Adding nanopowders to liquids

Today’s nanopowder applications vary widely. Inkjet inks that require very fine droplets incorporate nanoparticle pigments. Powdered drink mixes contain nanoparticles that make the powder reconstitute faster and more completely. Pharmaceuticals contain nanoparticles that increase dosage effectiveness with a smaller quantity of the costly active ingredient. Construction materials are stronger or more elastic because of the nanoparticles they contain.

The value of using nanopowders is the greater surface area they have in comparison to larger particles. Their greater surface area means that the material’s innate characteristics are magnified many times. So, for example, you can produce a much stronger material by adding a small quantity of your strengthening ingredient in nanopowder form than by adding a larger quantity of the same ingredient in micron-size or larger particles.

To give you an idea of the impact of nanoparticles versus larger particles, let’s look at the example of a powder with a specific gravity of 2.0. If you had a cube-shaped 1-pound particle of this material, it would be 2.4 inches by 2.4 inches by 2.4 inches, giving it 14.4 square feet of surface area. That same pound of material in the form of 60-micron particles would produce 244 square feet of surface area (1 billion particles). That same pound made up of 60-nanometer particles would produce about 0.25 million square feet of surface area (10^18 particles).

Adding the nanoparticles to liquid

The use of nanopowders is relatively new in many industries and can present challenges. One challenge is effectively incorporating these minute particles into a liquid.

To add a nanopowder to a liquid, you’ll likely use one or both of two common mechanisms: wetting the powder and dispersing the powder. (A third common mechanism, maintaining a dispersion, isn’t an issue with nanoparticles; unlike many larger particles, nanoparticles typically don’t settle out of a mixture.)

Wetting the powder

Some powders have a tendency to float on the liquid surface in a vessel rather than mixing properly. For example, if you try to make a chocolate drink by putting cocoa powder into milk, you’ll find that the cocoa powder sits on the surface and resists mixing with the milk. On the other hand, chocolate drink mix powder, which is mostly sugar, blends right in. The chocolate drink mix powder has wetted (or wetted out) and combined with the liquid, but the cocoa hasn’t. This is because cocoa is a fat and has a higher surface tension than sugar, and particles with high surface tension repel liquid rather than blend with it.

One technique for blending a high-surface-tension nanopowder into a liquid is to use a mixer that creates a vortex, such as a mixer that has an open impeller (or agitator) and no baffles. Open impellers include propellers, pitched-blade turbines, and others. The vortex produced by the impeller increases and renews the mixture’s surface area, giving the powder more opportunity to blend in.

Also consider how fast you’re adding the nanopowder to the liquid. If you add it too fast, you’ll flood the vortex, not allowing it to do its work of blending the powder into the mix. Flooding the vortex can also result in annoying fisheyes — clumps or lumps a few millimeters long that have a hard outside shell enclosing dry powder. Once a fisheye forms, a conventional mixer generally can’t break it up. The result is not only unattractive but unpalatable in a food product and harmful to some products’ effectiveness.

Dispersing the nanopowder

Some nanopowders tend to clump or agglomerate. To get the nanopowder’s full effect, it’s important to break up these clumps and distribute the nanoparticles throughout the mixture. High shear provided by a rotor-stator or an impeller with a sawtooth blade can break up many of these agglomerates, but sometimes this isn’t sufficient, or the nanopowders begin clumping again when the high-shear mixing stops. In such a case, you may need to add a dispersant (also called a surfactant) to your mix.

A dispersant acts like laundry soap: One end of a soap molecule is nonpolar to...
hold on to the dirt and the other end is polar to be soluble with the water. This keeps the dirt particle in suspension in the water. In a similar manner, a dispersant can keep your clumping nanoparticles in suspension rather than in clumps.

Many different dispersants are available. To keep your nanoparticles from agglomerating, you’ll need enough dispersant to coat each particle. Think about it as if you were going to paint the entire surface of each particle in the 1-pound sample previously described. To paint the 60-micron sample you would need enough paint to cover 244 square feet, but the very same quantity of material in the 60-nanometer sample would require enough paint to cover 250,000 square feet! So if your nanopowder requires a dispersant, you’re going to need a lot of it, which will require changing your product’s recipe.

Whether you need a dispersant is a factor to consider if you’re not using nanopowders now but plan to switch to them. Do thorough testing prior to switching to find out if you’re going to need a dispersant.

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