



## **Frequently Asked Questions on NanoSLICK**

### **What is NanoSLICK?**

The **NanoSLICK** product is proprietary in nature and was developed to liberate hydrocarbons from a variety of materials and media. The **NanoSLICK** base fluid can be built into several different products that share basic and inherent characteristics to act with hydrocarbons on a molecular level and cause them to lose their attraction to water, metals, minerals, and other particulate matter. **NanoSLICK** based products initiate ionic exchange to facilitate separation of materials.

### **Why does it work on hydrocarbons?**

When **NanoSLICK** contacts oil/hydrocarbons it acts as a surfactant, by reducing surface tension, and breaks the molecular bond of oil to other materials. Once the bond is broken between oil and other materials, **NanoSLICK** enhances the natural tendency of the oil to be hydrophobic and colloidal, thus promoting efficient separation. However, unlike common surfactants, **NanoSLICK** is derived from inorganic materials and will not form an emulsion. **NanoSLICK** also reduces the capillary pressure in tight formations so that fluids can be mobilized at lower pressures than they normally would. In gas wells, this enhanced fluid mobility allows gas to more efficiently move from rock to the wellbore. In oil wells the enhanced fluid mobility usually results in higher brine and oil production, long term.

### **How does it work in downhole environments?**

Many variables exist in oil formations, including mineral composition, temperature, pressure, oil type and quality, water type, and the presence of many compounds that affect the ability to produce oil/gas. **NanoSLICK** is designed to work within a wide array of variables encountered in hydrocarbon formations. Its basic functions are to release oil and gas, enhance flow characteristics (*increased permeability*), reduce corrosion, disperse paraffin and asphaltenes, and provide protection to metal production components. **NanoSLICK** based products performs these in most environments and formation types.

### **How does NanoSLICK work with water?**

**NanoSLICK** is a contact compound and uses water as a carrier. It readily disperses in water and is soluble. **NanoSLICK** will reside in the water until particle attraction causes the material to precipitate and leave a mono-layer on the rock and any tubulars that the product is attracted to. It's the properties of this mono-layer that is altering the rock properties. **NanoSLICK** does not mix with or change the characteristics of the oil. As a byproduct of the rock property alteration, the **NanoSLICK** will flip an oil wet rock to water wet and will thin the water layer that is immediately adjacent the rock so that oil and gas can move through tight pore spaces with less resistance.



### **Are NanoSLICK based products surfactants?**

No. **NanoSLICK** products have surfactant like qualities in that they readily reduce surface tension which allows oil to release from other materials. **NanoSLICK** is derived from inorganic materials; surfactants are typically made from organic materials which possess entirely different chemical properties.

### **Does NanoSLICK inhibit corrosion?**

Yes, **NanoSLICK** inhibits corrosion in several ways, it is an extreme oxygen scavenger and will draw and bind free oxygen when it can. Oxygen is one of the most prolific causes of corrosion and chemically binds with many compounds to form corrosive materials in the form of sulfides, oxides, and sulfates. These corrosive compounds and many bacteria thrive in an aerobic environment. **NanoSLICK** effectively binds the oxygen and destroys the corrosive issues. Additionally, **NanoSLICK** is highly negative in conductivity which promotes its ability to initiate ionic exchange. This combined with a silicon component in the formula make **NanoSLICK** attracted to metal. **NanoSLICK** readily bonds to metal production components leaving a microscopic layer of protection. This molecular mono-layer is held in place electrostatically. If a hole develops in the mono-layer over time, the introduction of as little as 50ppm of the product will allow the mono-layer to self-heal. Repeated applications will not cause the mono-layer to thicken over time.

### **Does NanoSLICK affect H<sub>2</sub>S?**

Yes, when designed as a H<sub>2</sub>S treatment product, **NanoSLICK** will reduce the corrosive effects of H<sub>2</sub>S by breaking the bond of hydrogen and sulfur. **NanoSLICK** also inhibits SRB related, H<sub>2</sub>S generation by not allowing oil to stick to rock. Downhole bacteria colonies feed off the oil in untreated pore space. By removing the bacteria's food source, the colony will starve and H<sub>2</sub>S generation will have been reduced.

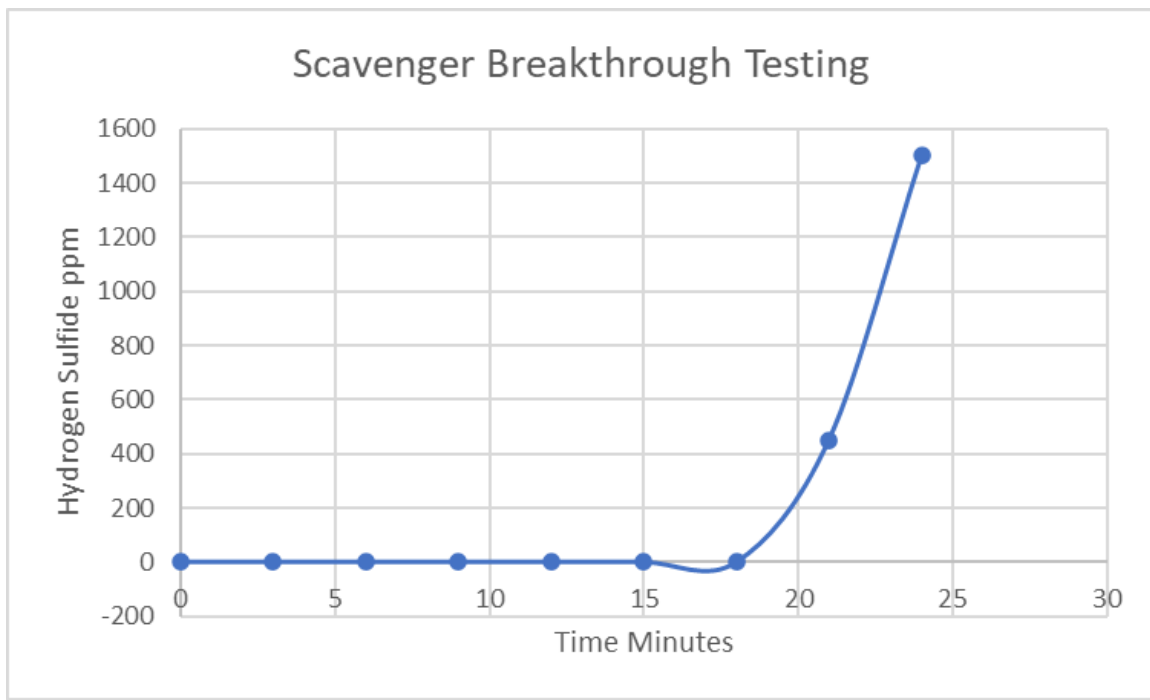
**Hydrogen Sulfide Scavenger Testing Test Method:** The procedure utilized in the hydrogen sulfide scavenger testing is as follows:

1. Product is measured and placed in the testing container.
2. Gas supply is attached to test apparatus.
  - a. System is checked for leaks prior to beginning test.
3. Gas valve is opened, and flow rate is set.
4. H<sub>2</sub>S is bubbled through the product being tested.
5. Treatment is continued until H<sub>2</sub>S is no longer consumed by the product and H<sub>2</sub>S is carried over to the detector.
6. Once H<sub>2</sub>S detector reaches 1500ppm, H<sub>2</sub>S supply is re-directed from the meter.
7. Time for breakthrough is recorded.
8. H<sub>2</sub>S continues being bubbled for 30 minutes after breakthrough.
9. H<sub>2</sub>S uptake of the product is calculated out to reported values.



Results Test is designed to bubble a hydrogen sulfide containing gas through the scavenger to simulate gas phase treatment.

The test gas is composed of 10% H<sub>2</sub>S in nitrogen and fed to the system at a rate of 241.69 mL/min. The gas is highly dispersed using a fritted glass cylinder to ensure maximum contact. Reaction is continued until rapid increase is seen from H<sub>2</sub>S carried over from the scavenger container. H<sub>2</sub>S consumed is calculated based on flow rate of gas and time of flow. Simulation of this nature does not produce a completely spent product in most chemistries but reaches a point where efficiency of H<sub>2</sub>S reaction greatly declines. Apparatus used is shown below with portion used for H<sub>2</sub>S supply on the left and sparging tower and trap on the right. Tubing connects the gas supply to sparging and tubing leaving the trap is lead to an H<sub>2</sub>S analyzer to determine H<sub>2</sub>S breakthrough during testing.



### **What effect does *NanoSLICK* have on paraffin & asphaltenes?**

When coupled with SURGITECH's FlowMor or GreenSolv products, the *NanoSLICK* it works as a solvent to breakdown paraffin build up. Once the paraffin is broken down it remains suspended in the produced oil to be carried out of the well. What makes this product line so unique is the *NanoSLICK's* molecular charge and the ionic exchange. The *NanoSLICK* initially coats and leaves a microscopic film on the production tubing. This penetrates the build-up along the surface of the pipe. Once this has taken place the microscopic barrier that now exists releases build-up and reduces surface tension which keeps the paraffin from adhering to the pipe walls going forward. The secondary reaction that occurs is the *NanoSLICK* now begins



to interact with the hydrocarbons, forcing them to release BS&W contained within the oil. At that point the **NanoSLICK** suspends the paraffin and carries it through the production system without the choke points associated with many of the other paraffin products in use, typical applications are in the 250 ppm – 750 ppm range.

### **How can NanoSLICK work in shales that are negatively charged? Won't the shale repel the negatively charged NanoSLICK material?**

Shales are interesting in that in the presence of salt water, they end up with what's called an electrical "double layer" or EDL where you have a layer of positively charged cations immediately adjacent the shale which are adsorbed on the shale due to chemical interaction and then a layer above that which is attracted to the first layer due to electrostatic attraction. The **NanoSLICK** is composed of a doubly negative anion combined with 2 cations. When then **NanoSLICK** interacts with the shale double layer, the double layer collapses due to the increased ionic strength (higher ion concentration than in the double layer) and the **NanoSLICK** ends up on the shale surface.

We know that this mechanism is working with shale because we've had the product tested at a university lab and the **NanoSLICK** permanently modified the wettability of the shale test slab. Where conventional surfactants could be applied and then rinsed off afterwards to restore the original properties of the shale, after being treated with the **NanoSLICK**, the shales slabs never went back to their original wettability state.

### **What does NanoSLICK do to perforations?**

Perforations that are fouled and choking off fluid entry from corrosion, scale, bacteria or other hydrocarbon buildups will benefit from a treatment by cleaning and opening the perforations. Once cleaned, **NanoSLICK** will deposit a molecular coating making those deposits less likely to attach to the perforations.

### **Will NanoSLICK harm my equipment?**

No, quite the opposite in fact. **NanoSLICK** will improve metal production components by cleaning and leaving a layer of protection to reduce further problems. **NanoSLICK** will act as a DRA reducing interfacial tension and surface tension. In pipeline applications, including gathering lines, **NanoSLICK** currently in the Permian Basin has reduced H<sub>2</sub>S by as much as 4%, BS&W issues are non-existent, Valve maintenance due to scale and fouling have been negated, Paraffin fouling in the gathering system has been negated and iron sulfide problems have been significantly reduced. In previous pipeline applications pig runs have been negated by as much as 80%.