

Controlled-Release Nitrogen Fertilizers



In North America, nitrogen (N) fertilizer is largely applied as anhydrous ammonia, UAN solutions or urea. However, these forms of N can be lost if wet weather conditions precede their uptake by crops. Controlled-release N fertilizers can reduce these losses by delaying the initial release of N and providing it gradually to coincide with crop uptake needs. Controlled-release (also called slow-release or delayed-release) N fertilizers include coated ureas, non-coated "chemical-release" forms and other products.

Coated Ureas

Coating urea prills (granules) with a water-insoluble, semi-permeable or impermeable (with pores) material delays the release of N from the urea. Urea is highly soluble in water, but the solubility of coated urea is dependent on the coating material, its thickness, and the coverage and uniformity of the coating on the granule. Materials used for urea coating or "encapsulation" include sulfur, polymers or both. As the urea is gradually released from the coated granule, it is exposed to the same chemical and biological processes as non-coated urea.

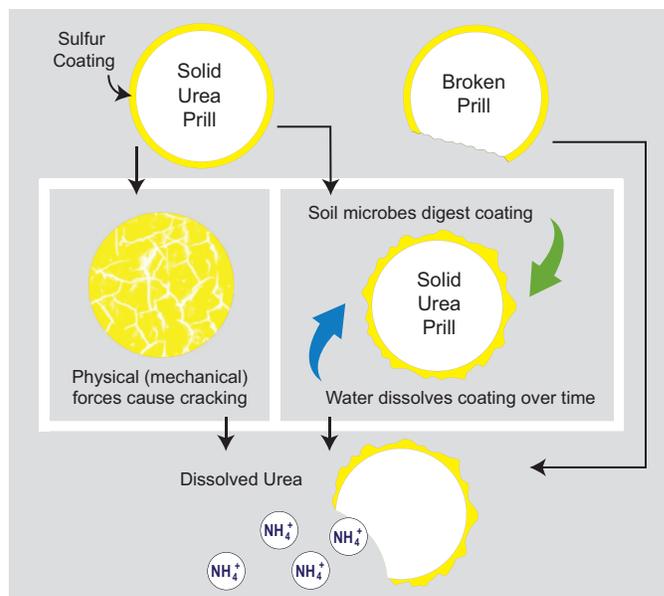


Nitrogen-sufficient corn field at V5. Most nitrogen is applied for corn well ahead of the period of peak crop uptake (V8 to tasseling).

Sulfur-Coated Urea - The additional labor and equipment required to produce coated fertilizers and the cost of the coating materials make them much more expensive than conventional N fertilizers. Due to the simplicity and relatively low cost of sulfur as a coating material, sulfur-coated urea has become the most commonly used coated urea product.

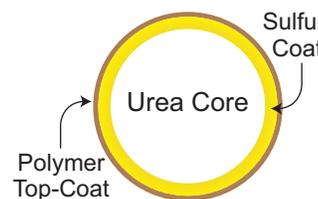
The Tennessee Valley Authority (TVA) developed the basic production process for sulfur-coated urea over 50 years ago, so the product is familiar to most farmers who use urea. This fact and the high N content of the product (30 to 40%, depending on the amount of sulfur applied) have added to its popularity among coated products. In addition, as a generic product, its cost has remained relatively low.

The sulfur coating is an impermeable layer that slowly degrades through microbial, chemical and physical processes. The completeness of the coating determines its effectiveness; incompletely coated or cracked prills are immediately amenable to dissolution in soil water and hydrolysis by urease. Because not all granules have complete integrity of their sulfur coating, some N is quickly made available to the soil solution. In fact, the "7-day dissolution rate" is routinely as high as 30% and may be as high as 60% of the total N content of the product in some cases. With such high rates of dissolution, a rapid initial effect on the crop would be expected (Trenkel, 2010).

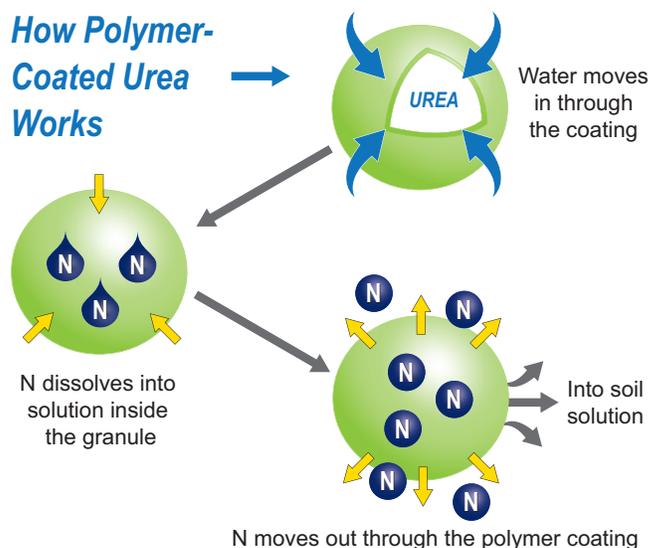


Breakdown of sulfur-coated urea. Adapted from Blaylock, 2010.

Sulfur + Polymer-Coated Urea - To help solve the problem of irregular nutrient release from sulfur-coated urea, a class of "hybrid" products has been developed. These products include a thin polymer coating on top of the low-cost sulfur coating. This has the benefits of reducing the over-all cost vs. that of polymer-only products, while providing a better seal than the sulfur-only products.



Polymer-Coated Urea - Polymer-coated urea fertilizers use a hydrophobic (water-insoluble) coating that temporarily isolates the urea prill from the soil environment. These polymer coatings may be resins or mineral-based products that act as semi-permeable membranes or impermeable membranes with tiny pores. Nutrient release through these membranes is controlled by the properties of the coating material; i.e., its permeability characteristics as affected by temperature and moisture.



N release from polymer-coated urea. Adapted from Blaylock, 2010.

Thus, they are not significantly affected by soil properties such as pH, salinity, soil texture, microbial activity, redox potential or cation exchange capacity. Therefore, it is possible to predict and control the nutrient release rate from these products more accurately than for sulfur-coated ureas (Trenkel, 2010).

Chemical Controlled-Release Products

The first chemical controlled-release products became available as fertilizers in the U.S. over 50 years ago. From the beginning, their high cost relative to other N fertilizers has limited their use in large-scale production of commodity crops such as corn, sorghum, wheat and canola. Rather, they have been more commonly used in specialty, high-value crops such as vegetables, orchards, nurseries, seed production, etc. Today, their use is limited but increasing in row crops, primarily due to higher grain prices, environmental concerns and regulations, and niche uses such as foliar fertilization. Common classes of chemical controlled-release products are described below.

Urea-Formaldehyde / Methylene Urea - By reacting urea with aldehydes, compounds with high molecular weights and complex chemical structures with low water solubility can be created. These products release their nitrogen slowly by gradually dissolving in soil water, decomposing by microbial activity, or both.

Reacting formaldehyde with excess urea under controlled conditions results in a mixture of methylene ureas with different polymer chain lengths. By changing the manufacturing conditions, the chain lengths, solubilities and nitrogen release rates can be varied. The release pattern is also influenced by soil temperature and moisture and by soil microorganisms and their activity (Trenkel, 2010).

Urea-Triazones - These compounds are produced by reacting an aldehyde and ammonia (or primary amine) with excess urea in an aqueous medium under controlled conditions. The resulting liquid fertilizer is a stable solution containing N from both triazone and unreacted urea. Products containing triazone-N remain in a liquid phase on plant tissue surfaces longer than some other urea-based products. These products have also proven safer to plant foliage than urea and UAN solutions in research studies (Clapp, 2001). Consequently, they are often used as foliar fertilizers.

Possible Uses of Controlled-Release Products

The higher cost of controlled-release products generally excludes their use in cases where conventional N fertilizers can perform the same function adequately. Most growers of commodity row crops who use controlled-release products likely apply most of their crops' N needs with conventional products and only use controlled-release products to supplement their primary N fertilization program. Controlled-release products may be most useful when:

- Growing a high-value crop (e.g., a seed crop)
- Applying on fields subject to high losses of N, for example:
 - light-textured, leachable soils
 - low-lying, heavy soils at risk of ponding and denitrification losses

- Applying in a regulated watershed
- Applying in a field that borders a stream, river, lake, etc.
- Applying in fields with limited opportunities for repeat applications due to expected weather patterns, field / crop conditions, distance, or labor / equipment issues
- Applying urea to the soil surface but not incorporating
- Applying as a foliar/remedial treatment
- Applying to contest plots to ensure constant N supply

Available Controlled-Release Products

A number of controlled-release nitrogen products are now available to row-crop producers in the U.S. or Canada (Table 1).

Table 1. Controlled-release N products available in North America. Adapted from Hergert et al., 2011.

Product Class	Product Name	
Sulfur-Coated Urea	Generic	
Polymer-Coated Urea	CoteN [®] Duration [®]	ESN [®] Polyon [®]
Sulfur and Polymer-Coated Urea	Poly-S [®]	Tricote [®]
Urea-Formaldehyde / Methylene Urea	Nitroform [®] Nutralene [®]	CoRoN [®] NFusion [®]
Triazone	N-Sure [®]	
Methylene Urea + Triazone	Nitamin [®] NFusion [®]	
Triazone + NBPT ¹	N-Pact [®]	
Urea + NBPT + DCD ²	SuperU [®]	

¹ A urease inhibitor (active ingredient in Agrotain[®] products).

² A nitrification inhibitor (active ingredient in Guardian[®] products).

References

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- Clapp, J. 2001. Urea-triazone N characteristics and uses. Proceedings of the 2nd International Nitrogen Conference on Science and Policy. The Scientific World (2001) 1(S2), 103–107. ISSN 1532-2246; DOI 10.1100/tsw.2001.356.
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- Trenkel, M. 2010. Slow-and controlled-release and stabilized fertilizers: an option for enhancing nutrient use efficiency in agriculture. Int'l Fertilizer Industry Association, Paris, France.