

Fertilizer

FOCUS

JANUARY/FEBRUARY 2018



The future of phosphate rock

Bayovar 12 project in Peru

European Union ETS update | Brazilian freight logistics | Precision nutrient management

Novel additives

for enhanced fertilizer formulations

by Daniel Zweifel, **Technical Service & Development Manager, The Dow Chemical Company, Switzerland,**
 Yuri Alencar, **Research and Development Manager, The Dow Chemical Company, USA**
 Wanglin Yu, **Research and Development Scientist, The Dow Chemical Company, USA**

Common issues of liquid fertilizers are poor dispersion on a plant surface, soil penetration and migration to the root zone. A key contributor to these problems is the hydrophobic conditions of soil. The majority of fertilizer tends to be water based, which means that when it comes in contact with soil, it is likely to bead rather than infiltrate the surface, given the hydrophobic condition of soil.

Surfactants are a type of adjuvant that reduces the surface tension of aqueous solutions of fertilizers. This allows the fertilizer solution to spread, versus bead, on the surface of soil or leaves. It also enables the formulation to migrate through soil to the plant's root zone more efficiently. By selecting the appropriate surfactants, formulators can improve a fertilizer's wetting and penetration in the soil for enhanced performance.

Compatibility of surfactants and fertilizers

A key criterion for the use of a surfactant is compatibility with a

fertilizer. Incompatibilities can result in turbidity, separation or even sedimentations, which can limit the effectiveness of the fertilizer formulation and lead to blockage of the equipment's filter and hose.

A research team from Dow Crop Defense evaluated the compatibility of concentrated fertilizers with surfactants, also concentrated between 2-5%. This range is based on previous research that suggests the surfactant is most effective at this concentration level when diluted. Often, producers prefer to sell their products in concentrated form, which before use, is diluted 100-200 times. Ideally, the surfactant is incorporated into the formulation at the elevated concentration.

The liquid fertilizers tested in the study included 28-0-0 UAN, 28-0-0 5S UANTS and 4-10-10 NPK, as they are the most common solutions for a broad range of applications and consist of two or more nutrient components.

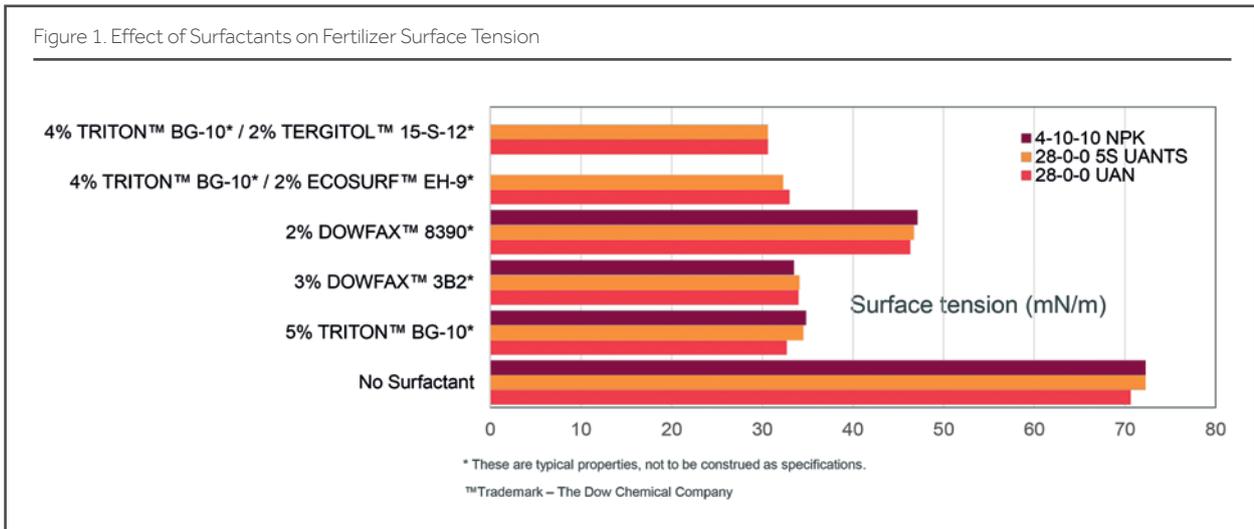
The surfactants used are specific to Dow's portfolio and include TRITON BG-10 Surfactant, a nonionic alkyl polyglycoside (APG) product, as

well as DOWFAX 3B2 and DOWFAX 8390 Surfactants, anionic alkyl diphenyloxide disulphonates. The TRITON BG-10 product was additionally tested in blends with two other nonionic surfactants, ECOSURF EH-9 Surfactant, an alcohol alkoxyolate and TERGITOL 15-S-12 Surfactant, a secondary alcohol ethoxyolate. A third combination of surfactants was also tested, TRITON H66, an anionic phosphate ester, and TERGITOL 15-S-12.

These surfactants were chosen because they have previously shown excellent solubility as well as good wetting and spreading characteristics. Additionally, complementary combinations of surfactants have been known to result in enhanced performance.

Solubility of the surfactants with each fertilizer was tested at room temperature for several days. Turbidity, settlement, sedimentation and phase separation are indicators of insufficient solubility. On the other hand, proper solubility is evident when the liquid is clear and one phase. Proper solubility is observed with a clear solution which has only one phase.

Figure 1. Effect of Surfactants on Fertilizer Surface Tension



Results showed excellent compatibility of each fertilizer with TRITON BG-10 Surfactant itself as well as DOWFAX 3B2 and DOWFAX 8390 Surfactants. The combination of an APG grade with alkoxyated/ethoxyated alcohols produced proper compatibility with the UAN and the UANTS fertilizers. However, the NPK fertilizer showed slight incompatibility, which should deter formulators from these specific combinations. Specifically, NPK fertilizer solutions tend to be challenging due to high electrolyte concentrations that reduce the solubility of certain surfactants and cause turbidity.

tension of 30-35 mN/m, which is a significant improvement in wetting when compared to the typical surface tension of a surfactant-free fertilizer formulation, 70 mN/m. Fertilizer formulations with more than one surfactant showed the best results, emphasizing the benefits of strategically blending products.

Surface tension was tested in each fertilizer at a 100 times dilution of fertilizer and surfactant in water. Given the lack of compatibility between combined surfactants and NPK at the onset of the research, NPK could not be tested with these solutions (see figure 1).

As described, a reduction in surface tension results in a lesser likelihood of the formulation to bead on the soil or leaf surface. This can be observed by measuring the contact angle of each fertilizer when combined with surfactants. Typically, each of the three fertilizer solutions tested has a contact angle above 90 degrees. The addition of TRITON BG-50 Surfactant concentrated at 5% reduced the contact angle below 90 degrees. When optimized with ECOSURF EH-9 Surfactant and DOWFAX 3B2 Surfactant, the contact angle was further reduced to below 75 degrees. A sample of the results in shown in figure 2.

Enhanced wetting through formulation

Each combination of liquid fertilizer and surfactant was further tested to understand the effect of the formulation on wettability. This was explored through measuring the surface tension of each combination, which is essentially the willingness of the fertilizer droplet to spread across the soil or leaf surface as opposed to beading. High surface tension implies low wettability, while low surface tension suggests increased wettability due to a greater willingness of the formulation to spread.

The addition of surfactants to fertilizers showed a significant reduction in the surface tension of each solution. The majority of formulations resulted in a surface

Figure 2. Impact of Surfactants on Contact Angle

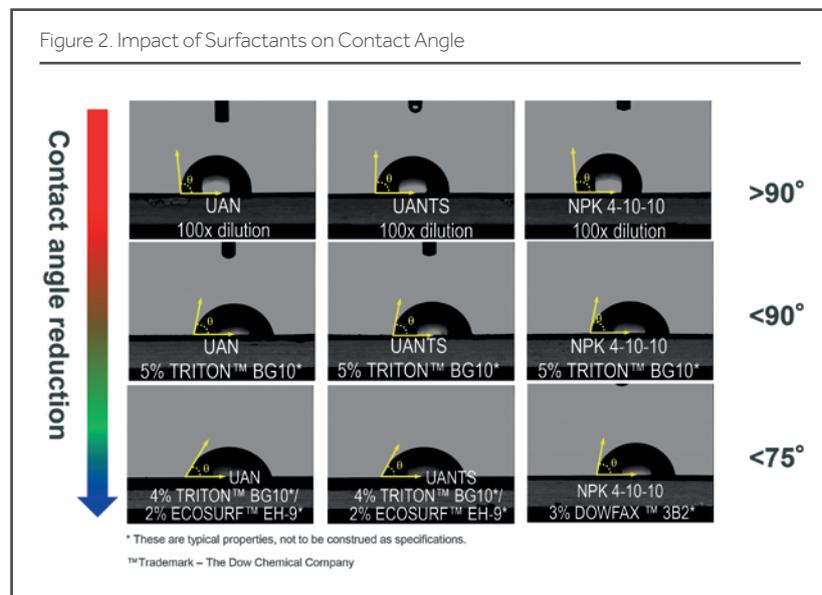
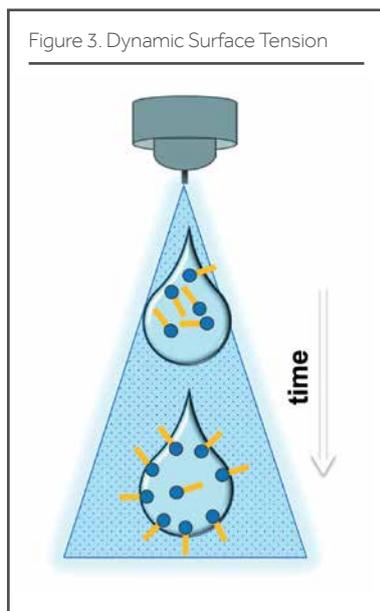


Figure 3. Dynamic Surface Tension



Increased fertilizer mobility for higher efficiency

For a liquid fertilizer applied directly to soil, its mobility within the soil matrix is critical to its effectiveness. The efficiency of fertilizer depends on the surface tension of the fertilizer as well as soil composition. Fertilizer reaches a plant's root zone by diffusing through water found in the soil, moving from an area of high solution concentration to low.

A standardized soil model of hydrophobically modified silica sand was used to study the impact of surfactants on fertilizer mobility. A diverse selection of representative surfactants was used to observe the significant performance difference between each.

Water pickup was measured by recording the mass increase of a packed hydrophobic soil column over time upon the contact of the bottom of the soil column with a surfactant solution, a method representative of the Washburn sorption test. Each surfactant was concentrated at 0.1%, which corresponds to the typical surfactant concentration in a diluted liquid fertilizer product.

Impact on mobility was shown to vary by product. While TERGITOL L-61 Surfactant, an ethylene oxide-propylene oxide block-copolymer, did not result in increased mass, TERGITOL 15-S-9, a secondary alcohol alkoxyate, exceeded water pickup by two to ten times. This highlights the differing performance of surfactants and the value in testing several options to create the most effective fertilizer formulation.

Agile surfactant molecules critical to performance

The time between the formation of a fertilizer droplet at the exit of the spray nozzle to when it hits the soil or leaf is critical to the effectiveness of any fertilizer and surfactant combination. During this time, the surfactant needs to "unfold" its surface activity. This occurs through a rearrangement of the molecules so that the surfactant molecules move the droplet's surface (see figure 3). Because the soil tends to be hydrophobic, it's critical that enough time elapses for this arrangement to take place and the observed benefits in this research to result.

The key parameter to measure this process is the dynamic surface tension of the fertilizer. A dynamic surface tension below 35-40mNm is preferred.

A variety of surfactants were tested to determine how differing chemistries affect dynamic surface tension. Each showed an adequate dynamic surface tension reduction within the first 100ms of leaving the spray nozzle when tested with NPK fertilizer. The resulting range in performance again emphasizes the importance of selecting the appropriate surfactant chemistry for the fertilizer type.

It's important to note that the maximum time for the process to occur differs in practice, specifically the height of the applicator impacts the time allowed. At 3ft from the soil or plant surface, 100ms is a reasonable duration of time for the benefits of surfactants to result.

Sustainability considerations of surfactants

As with any product introduced to the environment, the effects of surfactants on water and soil composition are important to take into consideration when formulating. Surfactants continue to evolve as companies develop a deeper understanding of their impact on the environment and human health and more stringent regulations are put into place. Efforts to reduce aquatic toxicity of surfactants are widespread and many biodegradable options are available in the market, breaking down rapidly to reduce the risk of run-off into aquatic environments. Additionally, due to more efficient wetting and uptake of the fertilizer into plants as a result of the use of surfactants, it is possible for applicators to reduce fertilizer use without losing the nutrition benefits.

The benefits of surfactants are clearly evidenced in this research. Combinations of surfactants and fertilizers enable increased wetting of soil and leaf surfaces and improved mobility in soil for faster travel to the root zone as well as more efficient pickup by the plant. Compatibility is key to harness these positive benefits however, and it is essential for formulators to understand the variety of surfactants available in the market and evaluate combinations in practice. ■

Dow Crop Defense has a range of solutions for enhanced liquid fertilizer application, as shown in the research. Dow's surfactants are available in several grades, including options with low-aquatic toxicity (EC 50 > 10mg/l) and ready biodegradability (OECD 301), to meet the needs of a producer and enable simple formulations which low foam production. Dow also provides formulations support and offers complementary products such as rheology modifiers, cellulose, preservatives and polyurethanes. For more information, visit www.dowcropdefense.com.

FOOTNOTE: TRITON, DOWFAX, ECOSURF and TERGITOL are trademarks of The Dow Chemical Company ("Dow") or an affiliated company of Dow.