

DuPont™ Zonyl® Fluorosurfactants

WELL STIMULATION ADDITIVES



The miracles of science™



Zonyl® additives in well stimulation:

- Minimize formation damage
- Increase fluid recovery
- Prevent formation of “worm holes” by providing a uniform coating of acid on the rock formation
- Provide foaming capabilities in a variety of solvents and water
- Decrease the need for demulsifiers due to their natural ability to prevent emulsification of water with oil/gas
- Create non-depleting simulation fluids

Zonyl® Well Stimulation Additives

Zonyl® fluorosurfactants are additives used for a variety of well stimulation applications due to their unique thermal and chemical stability in harsh environments, ability to alter wetting of rock formations and create low surface tension fluids. These surfactants are used in both aqueous and organic solvent systems to create formulations with surface energies as low as 16 dynes/cm.

The Zonyl® well stimulation products offer a variety of surfactants to meet your specific well stimulation needs. Non-ionic fluorosurfactants are useful in a variety of rock formations due to their decreased tendency for adsorption to rock formations. Cationic, anionic, and amphoteric fluorosurfactants are also available to allow for customization and compatibility with your existing stimulation fluids.

| Zonyl® Product | Ionic Type | Functionality |
|--------------------|------------|---------------|
| Zonyl® FSH/FSO/FSN | Nonionic | Ethoxylate |
| *Zonyl® FS-300 | Nonionic | Ethoxylate |
| Zonyl® FS-500 | Amphoteric | Betaine |
| Zonyl® FS-510 | Amphoteric | Amine Oxide |
| Zonyl® FS-200 | Cationic | Amine Salt |

* Passes OECD 301B test methods

Why Zonyl® Fluorosurfactants?

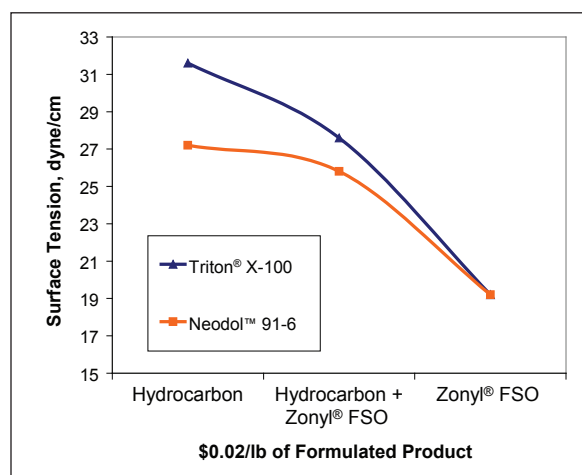
Zonyl® fluorosurfactants are applicable in well stimulation applications due to their superior wetting action, as well as stability in harsh environments, both thermal and chemical. This is due to the nature of the hydrophobic tail on the fluorosurfactant. The hydrophobic tail of a typical surfactant consists of a straight chain hydrocarbon; however, in fluorosurfactants, the hydrophobic tail is a straight chain fluorocarbon. Both orient at the liquid surface with the hydrocarbon or fluorocarbon tail of the molecule in the gas phase and the more polar portion in the aqueous phase. There is a significant difference in the surface tension between hydrocarbon surfactants and fluorosurfactants, as outlined in Table 1.

Table 1:
Zonyl® Fluorosurfactants versus Hydrocarbon Surfactants

| Property | Fluorosurfactants | Hydrocarbon |
|--------------------|-------------------|--------------|
| Effectiveness | 16 dynes/cm | 30 dynes/cm |
| Efficiency | 0.005% to 0.1% | 0.1% to 3% |
| Surface Activity: | | |
| Aqueous Systems | Excellent | Excellent |
| Strong Acids/Bases | Excellent | Poor to Good |
| Organic Solvents | Excellent | Poor |

Zonyl® fluorosurfactants can be used to reduce the total amount of surfactants required in a formulation, lower the overall cost, and provide better performance. Figure 1 illustrates that a mixed system containing Zonyl® and hydrocarbon surfactants achieve lower surface tension than the same cost level of the hydrocarbon surfactant alone (all cases are at 2¢ of surfactant per pound of formulated product). For example, when using Triton™ X-100, a typical hydrocarbon surfactant, at an addition rate of 2¢ per formulated pound of product the surface tension is 31 dynes/cm. When 1¢ of the Triton™ X-100 was removed and 1¢ of Zonyl® FSO was substituted in the mixture, the surface tension was reduced to 27 dynes/cm. A surface tension reduction of 4 dynes/cm was achieved for the same formulated cost. This is just one of the many examples of the synergy between Zonyl® fluorosurfactant and hydrocarbon surfactants.

Figure 1:
Zonyl® Fluorosurfactants are Cost Effective at Reducing the Surface Tension of Hydrocarbons

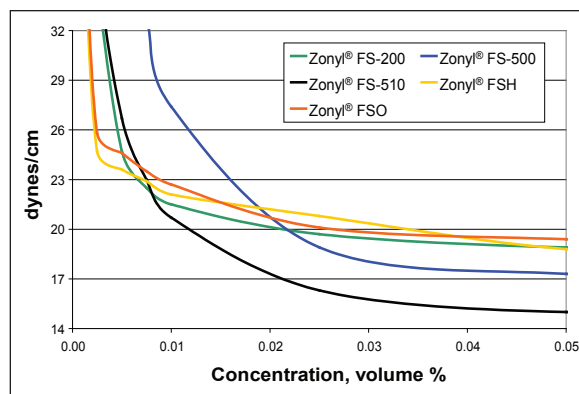


Surface Tension

Zonyl® fluorosurfactants provide substantially lower surface tension than hydrocarbon surfactants. Fluorosurfactants are particularly useful in low pressure and low permeability formations. Low permeability formations typically require surface tensions below 35 dynes/cm in order to prevent capillary blockage. Hydrocarbon surfactants are not able to achieve such low surface tensions at typical usage levels. Since fluorosurfactants are effective at such low concentrations (between 0.1 and 2 gal/1,000 gal of fluid), they can be added to existing stimulation fluids to reduce the overall surface tension of the fluid and allow faster and more complete fluid recovery. This translates into increased oil production and improvements in fluid recovery.

Zonyl® fluorosurfactants are effective in a variety of solvents for well stimulation applications. Figure 2 is a representative surface tension profile of Zonyl® fluorosurfactants in tap water. Solutions of KCl and HCl have also been tested; please see the Zonyl® Applications Guide to choose the right surfactant for your solvent system.

Figure 2:
Zonyl® Fluorosurfactants Achieve Surface Tensions Below 20 Dynes/cm* at Extremely Low Inclusion Rates



* Surface Tension in Hard Water (2.35% CaCl₂ and 1.34% MgCl₂ in deionized water)



Foam

Foaming is a desired property for many Oilfield related applications due to the ability of foams to:

- remove fines away from drill
- carry proppant
- remove water and condensate.

Zonyl® fluorosurfactants provide foaming in both aqueous and organic solvents. Please see the Zonyl® Applications Guide to choose the right foamer for your application.

Zonyl® Applications Guide

| | Zonyl® FSO/FSH/ FS-300 | Zonyl® FS-510 | Zonyl® FS-500 | Zonyl® FS-200 | Zonyl® FSG |
|---------------------------|------------------------------|------------------|------------------|------------------|---------------|
| Surface Tension Reduction | | | | | |
| HCl | ■ | ■ | ■ | ■ | |
| Water | ■ | ■ | ■ | ■ | |
| KCl | ■ | ■ | ■ | ■ | |
| Aqueous Foam | | | | | |
| Neutral | ■ | ■ | ■ | ■ | |
| Nonaqueous Foam | | | | | |
| Diesel | | | | | ■ |

The DuPont Commitment

Zonyl® fluorosurfactants are extremely effective at low concentrations and can be used in combination with existing surfactants in well stimulation fluids for faster, more complete fluid recovery. DuPont Zonyl® fluorosurfactants offer a sustainable solution to oilfield customers that is evident by DuPont's continued product availability and ongoing commitment to safety. DuPont is dedicated to the continuous improvements of our offerings, and to the EPA 2010/15 PFOA Voluntary Stewardship Program.* DuPont is committed to putting our science to work to ensure our workers are safe, the public is safe, our products are safe and the environment is well-protected.

The information set forth herein is furnished free of charge and based on technical data that DuPont believes to be reliable. It is intended for use by persons having technical skill, at their own risk. Because conditions of use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information. Nothing herein is to be taken as license to operate under or a recommendation to infringe any patents.

*PFOA is not used to make or added to our fluorotelomer surfactants but may be present at trace levels as an unintended reaction byproduct. DuPont will meet voluntary targets for reduction with the EPA 2010/15 PFOA Voluntary Stewardship Program in 2007. This will result in products that will be a "drop in" substitute for current products; Levels of PFOA and precursors that are expected to be reduced from current trace levels to below the level of quantification (currently less than 2 ppm).

**For more product information, visit our website:
www.dupont.com/zonyl or call DuPont: 1-866-828-7009.**



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