# Product Bulletin

Elevance RENEWABLE SCIENCES®

## Elevance Hydraulic Fracturing Solvents (HFS)™

Global energy needs are increasing. Primary energy demand is estimated by BP to increase by 41% from 2012 – 2035, averaging 1.5% growth per year[1]. Oil and gas process chemicals are critical enablers to efficiently and effectively harvest the sources of future fuels. As such, high performance chemicals that reduce environmental impact are key to smartly providing energy for future generations through our exploration of the earth's substructure, deeper waters offshore and unconventional sources of oil and gas.

### Slickwater Fracking

Over the past 20 years there has been renewed interest in applying slickwater fracking to stimulate unconventional shale gas reservoirs[2] over traditional crosslinking/gel fracturing fluids. This is due to slickwater's ability to have:

1. Better fracture-dimension confinement
2. Longer fracture lengths
3. Higher fracture conductivity
4. Less formation damage
5. Ease of cleanup, retrieval

Slickwater fracking's better overall cost-performance versus crosslinked/gelled fracking fluids[3] explains why slickwater fracking now accounts for over 30 percent of all stimulation treatments[4]. It has become a standard technique in fracture stimulation of several U.S. shales, including the Barnett, Marcellus and Haynesville formations. While this treatment requires larger volumes of water and proppant compared to crosslinked gels, it generally contains lower levels of biocides, friction reducers and surfactants. This much-reduced chemical package means that the fluids are more easily recycled. In areas with a plentiful water supply, total treatment costs are often lower with slickwater treatments.

While the exact composition of these fluids is often proprietary, the industry recognizes the need to use chemicals that are approved by local environmental regulations. The use of benzene, xylenes and other petroleum-based components are being phased out and replaced by more environmentally friendly components. For example, d-limonene (from orange peels) is being formulated into some commercial products for oilfield applications. D-limonene-based surfactant systems reduce the surface and interfacial tension between the rock and injected fluids. The water is held in place by capillary forces that must be overcome in order for the gas or oil to enter and flow through the created fractures. In fact, "this technology lowers capillary end effects associated with well bores and fractures in low-permeability reservoirs by as much as 50 percent. In other words, it makes slick water even slicker and remediates formation damage"[5]. While d-limonene is a major component in some slickwater fracking nanoemulsions, it suffers from chronic supply issues and price fluctuations.

### The Elevance HFS™ 10 and HFS™ 12 Advantage – Physical Properties & EHS Profiles

Elevance is developing the use of our bio-based products as hydraulic fracturing solvents. Our bio-based products, Elevance HFS™ 10 and Elevance HFS™ 12, are readily biodegradable, non-flammable and are benzene, toluene and xylene (BTX) free. Manufactured in Gresik, Indonesia through Elevance's joint venture with Wilmar International Limited, our bio-based products are available in the North America and Europe. This new product complements



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## Elevance Hydraulic Fracturing Solvents (HFS)™

Elevance's entrance into oilfield applications (ranging from onshore and offshore degreasing to flow assurance enhancement).

Both Elevance HFS™ 10 and Elevance HFS™ 12 can be derived from a variety of different vegetable oils to afford a more stable supply and price structure. Elevance-based materials have similar physical properties (Table 1) and possess better hazardous classifications as compared to d-limonene[6] (Table 2).

Table 1. The Physical Property Comparison of D-limonene Versus Elevance HFS™ 10 and Elevance HFS™ 12

| **Physical Property** | **d-Limonene** | **Elevance HFS™ 10** | **Elevance HFS™ 12** |
|---|---|---|---|
| Bio-Based | Yes | Yes | Yes |
| Melting Point, °C | -74 | -28 | -35 |
| Boiling Point*, °C | 176 | 233 | 267 |
| Flash Point**, °C | 43 | 102 | 127 |
| Density, g/ml | 0.84 | 0.89 | 0.88 |
| Surface Tension, dynes/cm | 26 | 28.8 | 29.7 |

*ASTM D2887 | Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
**ASTM D93 | Flash Point by Pensky-Martens Closed Cup Tester

Table 2. The Hazard Classification Comparison of D-limonene Versus Elevance HFS™ 10 and Elevance HFS™ 12

| **Hazard Classification** | **d-Limonene** | **Elevance HFS™ 10** | **Elevance HFS™ 12** |
|---|---|---|---|
| Flammable Liquid | Category 3 (H226 Flammable liquid and vapor*) | Not classified** as Flammable Liquid | Not classified** as Flammable Liquid |
| Skin Irritation | Category 2 (H315 Causes skin irritation)* | Not classified** for Skin Irritation | Not classified** for Skin Irritation |
| Skin Sensitizer | Category 1 (H317 May cause an allergic skin reaction*) | Not classified** as Skin Sensitizer | Not classified** as Skin Sensitizer |
| Aspiration Toxicity | Category 1 or Not Classified (varies with country***) (H304 May be fatal if swallowed and enters airways*) | Not classified** for Aspiration Toxicity | Not classified** for Aspiration Toxicity |
| Aquatic Toxicity | Category 1 (H400 Very toxic to aquatic life*) | Aquatic Acute - Category 1 (H400 Very toxic to aquatic life*) | Aquatic Acute - Category 1 (H400 Very toxic to aquatic life*) |
| Aquatic Chronic Toxicity | Category 1 (H410 Very toxic to aquatic life with long lasting effects*) | Not classified** for Aquatic Chronic Toxicity | Not classified** for Aquatic Chronic Toxicity |

*Numbered hazard statements show text that must appear on SDS and product label
**Not classified as hazardous



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***Criteria varies by country so d-limonene may be classified as hazardous for aspiration toxicity by some producers in some countries

**The Elevance HFS™ 10 and Elevance HFS™ 12 Advantage – Superior Friction Reduction in Slickwater Fracking**

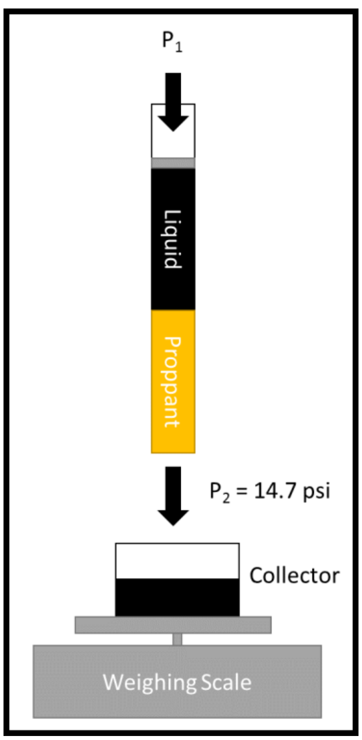
Independent lab testing of a nanoemulsion prototype has shown that those prototypes containing the Elevance HFS™ materials had:

1. Superior flowrate enhancement vs. d-limonene
2. Stability in use
3. Thermal stability

All of these should translate into improved oil recovery in the field.

The experimental design measured the friction reduction of the nanoemulsions as a function of flow rate through proppant (Figure 1).

Figure 1. The Test Method Used to Evaluate the Friction Reduction of the Various Nanoemulsions




**Nanoemulsion base:**

| | |
|---|---|
| Solvent | 24 wt% |
| BioSoft® N91-6 - Nonionic surfactant | 60 wt% |
| Dowanol DPM™ - Coupling agent | 16 wt% |

**Solvents Tested:**

D-Limonene
Elevance HFS™ 10
Elevance HFS™ 12

**Model Hydraulic Fracturing Fluid Composition:**

0.20% aq. Xanthan gum

**Composition of the microemulsion was held constant:**

Concentration: 0.2 wt%

**Proppant:**

Uncoated sand (20/40 mesh)

**Temperature:**

25°C

The proppant was placed into the tube flowed by the test nanoemulsion and pressure was applied with the material collected weighed as a function of time and plotted (Figure 2).



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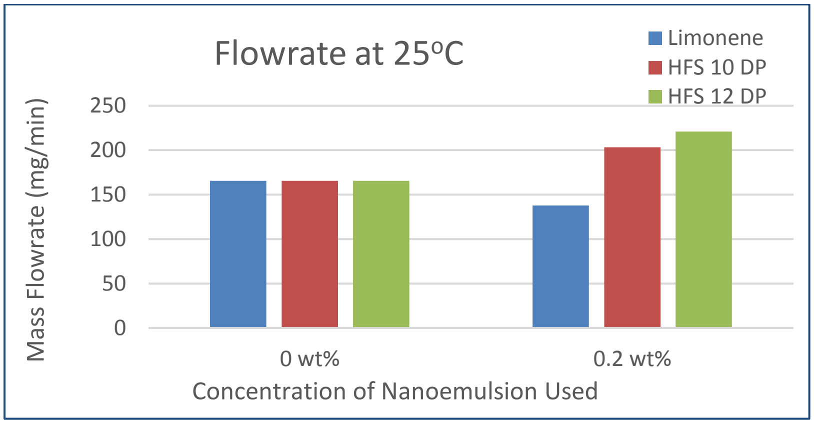
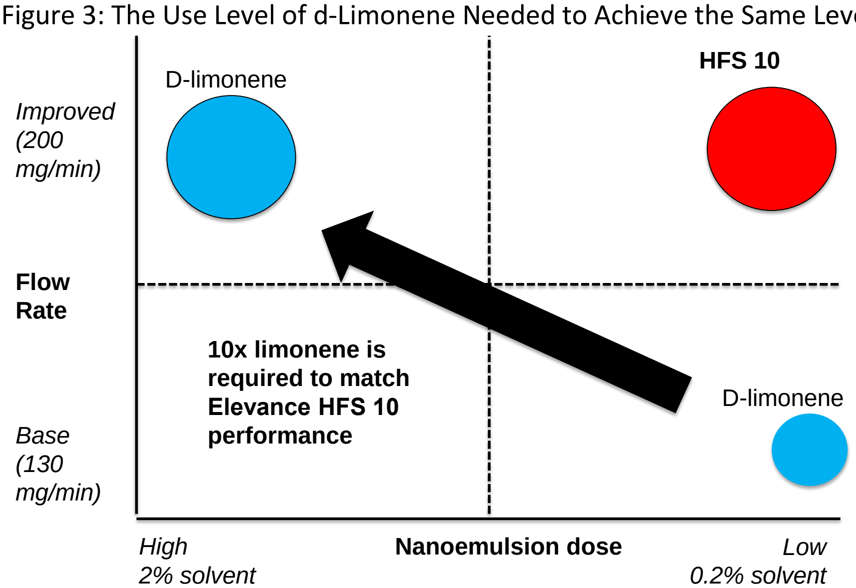
Figure 2: The Mass Flowrate of the Three Nanoemulsions (average of 3 readings)




The test was run using the nanoemulsion at the 0.2 wt% level with an equal amount of the xanthan gum thickener as this most closely matched the typical use rate of a d-limonene-based complex nanofluid[5]. In our studies, Elevance's HFS™ 10 and HFS™12 clearly outperformed the corresponding d-limonene-based nanoemulsion.. Additional studies showed that to achieve the same level of performance seen for the Elevance HFS™ 10 and Elevance HFS™ 12 products, the concentration of d-limonene in the slickwater nanoemulsion needed to be 10 times higher (2.0 wt%)!

Figure 3: The Use Level of d-Limonene Needed to Achieve the Same Level of Performance of HFS at 0.2 wt%




Finally, these prototype nanoemulsions were prepared and heated to 60°C for two hours to assess their homogeneity (stability) before, during and after each use. In each case, no phase separation was detected,

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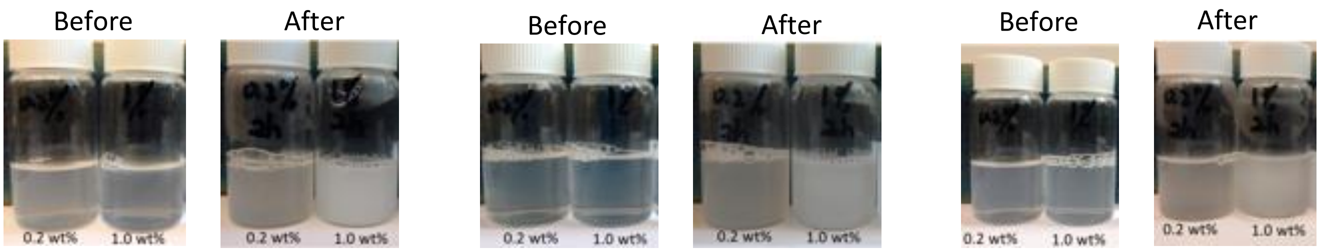
suggesting little or no complication associated with delivery or retrieval (Figure 4).

Figure 4: The Heat Stability of the Nanoemulsions Before and After Two Hours at 60°C




D-Limonene Elevance HFS™ 10 Elevance HFS™ 12

**Conclusion - Elevance HFS™ 10 & Elevance HFS™ 12 are Clearly Superior Performance in Slickwater Fracking**

Elevance HFS™ products offer a new level of performance in nanoemulsion technology for slickwater fracking. Their low inherent surface tension values, coupled with their superior environmental, health and safety profile versus d-limonene, makes them suitable candidates in slickwater fracking applications.

The initial testing of formulated nanoemulsion prototypes, using either the Elevance HFS™ materials or d-limonene, showed that the Elevance HFS nanoemulsions afforded:

1. Superior flowrate enhancement vs. d-limonene
2. Stability in use
3. Thermal stability

This should translate to enhanced oil recovery in the field.

Finally, since these Elevance materials can be derived from multiple vegetable oil sources (e.g. palm, soybean and canola), Elevance can provide a large, secure supply of materials to ensure price stability/competitiveness when compared to d-limonene[7].

## References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