

## Chemical Descriptions for Marcellus Shale Wells

The purpose of this document is to allow a better understanding of the chemistry that is commonly used in stimulating a Marcellus shale well. An explanation of the entire completion process is needed to understand the closed system in which the chemicals are injected into the fluid system and enter an isolated and specific formation. Additional documentation will lay-out the supporting information.

### Stimulation Chemicals

Below is a list of the typical chemicals used on Marcellus Shale wells completed by Universal Well Services, Inc. along with their function and typical loadings.

**FRP-121-** FRP-121 is a granulated anionic polyacrylamide based friction reducer used to reduce the friction pressure in surface lines and down the well casing during pumping operations. The typical loading for FRP-121 is 3-5 lb/1000 gal throughout the entire treatment.

**Flomax 70-** Flomax 70 is a nonionic micro-emulsion surfactant used to increase the recovery of injected water into a well. It has a typical loading of 2 gpt. Flomax 70 can be run throughout the entire treatment or just during the first portion of the job.

**EC6116A-** EC6116A is a bromine based biocide used to quickly kill organisms encountered in oilfield operations. The typical loading for EC6116A is 0.25 gpt throughout the entire treatment.

**Scalehib 100-** Scalehib 100 is a liquid polymer based scale inhibitor used to control the precipitation of calcium carbonate, calcium sulfate, barium sulfate and strontium sulfate. The typical loading for Scalehib 100 is 55 gallons injected during the pad.

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## Typical Treatment

The typical vertical well stimulation for Fortuna in the Marcellus shale consists of the following chemical summary. The clean fluid volumes range from 500K -700K gallons.

<i>Universal Product</i>	<i>Injection Duration</i>	<i>Concentration during injection</i>	<i>Volume Used</i>	<i>Concentration in total fluid</i>
				wt% in frac fluid
<b>FRP-121</b>	Entire Treatment	5 #pt	2500 lbs	0.06%
<b>Flomax 70</b>	First ½ of Treatment	2 gpt	500 gals	0.085%
<b>EC6116A</b>	Entire Treatment	0.25 gpt	125 gals	0.03%
<b>ScaleHib 100</b>	First 10,000 gals	5.5 gpt	55 gals	0.013%

*Note: Table based on 500,000 gals clean fluid  
gpt → gallons of chemical per 1000 gallons of clean fluid  
#pt → lbs of chemical per 1000 gals of clean fluid*

## Chemical Breakdown

The following table outlines the components of our frac fluids that are either listed on MSDS's or main components known to be found in the products.

<i>Universal Product</i>	<i>Loading</i>	<i>Density</i>	<i>Components</i>	<i>% Range</i>	<i>wt% in frac fluid</i>
<b>FRP-121</b>	5#pt		Anionic Polyacrylamide	98-100%	0.06%
<b>EC6116A</b>	0.25 gpt	10.4	Dibromoacetonitrile	1-5%	0.00156%
			2,2- Dibromo -3-nitrilopropionamide	10-30%	0.00935%
			Polyethylene Glycol	30-60%	0.01871%
<b>Flomax 70</b>	1 gpt	7.76	Methanol		0.085%
			Surfactant		0.085%
<b>Scalehib 100</b>	0.1 gpt	9.8	Ethylene Glycol	30-60%	0.00705%
			Polyacrylate		0.009%

*Note: wt% was taken from high range value*

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## Common Uses for Components

The following paragraphs compare the components of the typical Marcellus shale chemicals to products used in other industries or by the general public.

### Anionic Polycrylamide

Polyacrylamide is a polymer of acrylamide subunits that can be readily cross-linked. The primary non-oilfield use of polycrylamide (PAM) is in erosion prevention. Granular PAM is mixed with water and sprayed onto disturbed earth. The sediments suspended by PAM exhibit increased flocculation, reduce stormwater runoff turbidity thus improving water quality. A state stormwater quality association recommends in their handbook to mix ½ - 1 pound of PAM with 1000 gals of water to be sprayed directly on 1 acre of disturbed area. This would equate to a **wt% in frac fluid of 0.012%**. Toxicity and environmental impact testing have been completed by other industries on the PAM system and at their loadings have a minimal impact.

Other uses of PAM include; paper making process and waste water management as a flocculating agent, manufacturing process for soft contact lens, and a component of water expandable children's toys.

### 2.2- Dibromo -3- nitrilopropionamide (DBNPA)

DBNPA is a common pesticide used as a algicide, bactericide and fungicide (slime forming algae, bacteria and fungi; preservative (additive); fungicide (mold and mildew). The tables below lists the common in which DBNPA is used and there common %wt in the fluid.

<i>Aquatic non-food industrial</i>	
<b>Process</b>	<b>%wt in fluid</b>
<b>Pulp / Paper Mills</b>	0.0002% - 0.02%
<b>Cooling water systems</b>	0.0024%
<b>Heat exchangers</b>	0.0007% - 0.0024%
<b>Lab equipment (water bath)</b>	0.0024%

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<i>Indoor non-food</i>	
<b>Process</b>	<b>%wt in fluid</b>
<b>Preservative Uses: Industrial adhesives; Metal working cutting fluids; Latex/oil/varnish paints (applied films)</b>	0.002% - 0.2%
<b>Industrial preservative uses: Industrial coatings; resin/latex/polymer emulsions; Latex paints (in-can)</b>	0.001% - 0.2%

DBNPA is also used in food packaging and regulated by the FDA.

### Dibromoacetonitrile

No other common uses found at this time.

### Polyethylene Glycol (PEG)

Polyethylene glycol has a low toxicity and is used in a variety of products. It is the basis of a number of laxatives (e.g. macrogol-containing products such as Movicol and polyethylene glycol 3350).

Each 13.7g sachet of MOVICOL Plain contains the following:

- Macrogol (Polyethylene glycol) 3350: 13.125 g
- Sodium chloride: 0.3508 g
- Sodium hydrogen carbonate: 0.1786 g
- Potassium chloride: 0.0502 g

It is the basis of many skin creams, as cetomacrogol. When attached to various protein medications, polyethylene glycol allows a slowed clearance of the carried protein from the blood. PEG is used in toothpaste as a dispersant; it binds water and helps keep gum uniform in the paste.

### Methanol

The most common use of methanol is in the formation of other chemicals. About 40% of methanol is converted into formaldehyde, which is then used to make products such as plastics, paints, explosives, and permanent press textiles.

Methanol is also used as a solvent, and as an antifreeze in pipelines and windshield washer fluid. **A gallon jug of windshield washer fluid contains 31% methanol by weight.**

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## Surfactant

The exact surfactant chemistry that creates the micro-emulsion formulation in UWS surfactant solutions is proprietary to UWS, but has been given to the DEC by our suppliers. The following paragraphs discuss surfactants in a general basis.

The term 'surfactant' is a blend of "**surface acting agent**". Surfactants are usually organic compounds that are amphiphilic, meaning they contain both hydrophobic groups (their "tails") and hydrophilic groups (their "heads"). Therefore, they are soluble in both organic solvents and water. Surfactants reduce the surface tension of water by adsorbing at the liquid-gas interface. They also reduce the interfacial tension between oil and water by adsorbing at the liquid-liquid interface.

Surfactants play an important role in many practical applications and products, including: detergents, fabric softeners, paints, inks, anti-fogging agents, ski wax, foaming agents, laxatives, hair conditioners and agrochemical formulations (herbicides & insecticides)

## Ethylene Glycol

Ethylene Glycol is used as antifreeze in cooling and heating system (automobile), in hydraulic brake fluids, as an ingredient of electrolytic condensers, as a solvent in the paint and plastics industries, in the formulations of printers' inks, stamp pad inks, and inks for ballpoint pens, as a softening agent for cellophane, and in the synthesis of safety explosives, plasticizers, synthetic fibers (Terylene, Dacron), and synthetic waxes. Ethylene glycol is also used to de-ice airport runways and aircraft.

## Polyacrylate

Acrylates and acrylic chemistry have a wide variety of industrial uses that include:

- Sequestering agents in detergents. (By binding hard water elements such as Ca and Mg, the surfactants in detergents work more efficiently.),
- Thickening agents.
- Coatings.
- Super absorbent polymers. These cross-linked acrylic polymers are used in baby diapers. Co-polymer versions are used in agriculture and other specialty absorbent applications.