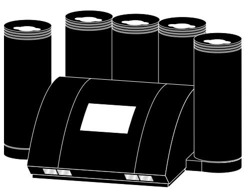
Application Note

Comparing the backscattering intensity using blue and IR light sources in dispersion stability analysis

Dispersions are encountered in everyday life in many different products, ranging from salad dressings and cocktails in the food sector, emulsions and creams in cosmetic and pharmaceutical products to multi-phased cleaning agents, emulsion paint or seal slurry in the building industry, to name just a few examples. For all these products the dispersion stability is an extremely important factor that has to be analysed and optimised during product development. The MultiScan technique is a powerful tool to quantify stability issues in dispersions. Traditionally this technology relies on IR light which works very well in most cases. However, the measured signals can be very low when the samples have a low concentration and especially if they are composed of nano particles. In this case, the signal to noise ratio can be low resulting in a negative influence on the accuracy of the destabilization analysis. To solve this problem, DataPhysics Instruments developed a new stability analyser utilising blue light. In this application note, commercial polymer microsphere suspensions with various particle sizes and concentrations are used to compare the signal quality of the new analyser using blue light with the system using IR light.

Measurement device
MultiScan dispersion stability analysis system



Measurement method
Optical dispersion stability analysis

Measured quantities
Mean particle size
Transmission intensity
Backscattering intensity

Environmental conditions
25 °C

Samples
Polymer microsphere suspensions

Industries
Chemcial mechanical polishing
Chemistry
Pharmacy
Cosmetic

dataphysics

Fig. 1: . DataPhysics Instruments stability analysis system MultiScan MS 20 with six independent ScanTower.

Technique and Method

The MultiScan MS 20 from the German manufacturer DataPhysics Instruments is a dispersion stability analysis system (Fig. 1).[1] It is a measuring device for the automatic optical stability and aging analysis of liquid dispersions, in particular suspensions and emulsions, and the comprehensive characterisation of time and temperature dependent destabilisation mechanisms.

To conduct the measurement, the liquid dispersion is poured in a sample vessel, which is then placed in one of the measuring chambers of the MultiScan MS 20. The MS 20 contains a light source, a detector opposite the light source to measure the transmitted light, as well as a second light source, positioned in a 45 degree angle from the detector, for measuring the backscattered light (Fig. 2). The light sources and detector move up and down along the sample vessel for each measurement so that position-resolved light intensities can be recorded. So far, ScanTowers utilizing infrared LEDs (i.e. IR tower) have been widely used for dispersion stability analysis.

According to Mie theory[2], transmission and backscattering intensities not only directly depend on the number, size, and type of dispersed particles, but also on the wavelength of the light source. To get higher values of backscattering intensity for liquid dispersions containing nanoparticles, DataPhysics Instruments has introduced a new type of ScanTower that uses blue LEDs with a wavelength of 470 nm (i.e. Blue tower). This broadens the utilisation of MultiScan MS 20 and expands its possibilities to study the stability and aging analysis of liquid dispersions.

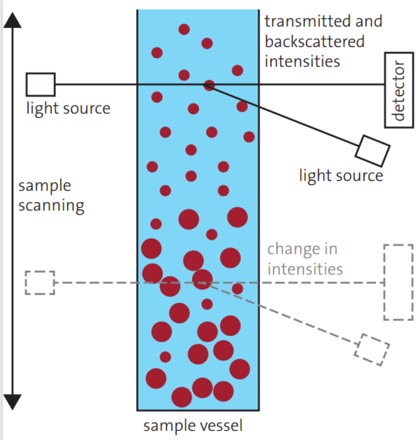


Fig. 2: MultiScan measuring principle

Experiment

To compare the accuracy and reliability of measurement data furnished with the Blue tower and IR tower, commercial polymer microsphere suspensions (PMSs) with various particle sizes and concentrations were used in this application note. According to the supplier information sheet, the particle diameters and concentrations of PMSs are shown in Table 1. The solvent of the polymer microsphere suspensions is water, its density and viscosity are 0.998 g/cm^3 and 1.002 mPas at room temperature, respectively. The polymer microspheres are made of polystyrene.

20 ml of each PMS was poured in a transparent glass vial and measured at T = 25 °C every 13 seconds for 40 seconds. The measured zone is between 0 mm (bottom of the glass vial) and 57 mm (top of the glass vial).

Table 1: Properties of the polymer microsphere suspensions

Particle size	Volume concentration (%)							
110 nm	-	-	1	-	-	10	-	-
190 nm	-	-	1	-	-	10	-	-
330 nm	-	-	1	-	-	10	-	-
420 nm	-	-	1	-	-	10	-	-
540 nm	0.1	0.5	1	2	4	10	20	30
740 nm	-	-	1	-	-	10	-	-
1.2 µm	-	-	1	-	-	10	-	-
2.3 µm	-	-	1	-	-	10	-	-
3.2 µm	-	-	1	-	-	10	-	-
4.3 µm	-	-	1	-	-	10	-	-

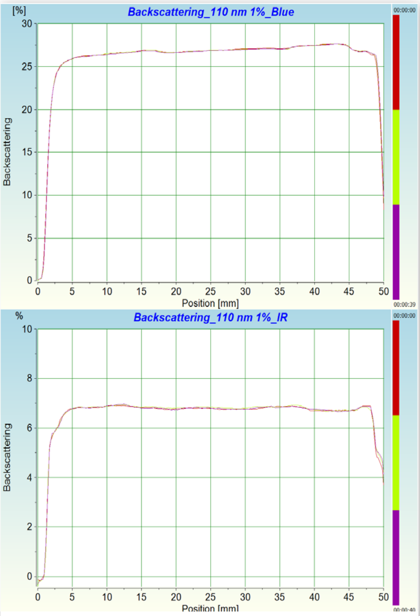


Fig. 3: Backscattering diagrams of 110 nm PMS at the volume concentration of 1% from Blue tower and IR tower, respectively

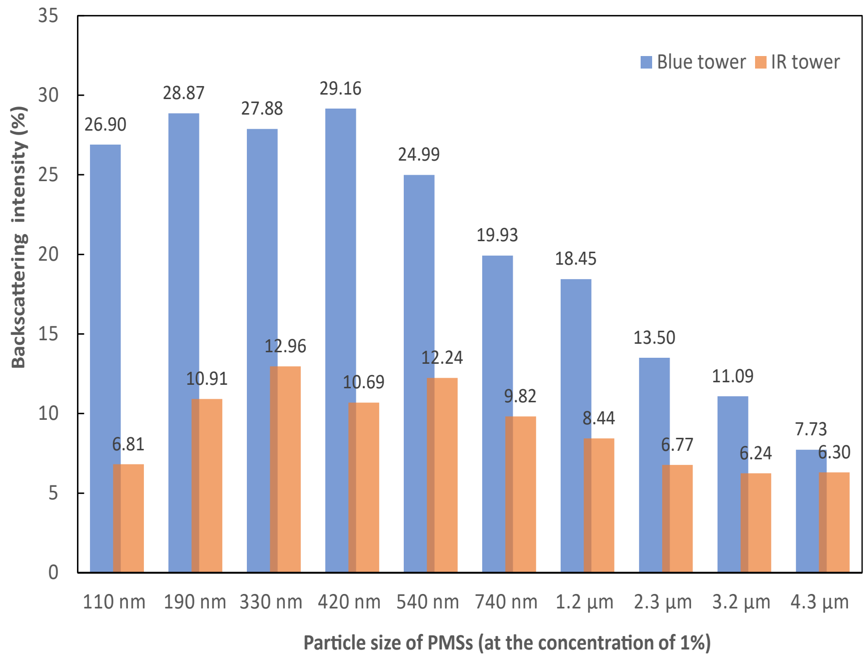


Fig. 4: The backscattering intensity of 1% PMSs with different particle sizes measured by Blue tower and IR tower, respectively

Results & Discussion

The backscattering intensity of all samples stays constant during the measurement. For example, Fig. 3 plots the backscattering intensities against the position within the PMS with a particle size of 110 nm and a volume concentration of 1% measured with Blue tower and IR tower, respectively. The color-coding of the curves indicates the time at which they were recorded, from red (first measurement, t = 0 s) to purple (last measurement, t = 40 s). Every curve represents an individual measurement.

With the 'Values'-method in the MSC software, the values of the backscattering intensities at a defined position range from 5 mm to 40 mm can be analysed utilising absolute backscattering intensities.

The data in Fig. 4 shows the backscattering intensities of the PMSs at the volume concentration of 1% with different particle sizes measured with the Blue tower and IR tower, respectively. For all samples, the values of backscattering intensities measured with the Blue tower are higher than those measured with the IR tower. Especially, the PMSs with smaller particle sizes show a bigger difference between the backscattering values measured with the Blue tower and IR tower. For example, the backscattering intensity of PMS with the particle size of 110 nm is 26.9% when it is measured with the Blue tower, while it is only 6.81% when measured with the IR tower. The backscattering intensities measured with both towers show a growing trend with the particle size when the particle size is smaller than 420 nm. When the particle size is larger than 420 nm, the backscattering intensities decrease with growing particle size. This is caused by the fact that the backscattering values depend on the particle size and volume concentration.

To get a deeper insight into the differences in the backscattering values measured with the Blue tower and the IR tower for higher concentrated PMSs, the backscattering intensities of PMSs with a volume concentration of 10% and different particle sizes were compared in the Blue tower and IR tower (Fig. 5). Similar to the data depicted in Fig. 4, the backscattering intensities of all samples measured with the Blue tower are higher than those measured with the IR tower. For smaller particles in the nanometer range the difference between the Blue

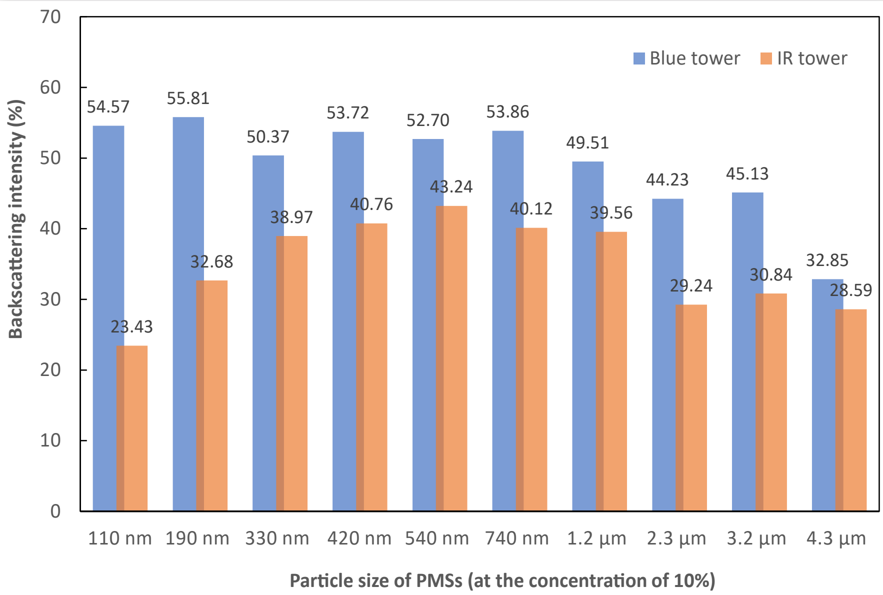


Fig. 5: The backscattering intensity of 10% PMSs with different paticles sizes measured by Blue tower and IR tower, respectively

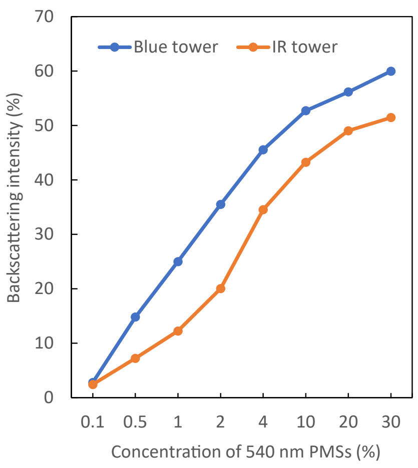


Fig. 6: The backscattering intensity of 540 nm PMSs with different volume contractions measured by Blue tower and IR tower, respectively

tower and the IR tower are bigger. In addition, the change characteristics of backscattering intensities over particle size are similar for both towers.

Furthermore, the influence of the concentration on the backscattering intensity was investigated. Fig. 6 shows that the backscattering intensities of PMSs with a particle size of 540 nm increase with growing concentration. Generally, the backscattering intensities measured with the Blue tower are much higher than those measured by using the IR tower within the tested concentration range. The general rule can be summarized as follows: The lower the volume concentration is, the larger the difference between backscattering values measured with the Blue tower and the IR tower (except for the extremely low concentration of 0.1% at which no significant backscattering was detected in either tower).

Summary

It can be concluded that the MS 20 MultiScan dispersion stability analysis system with a Blue tower can provide much higher backscattering intensities for dispersions with particles in the nanometer range, especially with low volume concentration samples. The general changes of backscattering intensities over particle size as well as concentration were found to be consistent for the Blue tower and the IR tower. This suggests a high reliability of the new Blue tower when dealing with nanoparticle supensions.

The new ScanTower with Blue-LEDs broadens the possibilities of our MultiScan MS 20 to study the stability and aging of liquid dispersions, in particular suspensions, and the comprehensive characterisation of time- and temperature-dependent destabilisation mechanisms. The new Blue tower will be especially useful to those who work with nano suspension and nano emulsions for example in the field of chemical mechanical polishing or the development of pharmaceutical nano emulsions.

References

[1] https://www.dataphysics-instruments.com/products/ms/
[2] Zhou H., Li L. *Experimental research on size distribution of suspended particles in water based on Mie scattering theory.* IOP Conf. Ser.: Earth Environ. Sci. 2021, 769, 042063. DOI:10.1088/1755-1315/769/4/042063

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