Preparing superior quality nanodispersions

Role of nanomaterials in modern products

Modern products and devices always have a way of evolving either out of need or opportunity. This time, advanced nanomaterials have something to do with it. Nanomaterials possess novel quantum mechanical properties because of their size (100 nanometers or smaller in at least one dimension). By incorporating nanomaterials into existing products, they enhance certain properties or provide new functionalities, such as increased strength, improved heat or chemical resistance, better conductivity, etc. And it seems this “evolution” is virtually all across the board, too. Nano-enabled products cover a whole gamut of fields and applications including electronics and semiconductors, textiles, energy, food, drug delivery, chemicals and advanced materials, printing and packaging, automotive, aerospace and defense, medical devices, etc.

For manufacturers, this trend comes with a new set of unique processing challenges, including the efficient mixing and dispersion of nanoparticles into a formulation.
Mixing equipment for nanodispersions

Various mixing technologies are available for the efficient processing of products containing nanomaterials depending on rheology and shear requirements.

Low-Viscosity Nanodispersions. The dispersion of nanomaterials into a low-viscosity formulation typically involves a pre-mix stage to combine the raw materials. This is done with the use of low-speed propellers, turbines, or simple agitators. Due to attractive forces between the individual nanoparticles, they combine with the liquid vehicle in the form agglomerates. High shear forces are necessary to break up these groups of agglomerates. How aggressive those shear forces need to be can vary from one formulation to another. One proven method is the use of Ross Ultra-High Shear Mixers, specially engineered rotor/stator devices that run at extremely high Ross MegaShear used for dispersing and debundling carbon nanotubes in a resin matrix.

Medium-Viscosity Nanodispersions. Higher loadings of nanoparticles can result in a premix of substantial viscosity, rendering single-shaft devices inadequate. For these requirements, a multi-shaft mixing system is recommended wherein two or more independently-driven agitators work in tandem such as a low-speed anchor agitator, a saw-tooth disperser blade and a rotor/stator assembly equipped for powder induction. This configuration provides a unique combination of laminar bulk flow, high shear mixing, dust-free sub-surface powder addition, deagglomeration and superior heat transfer. After a batch cycle, the nanodispersions may be further polished by running it through an Ultra-High Shear Mixer.

High-Viscosity Nanodispersions. As product viscosity continues to build up, a multi-shaft mixing system will eventually fail to produce adequate flow. When agitators with a fixed axis of rotation no longer suffice, a move to a planetary mixer is required. The agitators of a planetary mixer rotate and travel through the mix vessel by passing through every point within the batch – regardless of product rheology. Examples are the classic Double Planetary Mixer (DPM) and “hybrid” planetary mixers featuring one or two stirrer blades (similar to those in a DPM) supplemented by one or two high speed disperser shafts which also revolve on their own axes while orbiting the mix vessel.

Sample Application: Nano-Silver Paste for Semiconductors

A uniform dispersion of silver nanoparticles into a binder solution is achieved in a Ross Double Planetary Mixer under vacuum. After mixing, the paste is fed into a Ross Three Roll Mill to break down any agglomerates. The milled material exhibits a markedly glossier, more homogenous appearance indicating an improvement in dispersion quality.