ZKZ 62006

drinkworld
Technology + Marketing

ISSN 1433-1594 Vol. 27 No. 1 March 2023 US $ 12 · € 12

Dr. Harnisch Publications

Cover: Quantifying drink stability

Keeping soda relevant

Refreshing anniversary beer

Trends in bottling and capping

Quantifying the Long-Term Stability of Drinks

Drinks are often mixtures of different ingredients and are therefore liable to separation processes. It is important to quantify these separation processes to optimize drink formulations. The MultiScan MS 20 dispersion stability analysis system, developed by DataPhysics Instruments, can reliably and efficiently analyze drink dispersions regarding their destabilization mechanisms and ageing characteristics. The following use case evaluates four whey-based drinks and compares their overall stability.

by DR QIONGJIE LIU

Many drinks, such as fruit juice and protein shakes, are complex multicomponent mixtures. A homogeneous composition with good flavor, texture, and nutritional values is desired. However, separation processes in these mixtures can strongly influence their taste and mouthfeel. Assuring long-term homogeneity and thus a long shelf life for such products requires thorough formulation optimization.

Traditionally, separation processes were observed with the naked eye in a so called 'shelf-life-test'. This procedure is highly subjective and time-consuming, hindering an efficient formulation optimization. However, understanding the stability of drink dispersions in detail is important for research and development departments in the drinks industry.

MultiScan MS 20: Characterize Dispersions in Detail

To solve the above issues, the German measuring device manufacturer DataPhysics Instruments has developed the MultiScan MS 20 dispersion stability analysis system for automatic optical stability and ageing analysis of liquid dispersions (Figure 1). The device was developed to characterize suspensions and emulsions in particular, and to allow a time- and temperature-resolved analysis of destabilization mechanisms. The MultiScan MS 20 can detect and evaluate such mechanisms in more detail than any traditional shelf-life test would permit.

Figure 1: DataPhysics Instruments' MultiScan MS 20 stability analysis system can be fitted with up to six sample chambers.

The MultiScan MS 20 consists of a base unit to which up to six sample chambers can be added. Samples can be registered quickly and conveniently with a built-in as well as an optional handheld barcode reader. The six sample chambers, called ScanTowers, can be individually operated at different temperatures. Electric heating, with liquid counter-cooling, enables measurements between -10 °C and 80 °C.

Visualizing and Quantifying Destabilization Processes

With a MultiScan MS 20, destabilization mechanisms in dispersions can be visualized and quantified. The device achieves this through tracking changes in light intensity. To do so, it scans the sample repeatedly in a position-resolved manner. The patterns arising in the light intensity can give information on how the dispersion changes over time and what destabilization mechanisms might cause these changes.

The setup is as follows: A sample is poured into a glass vial, which is then placed in a sample chamber, i.e., ScanTower. Two light sources and a light detector simultaneously move up and down along the sample (Figure 2). During the measurement, the whole sample height is scanned, detecting global and local changes. The software analyzes the light intensities transmitted through and backscattered by the sample. The transmission (light penetrating through the sample) and backscattering (light reflected by the sample) intensities depend directly on the number, size, and type of the dispersed drops or particles.

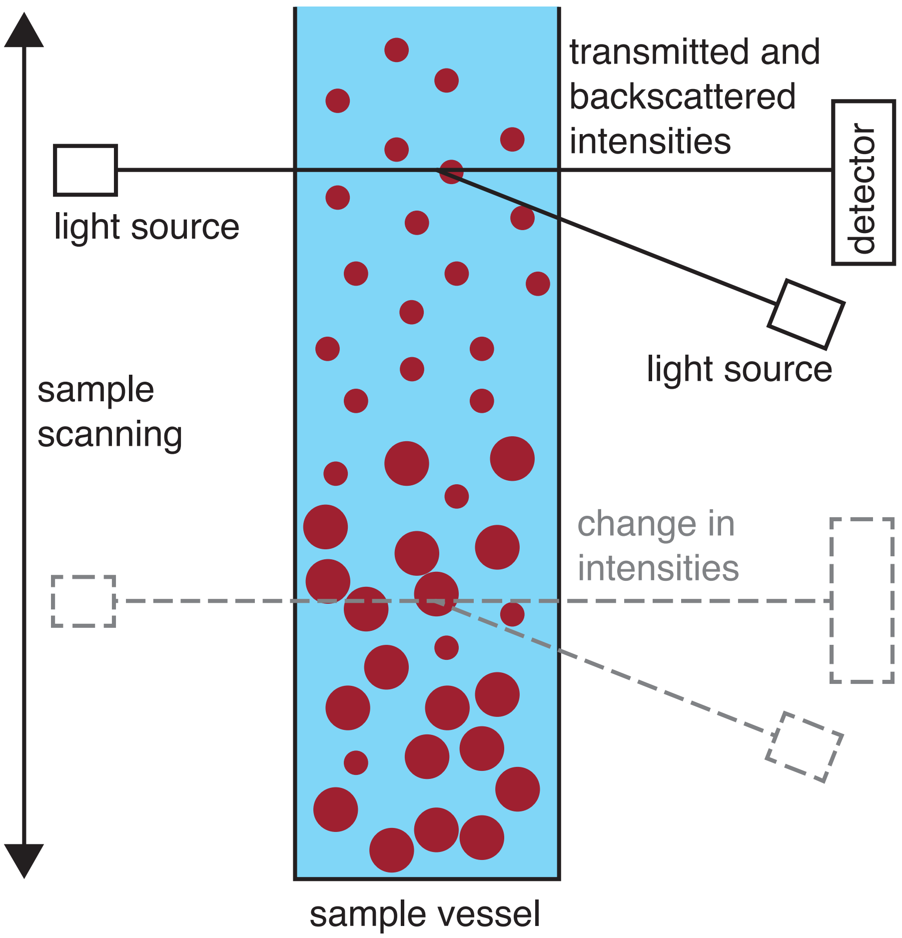
Hence, the light intensity changes when the dispersion destabilizes. Particles can sediment to the bottom of the sample container, so more particles interact with the light in this layer. Particles can also cream, meaning particles with a lower density than the surrounding liquid phase collect at the top of the liquid; therefore, more particles will interact with the light in the top layer of the dispersion. The measured profile of the dispersion shows decreasing transmission intensities in the respective area of the dispersion, while the backscattering intensities increase. Moreover, particles can cluster, minimising their interfacial area with the surrounding liquid phase. Such changes can be viewed as global changes in the transmission and backscattering intensities.

Figure 3: In the use case, four whey-based drinks were analyzed, flavored with peach, blood orange, multifruit and cassis (from left to right).

Use Case: Whey-based Drinks

Whey-based drinks are one of the most popular ready-to-drink protein drinks, owing to their superb nutritional qualities and neutral flavor. For a favorable taste, whey proteins are usually mixed with fruits or vegetables. The stability of such multi-component recipes is a major issue during production, transport, and storage. Common challenges include crystallization of lactose stored in the fridge and coagulation of whey proteins. Therefore, it is of great importance to study whey-based drinks and modify their formulations to achieve high stability.

Figure 2: The measurement principle of the MultiScan MS 20: The two light sources and the detector move up and down the sample vial for each measurement.



Experimental Setup

In this use case, four whey-based drinks, with cassis, peach, blood orange, and multifruit additions were analyzed using the MultiScan MS 20 dispersion stability analysis system. 20 ml of each formulation were poured into a transparent glass vial and measured at a stable temperature of 30 °C for five hours and 45 minutes. The samples were scanned every five minutes. The measured height was between 0 mm (bottom of the vial) and 57 mm (top of the vial). Figure 3 shows the sample vials at the end of the measurement.

As all samples were opaque, little information could be gained from the transmission signal, as it was too weak to penetrate the sample. Therefore, the backscattering signal was consulted. The changes are exemplified in Figure 4, which shows the backscattering intensities plotted against the height for the cassis sample. The graph points out a decrease of the backscattering signal in the upper

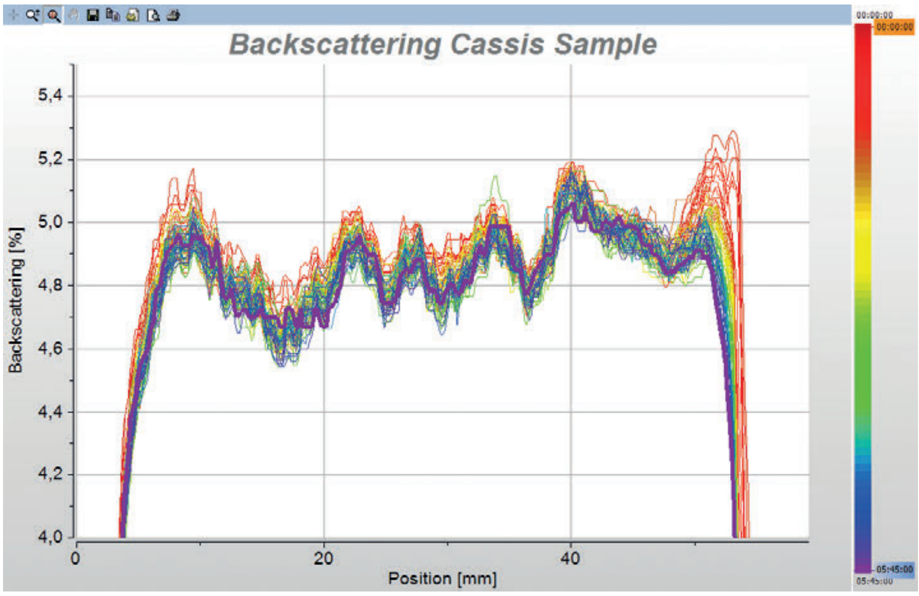


Figure 4: Analyzing backscattering intensities plotted against the height of the sample vial reveals which destabilization mechanisms are occurring.

layer of the drink sample (between 50 mm and 55 mm), indicating a typical sedimentation process.

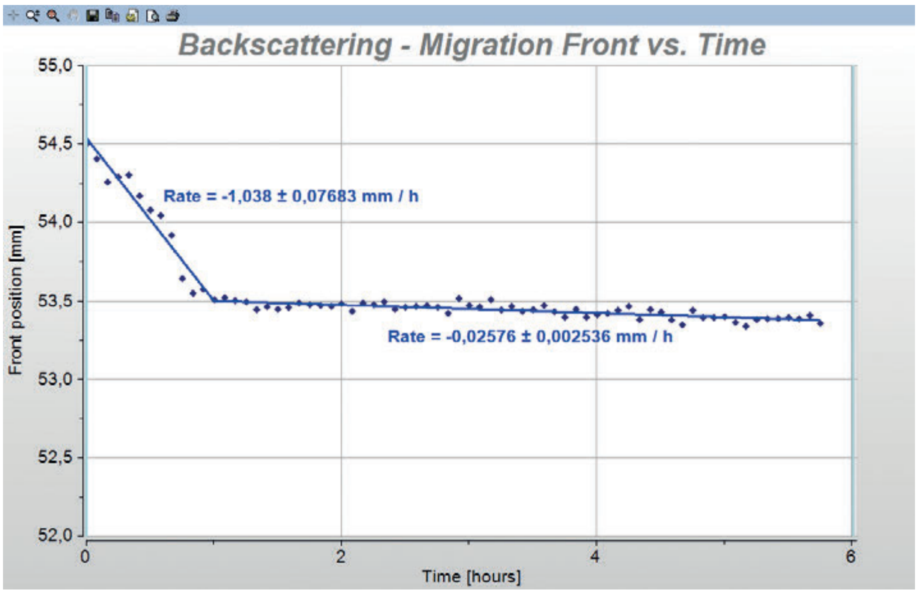
Comparing Sedimentation Rates

Besides intensity-height plots, the MultiScan MS 20 software offers further options for deeper analysis and comparison of the results. For example, the 'migration-front'-function of the software makes it possible to look at the sedimentation process in more detail. For the cassis-flavored sample, the average sedimentation rate is calculated as 1.038 mm/h in the first hour and as 0.026 mm/h in the remaining four hours and 45 minutes (Figure 5). This indicates that most of the particles have already sedimented in the first hour of the experiment.

The sample with blood orange shows a similar pattern as the cassis-flavored sample, with a sedimentation rate of 1.012 mm/h in the first hour and 0.039 mm/h in the remaining four hours and 45 minutes.

Looking at the sedimentation rate of the peach-flavored drink, one can see a comparable pattern: the sedimentation rate in the first hour is calculated as 1.491 mm/h. In the remaining measurement time, the peach-flavored drink shows a sedimentation rate of 0.036 mm/h, which is very similar to the one for the cassis-flavored drink (0.026 mm/h) and the blood orange drink (0.039 mm/h).

Figure 5: Using the 'migration front'-function in the software, the sedimentation rate can be analyzed in detail.



Overall, the cassis-, peach- and blood-orange-flavored drinks show very similar sedimentation behaviors with a higher sedimentation rate in the first hour and a very low sedimentation rate during the remaining experiment time.

The last, multifruit-flavored sample deviates from the other three samples – a difference readily apparent using the sedimentation rate analysis. In the first hour its sedimentation rate is 0.103 mm/h and thus much lower than the one calculated for the three other samples. This means that the multifruit-flavored sample is much more stable in this period compared to the other samples. In the remaining period, the sedimentation rate for this sample is also 0.103 mm/h. These results indicate that the sample sediments in a linear fashion throughout the entire experiment. The sedimentation rates of all four samples are compared in Figure 6.

Easy-to-read Stability Index

Notably, the software can also calculate an overall stability index value for a sample. To directly compare the stability differences, the results of all samples can be displayed in an overlay window (Figure 7). In consistency with the results above, the stability index supports the interpretation that the multifruit drink is the most stable formulation, while the peach drink is the most unstable.

Conclusion

Destabilization processes occur in most multicomponent mixtures, including drink products. Such processes strongly influence the product's final appearance, taste, and mouthfeel. Therefore, it is essential for research and development departments in the food industry to quantify and analyze the destabilization processes of multicomponent mixtures. Such evaluations enable efficient optimization of the product formulations. Using the MS 20 stability analysis system and its corresponding software, a convenient and rapid means to study the stability of multicomponent mixtures, such as whey-based drinks, is available. Such a thorough and quantitative analysis of drink formulations enables producers to anticipate and quantify stability issues and thus allows a time- and cost-optimized product development.

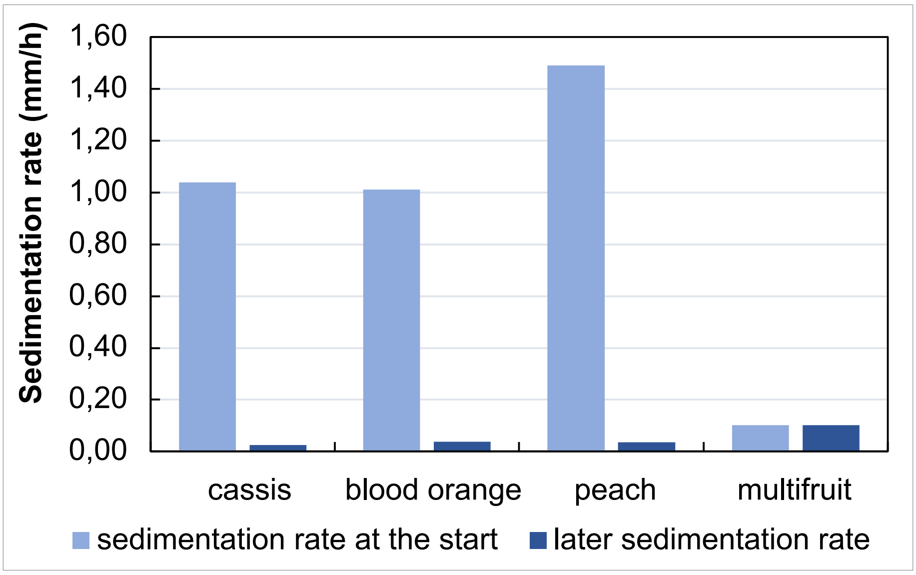


Figure 6: The comparison of the sedimentation rates reveals which drink formulations are stable and which ones are unstable.

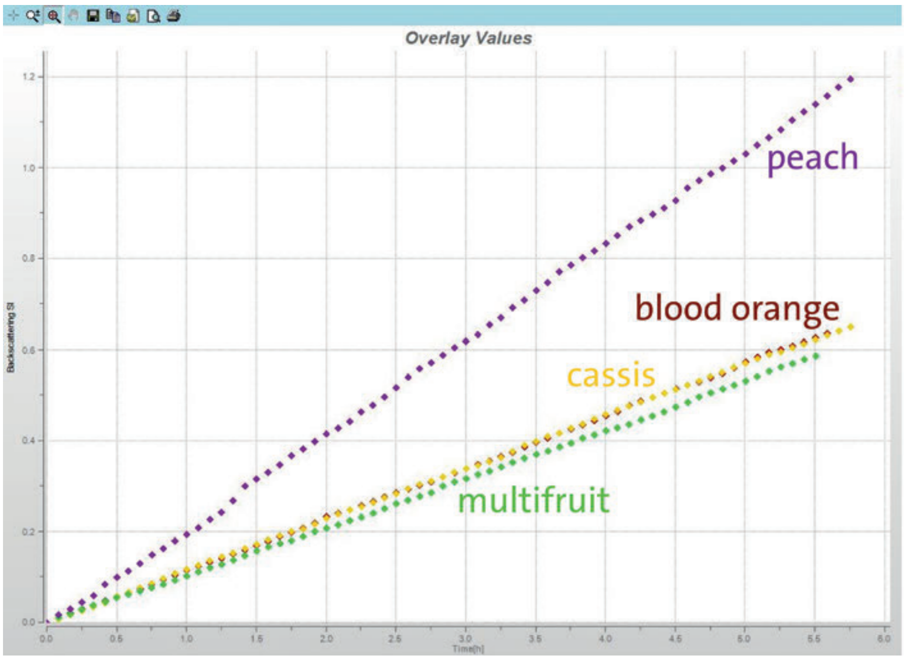


Figure 7: The stability index of all samples can be overlayed in one graph to compare them easily to each other.

The Author

Dr. Qiongjie Liu has been Product and Application Manager at DataPhysics Instruments in Filderstadt, Germany, since 2021. Among other responsibilities, she writes application notes – such as this one on whey-based drinks – showcasing how instruments from DataPhysics Instruments can be used in real-life use cases, spanning many applications and industries. Liu studied chemistry and received a doctorate from the Chinese Academy of Science in 2017 for her thesis: "Cu(II)/SaBOX Catalyzed Highly Stereoselective Synthesis of Poly-Heterocyclic Compounds"