

A Quadro Engineering White Paper



QUADRO

Leading Process Equipment Innovation

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Cutting Costs in Submicron Processing Is There a More Productive Way?

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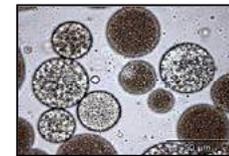
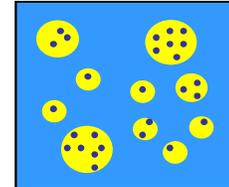
May 7, 2009

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Industry Issue

Today there are numerous consumer products on the market that take advantage of the benefits submicron emulsions or dispersions have to offer. Reduced droplet sizes can have various desirable effects on the characteristics of an emulsion. Fluidity or the optical properties of a mixture may be altered, while improving stability and reducing the need for thickening agents to avoid the sedimentation of ingredients. Another benefit to a topical emulsion such as in a cream or lotion is the ability for submicron droplets to enter the rough surface of the skin and form an occlusive film that enhances penetration of active ingredients (i.e. vitamins, antioxidants, etc.) or improve the protection characteristics of a sunscreen. Submicron droplets can even be suspended in larger droplets to form a multiple emulsion (i.e. Water-in-Oil-in-Water), which can be used for the sustained release of additive ingredients over time so long as the breakdown process is controlled on application.



■ oil ■ water

There are a couple of processing methods currently used to produce submicron emulsions, however they all suffer from similar limitations. Restricted capacity and high energy consumption are common hurdles processors have to overcome in order to produce product cost effectively. What then is a company to do if they're looking to increase productivity while cutting cost on submicron processing?

Previous Options

One of the most common methods for producing fine emulsions and achieving submicron size reduction is the use of high-pressure valve homogenizers. Like colloid mills, they are more effective at reducing the size of droplets in a pre-emulsion than they are at creating an emulsion from two separate liquid phases. To resolve this issue, a coarse emulsion is usually produced using a high-shear rotor-stator mixer which is then fed directly into a high-pressure valve homogenizer. The homogenizer has a piston pump that pulls the coarse emulsion into a chamber on its backstroke and then forces it through a narrow valve at the end of the chamber on its forward stroke. As the coarse emulsion passes through the valve it undergoes intense disruptive forces that result in the breakdown or size reduction of larger drops into smaller ones.

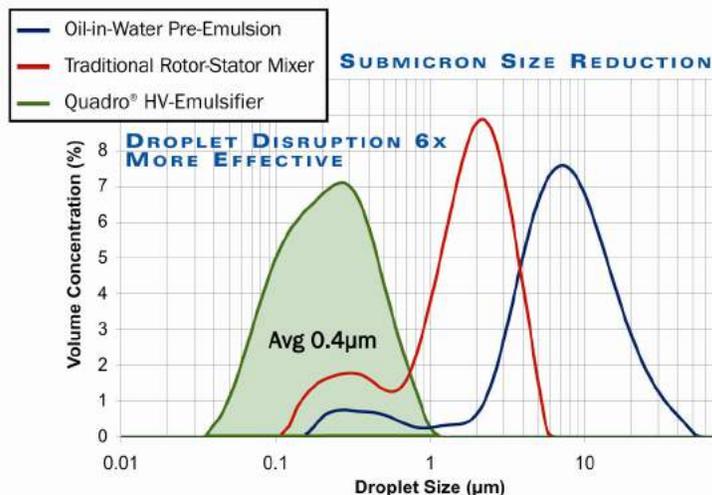
Over the years different types of valve nozzles have been designed to increase the efficiency of droplet disruption for various kinds of applications. Most commercial homogenizers use a spring-loaded valve so the narrow gap can be adjusted (typically between 15 and 300 μm). Decreasing the gap size increases the pressure dissipation across the valve resulting in improved droplet size reduction; however as a consequence the energy requirements to form the emulsion significantly increase which raises the cost of production. As a result, if very fine emulsion droplets are required for an application the choice is often made to pass the emulsion through the homogenizer a number of times rather than considerably increasing process pressure. The use of narrow valve nozzles also limits production capacity, as most industrial homogenizers are typically restricted between 0.5 and 50 gpm (1.7 to 190 l/min). The restricted capacity of a valve homogenizer requires long batch times for large production volumes, which raises the cost of processing even further.

A large gap in performance is perceived in the industry between high-pressure valve homogenizers and traditional high-shear rotor-stator mixers. Rotor-stator mixers have typically been used to produce coarse emulsions with an average size reduction down to approximately 2 μm . But what if there was a way to achieve submicron size reduction with rotor-stator technology? The result could potentially be an ideal blend of increased productivity and cost reduction with higher throughput capacities and lower power consumption.

Quadro Solution

Quadro Engineering has recently developed a breakthrough in rotor-stator technology that defines new limits in shear energy and closes the gap in performance between traditional in-line mixers and high-pressure valve homogenizers. With unique high velocity rotor technology, the Quadro[®] HV-Emulsifier can generate more than 30x the disruptive forces of a traditional rotor-stator mixer.

Submicron droplet size reduction can now be easily achieved without the use of a high-pressure homogenizer. Unlike colloid mills or valve homogenizers, the HV technology is effective at creating a submicron emulsion from two separate liquid phases in addition to reducing the size of droplets in a pre-emulsion. This means that the traditional setup of a rotor-stator mixer feeding a valve homogenizer can now be displaced with a single machine while increasing productivity and cutting costs.



The HV-Emulsifier is offered in three different model sizes, starting at capacities below 50 gpm (190 l/min) and ranging up to 250 gpm (950 l/min) for the largest unit. With significantly higher production capacities, an HV solution can displace a valve homogenizer setup at roughly 30% of the initial investment while increasing manufacturing productivity to new levels. Since the droplet disruption mechanism of the HV does not depend on high homogenization pressure (i.e. ~500-3000 psi), there are less wearing components to be concerned with and lower overall service requirements for the machine. Annual maintenance costs can often be as low as 10% of those required for a high-pressure homogenizer.



The high velocity size reduction mechanism of the Quadro[®] HV-Emulsifier defines new limits in rotor-stator technology leading to innovative opportunities in submicron processing. The industry issues of restricted capacity and high energy consumption leading to costly submicron emulsions can now be overcome with an HV solution to maximize productivity while cutting the cost of production.