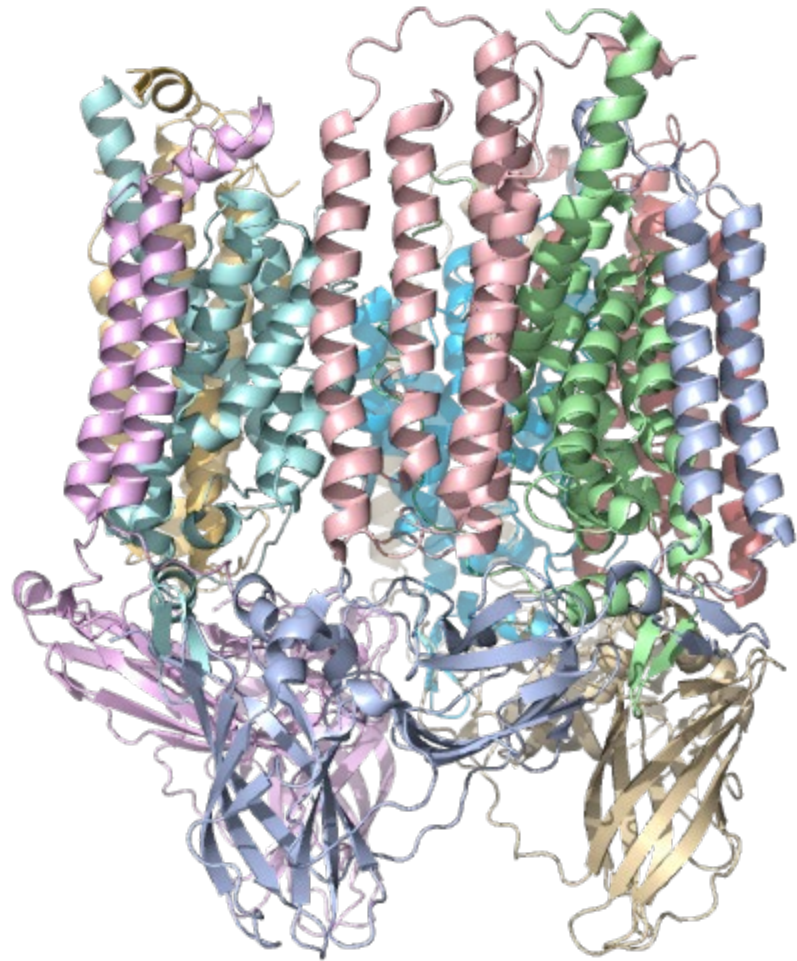


Image from PubChem

<https://pubchem.ncbi.nlm.nih.gov/compound/Dicyandiamide#section=Top>

**DCD is bacteriostatic-
It interferes with
bacteria metabolism,
preventing
replication.
Mode of action
proposed is
inhibition of
ammonia
monooxygenase,
a key enzyme in
nitrification.**



Ammonia monooxygenase

http://www.genome.jp/dbget-bin/www_bget?mca:MCA1797+mca:MCA2854

DCD- a nitrification inhibitor

Found in

AgrotainPlus (Agrotain, Int.)

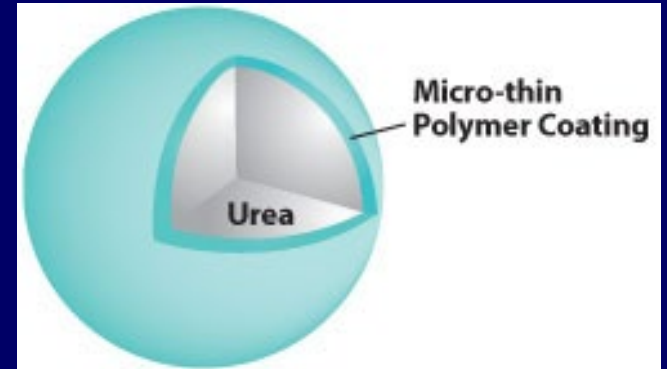
SuperU (Agrotain, Int.)

Others.....

**Needs to be added at >1% of total N
content of fertilizer needing protection.**

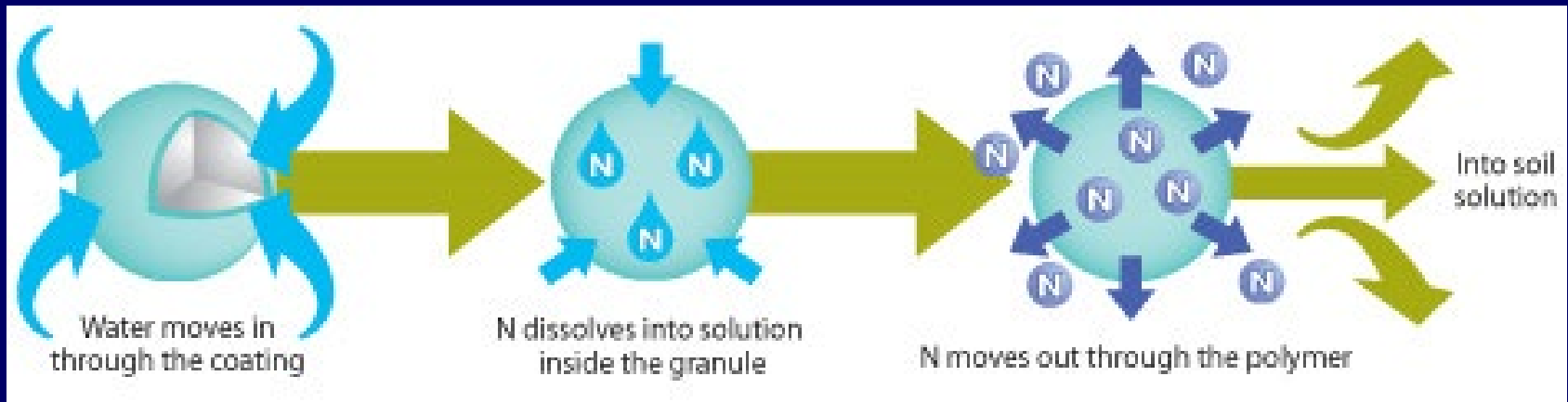
Best commercial product is about 1.2%

ESN- Agrium



Images from Agrium ESN website

How ESN works (Agrium website)



Urea in ESN remaining after field burial, Casselton, ND, fall 2013.

Ransom, unpublished data, North Dakota State University.

Date of sampling	Date of burial	
	10/11	10/25
	% urea remaining	
10/25/2013	89 a	na
11/08/2013	84 a	96 a
04/29/2014	55 bc	65 b
05/13/2014	50 c	59 bc
05/27/2014	37 d	45 cd
06/10/2014	na	38 d

Illinois-

4 locations over 12 years, ESN was similar in corn yield to urea + Agrotain, and 3 bu/a higher in yield than urea alone.

In 4 years of no-till, ESN was 21 bu/a better than urea surface-applied.

(Ebelhar et al., 2010)

Minnesota-

**3 different ESN application methods-
deep band (4 inches), broadcast incorporated
fall and spring resulted in similar corn yield
to urea using the same methods over a
4-year period.**

(Randall and Vetsch, 2009)

Corn grain yield as affected by 80 lb N/acre applied as N source, timing, method of application and additive. Manhattan, KS. Weber and Mengel 2009.

Treatment	Yield, bushels/acre
Control	104
Winter urea	138
Winter ESN	154
Spring urea	165
Spring Urea + Agrotain	169
Spring Urea as SuperU	173
Spring ESN	167
Spring 50% ESN:50% Urea	174
Spring UAN broadcast	148
Spring UAN + Nutrisphere	149
Spring Coulter UAN	162
LSD (0.05)	19

Best fit for ESN-

Spring wheat/Durum- in soil

**Corn as a blend in preplant to keep
plant healthy until side-dress**

Maybe a 4 part urea / 1 part ESN

**Enough ESN to carry N into late
grain fill season for higher protein.**

What about other products where a claim of N activity is made, but there is no mode of action nor is there convincing evidence they they work on N availability at all?

Buyer beware is more important these days than ever-

- Letting Tech reps go**
- Development, then maybe research**
- Be extremely skeptical**

<http://extension.agron.iastate.edu/compendium/index.aspx>

You can find this link at the bottom of my home page

<Dave Franzen NDSU>

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