With New Dispersing Technologies Towards Nanoscale Systems

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ABSTRACT

The presentation will give an overview of state-of-the-art technologies and today's possibilities as well as technical and regulatory limitations. The focus will be on the potential of a new generation of homogenizers, which allow for the efficient and energy-saving dispersion of cosmetic formulations. Examples of modern formulations with its specific technological requirements are presented.

Keywords: nanoscaled systems, technologies, emulsion, lipsomes, dispersion, formulations

1 NANOTECHNOLOGY

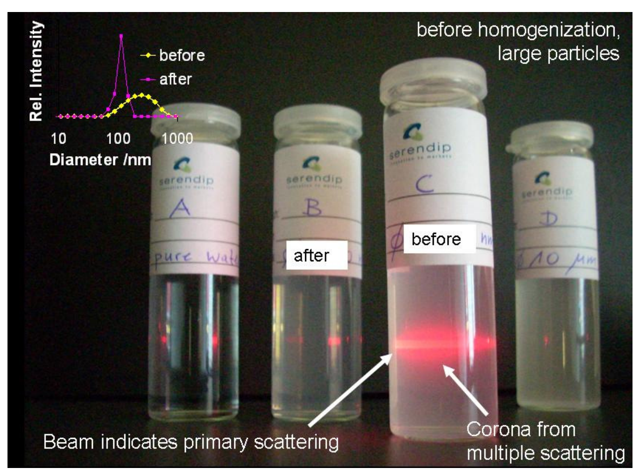
During the last decades, nanotechnology has become an integral part in research and development. Effort in the field of nanoparticle synthesis and analysis as well as the development of their industrial fabrication processes allowed for the emergence of an interdisciplinary science with new and widespread applications. Simultaneously, the development of suitable analytical techniques such as electron microscopy permitted deeper insights in the structure of materials. As indicated by the name, the main feature in nanotechnology is the particle dimension and it is known that the consequent reduction of the latter one can give rise to significant changes in the particle properties.

Nanoparticle production is described either by the "bottom-up" or the "top-down" approach, e.g., the assembly of particles starting from the molecular level or the subsequent particle downsizing of macro-material. Very often, the pathway for molecular assembly is not accessible as raw products provided by nature exist as macro-sized and "pre-formed" material. Here, new technologies are required that allow for efficient and economical dispersing resp. homogenization of materials towards nanoscale products.

2 WHY ARE SMALL PARTICLE SIZE AND HOMOGENEITY IMPORTANT?

In various application fields, small particle size is essential for an improvement of product quality. For example, colors in paints or lacquers develop an enhanced level of brilliance and may even display special effects, when the pigments in the film are small and homogeneous in size. This holds true also for coatings, where the scratch resistance is based on effects from the small particle dimension. Further, dispersions based on waxes, resins and various other classes are economically important in various industrial sectors and their properties depend considerably on size. When applications in the field of cosmetics are concerned, the search for a suitable type of transport medium (e.g. emulsion, liposomes, etc.) is as important as the particle physico-chemical parameters, such as size and size distribution. This is due to the general observation that small particles are often more stable and more capable of undergoing skin penetration. As a consequence, the delivery effect is more pronounced in this case.

In the following, we would like to give an example illustrating the importance of size and homogeneity. In certain cases, products with pleasing optical properties with high degree of transparency are required. Generally, transparency is enhanced, when the particles in the dispersion are preferably small and homogeneous. The optical aspect of the sample can be visualized by laser light transillumination. In Fig. 1, a dispersion with a broad spectrum of particles sizes in the submicron range is shown before homogenization. At first sight, the sample appears indeed homogeneous but it is perceptible that the opalescent character is limited due to the blearing effect resulting from the fraction of large particles. Dynamic Light Scattering (DLS) analysis reveals that the hydrodynamic mean diameter is about 300 nm and that particle sizes range from 80 nm to 800 nm circa (yellow curve).



Clean Technology 2008, www.ct-si.org, ISBN 978-1-4200-8502-0

Figure 1: Laser light scattering of non-homogenized sample (mean diameter circa 300 nm). The laser beam is surrounded by a diffuse corona of multiple scattering processes, and indicates a broad spectrum of large particles.

During the homogenization process the mean diameter of the particles is strongly reduced (after few homogenization passages only) and the size distribution clearly shifts to smaller particle sizes (see Fig. 2, red curve). When laser light transilluminates the homogenized sample, the enhanced transparency and the less diffuse character of the scattered light become visible. This is due to the fact that small particles scatter light less efficiently than large ones.

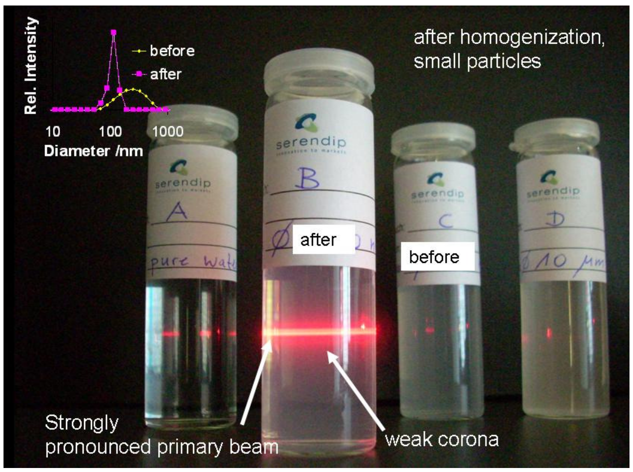


Figure 2: Laser light scattering of homogenized sample (mean diameter circa 120 nm). The laser beam is more pronounced and the corona from multiple scattering is reduced, indicating smaller and more narrowly distributed particles.

However, likewise important is the effect on the shape of the size distribution, which undergoes a significant narrowing upon homogenization. The homogenized sample completely lacks particles above 200 nm circa, which is important as the particle properties are strongly correlated with their dimension. Therefore, a narrow size distribution of particles corresponding to an enhanced level of homogeneity promises products with advantageous properties and a smaller spectrum of side effects as imposed by “odd” particles.

3 LOW PRESSURE HOMOGENIZATION: EFFICIENT AND ENERGY-SAVING DISPERSING OF PARTICLES

Summarizing, the given examples point towards the general need for the development of new technologies that are able to fulfil the market requirements of various products (color brilliance, scratch resistance, etc.).

The Serendip Low Pressure Nanogenizer technology (LPN, see Fig. 3) is based on a well-known high pressure homogenizing technology. The core of our technology is a new pressure cell that is designed according to the latest scientific know how, considering the optimised effects of friction, turbulence and cavitation. The technology combines the advantages of valve and nozzle systems allowing for very low working pressures and thus gentle process conditions. The technology opens the door to high quality dispersions in the field of nanoparticles and aims particularly to supersede conventional technologies such as bead mills, etc.

Figure 3: Serendip LPN 60

As the LPN works at moderate pressures (e.g. 300 or 500 bar) compared to high pressure homogenizers (up to 2500 bar), energy consumption and wear are considerably reduced. Fig. 4 reports about the mean particle decrease as a function of the number of homogenization passages. In the diagram, the effect on the particle mean size upon LPN homogenization at two working pressures (300 and 500 bar) is schematically illustrated and compared to the effect upon conventional bead mill processing. Clearly, the homogenization process with the LPN leads to significantly better results concerning the homogenization rate as well as the final particle size. As one can see, the final homogenization result is obtained after few passages only, corresponding to much shorter production times and thus less energy consumption.

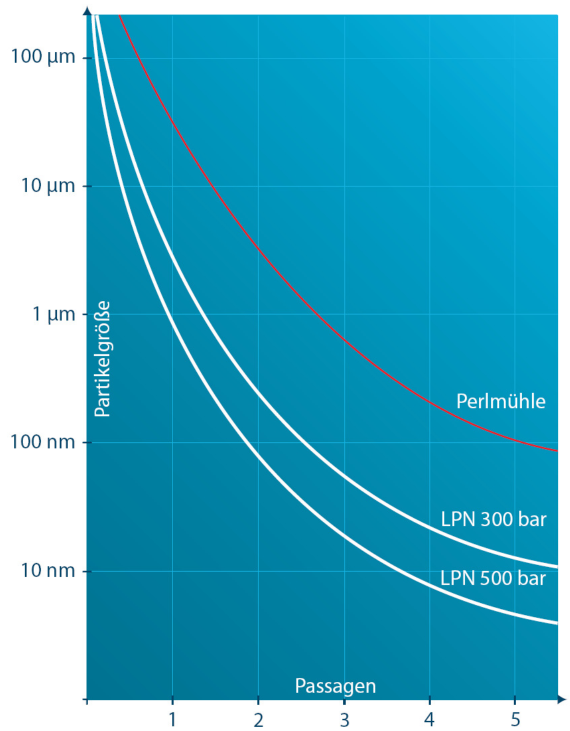


Figure 4: Mean particle size decrease during homogenization as a function of the number of passages for the Low Pressure Nanogenizer (LPN) and a conventional bead mill

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