2-Ethyl-Hexyl Alkoxylates as Adjuvants

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Change is a constant across multiple industries. The adjuvant world is no different. Regulatory pressure and a new generation of crop protection practices steer pesticide and adjuvant formulators from traditional adjuvants such as tallow amine ethoxylates and alkyl phenol ethoxylates to adjuvants that offer ready biodegradability, low aquatic toxicity, multifunctional performance and applicator convenience.

2-Ethyl-hexyl alkoxylates are nonionic surfactants that are commonly utilized in the household and industrial cleaning industry because of their excellent detergency, solubilization and emulsification performance. When formulated in pesticide and adjuvant formulations, this class of nonionic surfactants provides benefits such as wetting, rapid dissolution, rapid foam collapse, low odor and adjuvancy with actives such as glyphosate. These benefits coupled with low aquatic toxicity and ready biodegradability position 2-ethyl-hexyl alkoxylates for widespread adjuvant use.

Wetting

Coverage of pesticide spray solutions can be improved through chemical and mechanical methods. Surfactants are commonly utilized as chemical wetting agents, providing coverage on target by reducing the surface tension of an aqueous spray solution and improving adsorption on the solid surface.

Wetting properties of nonionic alcohol alkoxylate surfactants can vary widely depending on the choice of hydrophobe and the number and nature of alkylene oxide units. Highly branched hydrophobes tend to provide improved wetting and surface tension reduction. However, a high degree of branching has a negative impact on biodegradation. Moderately branched alcohol alkoxylates such as 2-ethyl-hexyl alkoxylates provide a good balance of properties, along with performance equaling or surpassing alkyl phenol ethoxylates while maintaining good biodegradability and low aquatic toxicity profiles.

Table 1

Nonionic Surfactant	Abbreviation	Spread Index
Nonyl phenol ethoxylates - 9 EO	NP9	1.55
2-Ethyl-hexyl alkoxylates - 6EO	EH6	1.56
C8-C10 Alkyl polyglucoside	C8-10 APG	1.25
C8-C16 Alkyl polyglucoside	C8-16 APG	1.57

Spread index measurements are expected to vary as much as +/- 0.03 units simply due to measurement error.

Spread index is a simple technique to quickly compare the wetting performance of spray solutions in any laboratory. Spread index measurements are obtained by depositing a controlled volume of test solution onto a test substrate of interest such as Parafilm (Pechiney Plastic Packaging Co.). The droplet is allowed to spread for one minute after which the drop size is determined. A color-coded grid is placed underneath the transparent Parafilm prior to the experiment to quantify the droplet size. Typically, measurements are performed in triplicates. The spread index value is determined by dividing the average droplet diameter of the sample by the droplet diameter of water under identical laboratory conditions. Reproducibility is very high when the deposition rate, spread time, temperature, and droplet size measurement are well-controlled. Spread index data correlate very well with the alternative contact angle method.

Spread index measurements of common nonionic surfactants are shown in Table 1. A 2-ethyl-hexyl alkoxylate with 6 units of ethylene oxide (EO) provides a spread index equivalent to those of nonylphenol ethoxylate with 9 EO and a C8-C16 alkyl polyglucoside (APG). As expected, an APG with a small hydrophobe such as a C8-C10 alkyl polyglucoside has a smaller spread index than an APG with a longer hydrophobe.

It is well-known that synergistic wetting can be observed through blending nonionic surfactants. However, it is not easy to predict synergistic pairs. The

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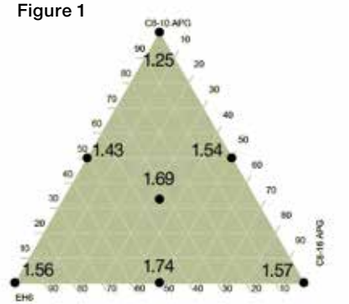
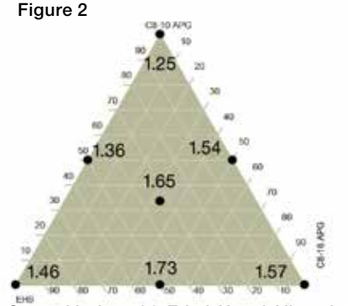
combinations with improved performance are identified experimentally. Figures 1 and 2 summarize the spread index of 2-ethyl-hexyl alkoxylate, two APGs, and their blends in ternary diagrams. When blended with a C8-C16 alkyl polyglucoside, 2-ethyl-hexyl alkoxylates exhibit improved wetting performance exceeding values obtained with either surfactant alone. Values obtained with these blends exceed the spread index of nonylphenol ethoxylate (9EO) as well.

Figure 1



Spread Index of 2-Ethyl-Hexyl Alkoxylate (6 EO), APGs, and Blends in a Ternary Diagram

Figure 2



Spread Index of 2-Ethyl-Hexyl Alkoxylate (9 EO), APGs, and Blends in a Ternary Diagram

Dissolution

Agricultural tank mix adjuvant formulations are applied under a wide variety of conditions. Spring applications often utilize cold water for dilution with limited mixing capabilities. Therefore, it is important for the adjuvant formulation to rapidly dissolve upon dilution in the spray tank. The dissolution rate of a nonionic surfactant adjuvant formulation varies with surfactant composition.

The dissolution rate of common nonionic surfactants in cold water was measured by adding the surfactant at a concentration of 10% by weight to 40 °F water with constant stirring. A timer was started upon addition and the time for the surfactant to fully dissolve in the cold water was recorded. Figure 3 illustrates the dissolution time of a variety of nonionic alkoxylates.

Nonyl phenol ethoxylates and primary alcohol ethoxylates dissolve slowly (Figure 3) and form gels readily upon dilution with water. In this experiment, the dissolution time for these materials was well over 1 hour. 2-ethyl-hexyl alkoxylate and a blend of 2-ethyl-hexyl alkoxylate with an alkyl polyglucoside provided a reduction in dissolution time of over 90% with dissolution times of less than 4 minutes versus over an hour. Rapid dissolution provides enhanced user convenience when applicators are operating in cold temperatures with limited agitation facilities.

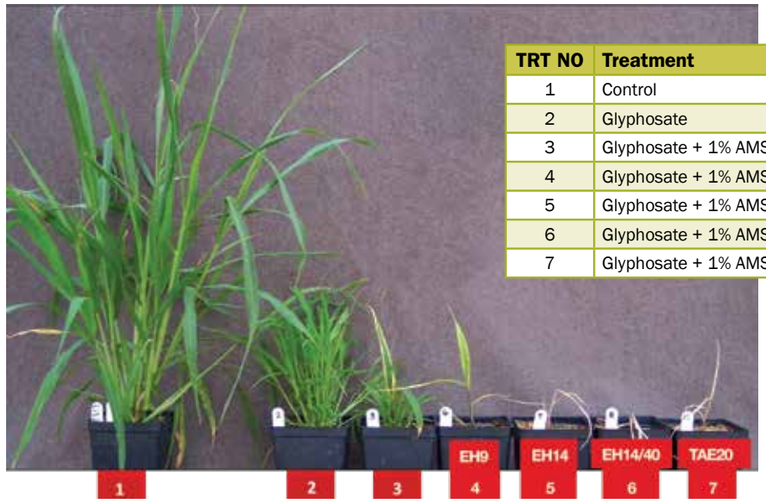
Bio-Efficacy

Adjuvants are broadly defined as substances which improve the performance of an active ingredient. In order to evaluate the adjuvant performance of 2-ethyl-hexyl alkoxylates, they were applied with glyphosate IPA to giant foxtail in the presence of 1% ammonium sulfate (AMS). For comparison purposes tallow amine ethoxylate with 20 EO (TAE20) was also included in the study. When used with glyphosate, 2-ethyl-hexyl alkoxylates, improve the control of giant foxtail (Figure 4). The adjuvant effect improves as EO levels increase. The right balance of hydrophobe and hydrophile is crucial to achieve optimum results. The 2-ethyl-hexyl alkoxylate with the highest level of EO evaluated provided similar efficacy to TAE20.

Environmental Profile

With the increase of urbanization, societal pressures, and regulation, environmental profiles of surfactants are becoming increasingly important. 2-Ethyl-hexyl alkoxylates have an excellent environmental profile. These moderately branched surfactants are readily biodegradable (> 60% biodegradation within 28 days per OECD 301F) and exhibit low aquatic toxicity (LC50/EC50 between 10 and 100 mg/L in the most sensitive species tested). The combination of excellent biodegradability with low aquatic toxicity enabled these surfactants to be listed on CleanGredients where they can be used in formulations that meet the U.S. Environmental Protection Agency Design for the Environment Surfactant Screen criteria.

Figure 4
Control of Giant Foxtail on Day 21



TRT NO	Treatment
1	Control
2	Glyphosate
3	Glyphosate + 1% AMS
4	Glyphosate + 1% AMS + 0.25% EH9
5	Glyphosate + 1% AMS + 0.25% EH14
6	Glyphosate + 1% AMS + 0.25% EH14/EH40 Blend
7	Glyphosate + 1% AMS + 0.25% TAE20

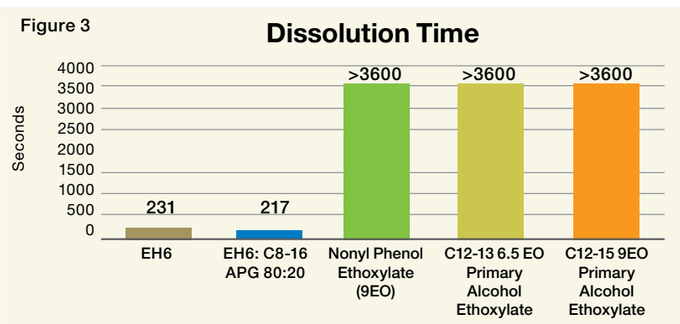
Glyphosate = Glyphosate IPA at 0.20 lb a.e. / A
AMS = Ammonium sulfate
EH# = 2-Ethyl-hexyl alkoxylate with # EO
TAE20 = Tallow amine ethoxylate 20 EO

June 2013 at Michigan State University with Professor Donald Penner

Conclusion

2-Ethyl-hexyl alkoxylates add a new environmentally friendly, nonionic alkoxylate to formulators' tool boxes. Their optimal molecular structure provides the desired biodegradability and low aquatic toxicity. 2-Ethyl-hexyl alkoxylates provide comparable and often even better performance than nonyl phenol ethoxylates. They also complement eco-friendly alkyl polyglucosides that are commonly utilized in adjuvant formulations. Synergistic wetting and improved dissolution time can be achieving through these blends. 2-Ethyl-hexyl alkoxylates also show good adjuvancy with glyphosate. The performance attributes and environmental profiles of 2-ethyl-hexyl alkoxylates position these materials as a viable option for future widespread adjuvant use.

Figure 3



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