An Introduction to

Suspension Concentrates

30% to 70% Suspension of Fine Insoluble Particles
Pesticides, Biocides, Chemicals, Abrasives, Pigments

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Suspension Concentrates

**Formulation Goals:**

- Maximize Suspension Uniformity and Stability
- **Minimize Viscosity / Optimize Fluidity**
- Optimize Dilutability

A readily pourable or pumpable concentrate is usually preferred to facilitate addition to the target medium and to ensure maximum evacuation of the concentrate’s container.

Suspension Concentrates

**Formulation Goals:**

- Maximize Suspension Uniformity and Stability
- Minimize Viscosity / Optimize Fluidity
- **Optimize Dilutability**

When added to dilution water or a target formulation, the concentrate should disperse evenly and uniformly.
Suspension Concentrates

Basic Ingredients:

Water

Insoluble Particles (pigment, biocide, etc.)

Wetting Agent

Dispersing Agent

Water may be from the local supply or softened to reduce reaction of hardness (Mg, Ca, Fe) with wetting and dispersing agents.

Suspension Concentrates

Basic Ingredients:

Water

Insoluble Particles (pigment, biocide, etc.)

Wetting Agent

Dispersing Agent

There are usually particle size requirements to ensure proper bioactivity, chemical activity, color strength, etc.

If the particles are pre-milled to the required size, they are simply dispersed in the liquid phase. For toxic actives, a coarser size is often used; milling and suspension formation are simultaneous in a media mill.
**Suspension Concentrates**

**Basic Ingredients:**
- Water
- Insoluble Particles (pigment, biocide, etc.)
- **Wetting Agent**
- Dispersing Agent

Most fine particles are not easily wet by water because of occluded air and/or natural hydrophobicity. This is a particular problem at high concentrations.

The wetting agent molecule has a portion with an affinity for the particle surface and a portion with an affinity for water. It facilitates intimate contact of the liquid with particle surfaces.

Wetting agents for concentrates are usually nonionic surfactants.

![dispersed, but not wet](image1.png)

![well wet](image2.png)
Suspension Concentrates

Basic Ingredients:
Water
Insoluble Particles (pigment, biocide, etc.)
Wetting Agent

Dispersing Agent
The dispersant keeps the wetted particles separated and mutually repulsed. Most are anionic: one portion has an affinity for the particle, and the hydrophilic anionic group extends into the water.

Dispersing agents are generally poor wetting agents, but some wetting agents are also dispersants.
Suspension Concentrates

Often Included Ingredients:

**Antifreeze (glycol)**
Evaporation Control Additive (glycol)
Preservative
Antifoam
Suspending Agent(s)

A glycol, e.g. propylene glycol, is added to depress the freezing point if the dispersion will be stored or transported in a sub-freezing environment.

Suspension Concentrates

Often Included Ingredients:

Antifreeze (glycol)
**Evaporation Control Additive (glycol)**
Preservative
Antifoam
Suspending Agent(s)

A glycol is added to retard surface evaporation and skinning if it is likely that the container of concentrate will be left uncovered for extended periods during normal use.
A preservative is used when the concentrate's organic ingredients (wetting agent, dispersant, suspending agent) are susceptible to degradation by bacteria or fungi.

The surfactants used as wetting agents are often sufficiently surface active to form air bubbles in the concentrate, which suspending agents can make difficult to remove. An antifoam is used to inhibit bubble formation.
Suspension Concentrates

Often Included Ingredients:
Antifreeze (glycol)
Evaporation Control Additive (glycol)
Preservative
Antifoam

Suspending Agent(s)

Some dispersions are made without a suspending agent because the particle size is extremely fine, the concentration is very high, or the viscosity is high.

The rest rely on suspending agents for optimum stability.

Often Included Ingredients:

- Antifreeze (glycol)
- Evaporation Control Additive (glycol)
- Preservative
- Antifoam

**Suspending Agent(s)**

A suspending agent will impart yield value to the dispersion: the insoluble particles remain separated and suspended. A suspending agent is usually a thickener as well, but not all thickeners are suspending agents.

<table>
<thead>
<tr>
<th>Suspending Agent</th>
<th>Thickener</th>
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</thead>
<tbody>
<tr>
<td>Smectite Clay</td>
<td>CMC</td>
</tr>
<tr>
<td>Magnesium Aluminum Silicates</td>
<td></td>
</tr>
<tr>
<td>Bentonite Clays</td>
<td></td>
</tr>
<tr>
<td>Xanthan Gum</td>
<td>Nonionic Cellulosics</td>
</tr>
<tr>
<td>Xanthan Gum No. 1</td>
<td>Polyacrylates</td>
</tr>
<tr>
<td>Attapulgite</td>
<td></td>
</tr>
<tr>
<td>Crosslinked Polymers</td>
<td></td>
</tr>
</tbody>
</table>

Combinations of suspending agents (smectite + xanthan gum) or suspending agent and thickener (smectite + CMC) are synergistic and can be more effective in balancing suspension stability, fluidity and cost. A synergistic combination can also provide processing advantages.
SUSPENDING AGENTS

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAN GEL B</td>
<td>The standard economical grade for most suspensions</td>
</tr>
<tr>
<td>VAN GEL ES</td>
<td>The most electrolyte tolerant grade</td>
</tr>
<tr>
<td>VAN GEL SX</td>
<td>Smectite clay/Xanthan Gum blend; high efficiency stabilizer</td>
</tr>
<tr>
<td>VANATURAL</td>
<td>OMRI listed purified bentonite clay</td>
</tr>
<tr>
<td>VEEGUM</td>
<td>The standard grade for a wide range of applications</td>
</tr>
<tr>
<td>VEEGUM CER</td>
<td>Smectite clay/CMC blend; high efficiency stabilizer</td>
</tr>
</tbody>
</table>

Several additional grades are available to match formulation requirements.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VANZAN</td>
<td>The general purpose grade suitable for most applications</td>
</tr>
<tr>
<td>VANZAN D</td>
<td>Surface-treated to facilitate dispersion without lumping</td>
</tr>
</tbody>
</table>

DISPERsing AGENTS

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DARVAN 2</td>
<td>Sodium lignosulfonate</td>
</tr>
<tr>
<td>DARVAN 670</td>
<td>Sodium polynaphthalenesulfonate</td>
</tr>
<tr>
<td>DARVAN 7-N</td>
<td>Sodium polymethacrylate</td>
</tr>
<tr>
<td>DARVAN 811</td>
<td>Sodium polyacrylate</td>
</tr>
<tr>
<td>DARVAN 821A</td>
<td>Ammonium polyacrylate</td>
</tr>
</tbody>
</table>

Several additional grades are available to match formulation requirements.

Making Suspension Concentrates

Wet-Mill Method

Dispersion Method
Wet-Mill Method

Dispersion Method

Water, wetting agent, dispersant, coarse particles and all other ingredients that are not shear degradable are added to a media mill: Attritor® (pictured), ball mill, bead mill, sand mill.

The suspension is formed as the particles are milled to the required size. Shear degradable ingredients, particularly any that will increase viscosity (e.g., xanthan gum) are added at the end of the process with only enough milling to dissolve them.
Making Suspension Concentrates

**Wet-Mill Method**

Smectite/Xanthan Gum Stabilization

The smectite is added with all ingredients, except the xanthan gum. While milling, the clay delaminates.

The clay contributes no viscosity, so milling efficiency is maintained. When the particles have been reduced to target size, the xanthan gum is added and interacts with the clay to form the suspension system.

**Example: Wet-Milled Suspension Concentrate**

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VAN GEL B®</strong> magnesium aluminum silicate</td>
<td>0.25</td>
</tr>
<tr>
<td>Water</td>
<td>22.87</td>
</tr>
<tr>
<td>Na Polynaphthalenesulfonate</td>
<td>2.50</td>
</tr>
<tr>
<td>Propylene Glycol</td>
<td>10.00</td>
</tr>
<tr>
<td>Surfynol® 104H acetylenic diol</td>
<td>0.05</td>
</tr>
<tr>
<td>Triton® X114 ethoxylated nonylphenol</td>
<td>0.20</td>
</tr>
<tr>
<td>Preservative</td>
<td>0.20</td>
</tr>
<tr>
<td>Flour Sulfur</td>
<td>64.00</td>
</tr>
<tr>
<td><strong>VANZAN®</strong> xanthan gum</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Making Suspension Concentrates

Wet-Mill Method

Dispersion Method

The particles are already at their required particle size. Using a dispersing mixer, the suspension system (e.g., smectite/xanthan gum) is hydrated first.

Then wetting and dispersing agents are added followed by the particles until they are well dispersed. The remaining ingredients are then added.

Alternatively, the xanthan gum can be held until the end so that viscosity is minimized while the particles are dispersed.