Drop size measurements of waterborne basecoats during atomization - a SpraySpy® field report

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A look into the atomization

The application of paints plays a decisive role in influencing final product properties such as colour tone, flop of the aluminium effect pigments or the appearance of paints. Not only the application method itself is decisive. In the case of high-rotation atomization, for example, the selected application parameters such as speed, flow rate or steering air also have a decisive influence on the result. It is therefore of great interest to understand the atomization process of paints. Using the SpraySpy® droplet size measuring device marketed by AOM-Systems (Figure 1), BASF's Coatings division has developed a measurement setup that allows the atomization process of automotive coatings, even with electrostatic atomization, to be investigated in detail. In this way, it is possible to derive forecasts for more efficient paint development or optimal application parameters from the knowledge gained during the atomization process of paints.

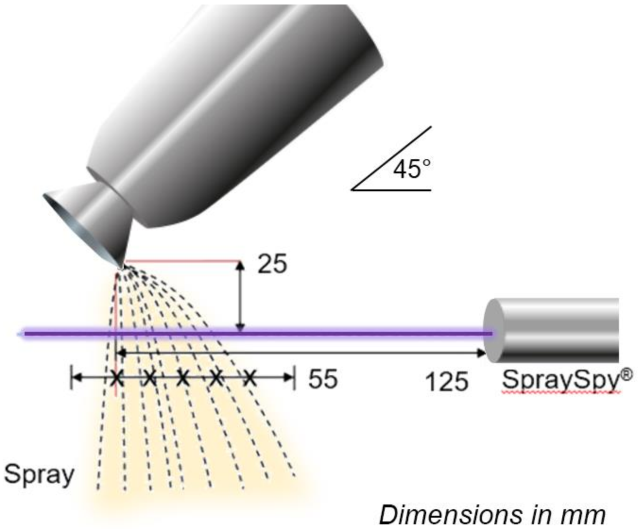
Figure 1: SpraySpy® model LabLine 450 from AOM-Systems.

Getting more information about the atomisation process by using SpraySpy®

The SpraySpy® measurement technology is based on the light scattering of a moving drop that is illuminated by a laser beam. The resulting light scattering is temporally separated into the individual scattering orders and registered by photon receivers. The characteristics of the scattering orders clearly correlate with the size, velocity and opacity of the drop. This makes the SpraySpy® technology a direct and counting measurement method. In contrast to other measuring methods, the measurement of opacity allows the determination of both transparent and non-transparent drops in the spray. The system measures the transmission or the reflection of the laser beam in or on the drop. If these results are put in relation to each other, this results in an important measurement value for the characterization of sprays, which is difficult to determine otherwise. This is an advantage of the Time Shift measurement method. SpraySpy® enables the measurement under real application conditions. It is also possible to measure solvent-containing paints within an ATEX zone with high voltage applied.

Simple measurement setup

For the characterization of automotive paint spray cones, the test setup shown in Figure 2 was used.



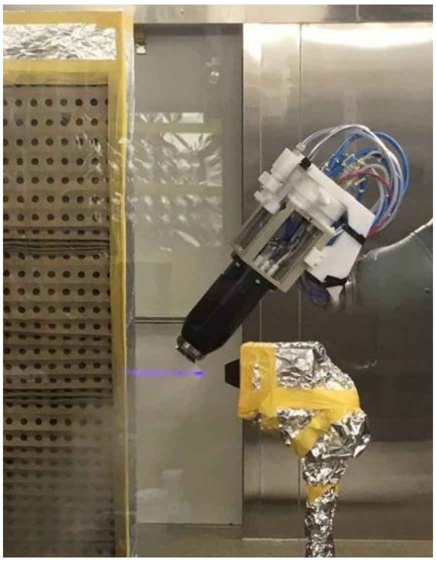


Figure 2 left: schematic structure for drop size measurement of coatings using SpraySpy®.
Right: exemplary measurement setup: measurement of a high rotation atomizer with SpraySpy® in the pilot plant.

The high rotation bell is arranged at a 45° angle to the measuring section, whereby under standard conditions the actual laser measures 25 mm below the edge of the bell. Overspray, turbulence and reverse flow are thus minimized. This measurement geometry offers the advantage of less contamination of the laser lens or detector. Due to the relatively dense spray, a high drop density is guaranteed, which contributes to a high statistical certainty of the measurement results. In addition, with a section of measurements of 55 mm all fractions are absorbed by the spray, so that even very wide spray cones can be addressed. All in all, this test setup allows reproducible measurements of all atomizers, bells and paint systems with a wide range of application parameters. Furthermore, there are a number of advantages for the user of this measuring device. Compared to alternative droplet size measuring devices, both the test setup and the measurement procedure can be realized quickly and easily. Likewise, misalignment of the measuring system occurs very rarely - transport to other rooms is therefore possible without any problems.

Analysis of four aqueous basecoats

In a study, four different waterborne basecoats (WBL) were analysed using SpraySpy® in a standard test set-up. To address the influence of the transparency of the systems

a) a WBL without fillers (**M1**),

b) a WBL with barium sulphate as filler (**M2**),

c) a WBL with filler and carbon black pigment (**M3**)

d) a WBL with filler, carbon black pigment and aluminium effect pigments (**M4**)

were analysed. For this purpose, transmission measurements at 405 and 450 nm (wavelengths of the SpraySpy® laser) of the dried resists at 10 µm film thickness were carried out in advance. (Figure 3).

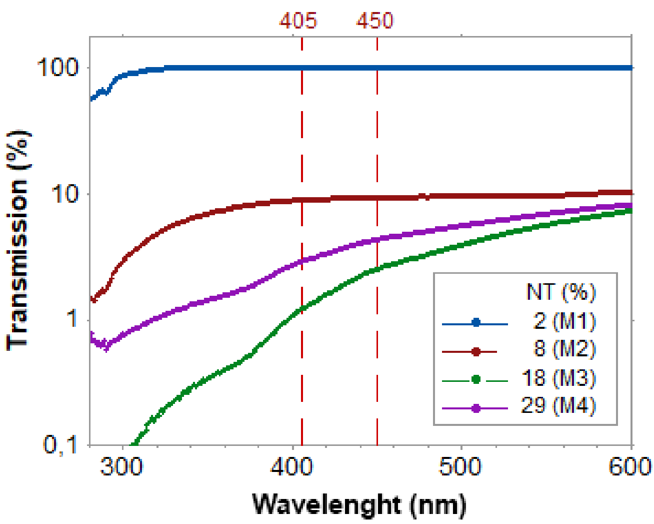


Figure 3: Transmission measurements of dried resists **M1** - **M4** at 10 µm film thickness. NT (%) = proportion of non-transparent drops from the SpraySpy® measurements.

While **M1**, as expected, shows the highest transparency, **M2** and **M3** absorb more energy in this order. Finally, with the exception of the aluminium system **M4**, there is a good correlation between the transmission in the dried film and the proportion of non-transparent droplets in the atomization process. This can be explained by the aluminium pigments in the dried film, which are not perfectly planarly aligned, resulting in a higher transmission than in the droplet of the spray cone. Via high rotation atomization, the four coatings were analysed at three different speeds (23k, 43k and 63k rpm) using SpraySpy®. As Figure 4 illustrates, the different paints can be clearly differentiated from one another. Large transparent droplets of more than 35 µm (D_{median}) result in the atomization of **M1**, while the filler in **M2** reduces the droplet size to 27 to 31 µm. Significantly smaller transparent droplet sizes of about 15 to 17 µm were found for the pigmented coatings **M3** (carbon black) and **M4** (aluminium effect pigments). As expected, smaller droplets are obtained at higher velocity, which is especially observed in the non-transparent measuring mode. Here, a further differentiation of the systems **M3** and **M4** succeeds, whereby larger non-transparent drops were measured at all velocities for the aluminium system **M4**. In general, the highest velocities are obtained for larger drops, as the linear trend lines in the figures illustrate.

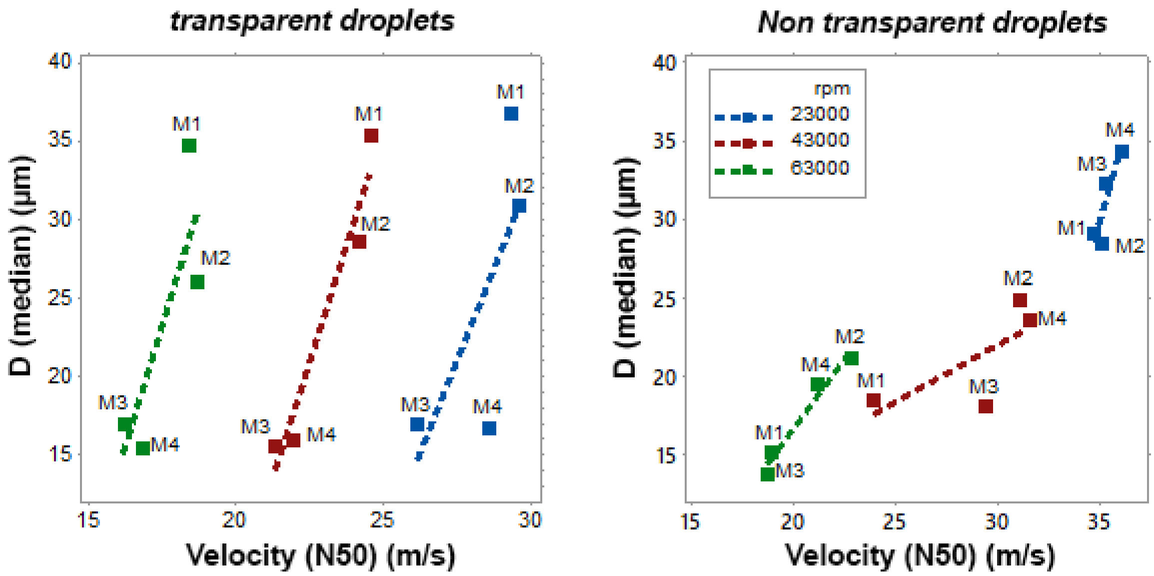


Figure 4 Correlation of the *D(N50)* against the velocity *(N50)* at different velocities for the coatings **M1** - **M4**. Left: transparent drops, right: non-transparent drops.

Bell serration decisive for spatially resolved drop sizes

In a further study it could be shown that the bell edge has a significant influence on the spatially resolved drop size. For this purpose, a selected WBL was atomized at a speed of 43000 rpm, an outflow rate of 300 mL/min and a steering air of 400 NL/min with two different bells: a) a bell without serration and b) a bell with line serration. If one looks at the average values at first, there is no significant difference between a bell without serration (D_{median} = 18.2 µm) and a bell with line serration (D_{median} = 18.9 µm). Nevertheless, the spray cones differ significantly from one another, as Figure 5 shows on the basis of the spatially resolved drop speeds of 0 to 30 mm. While the droplet velocity decreases from the inside of the spray cone (0 mm) towards the centre for both bell types, the line serration in the outer area of the spray cone (18 to 25 mm) causes conspicuously high velocities for transparent and non-transparent droplets. This characteristic is not pronounced for the bell without serration.

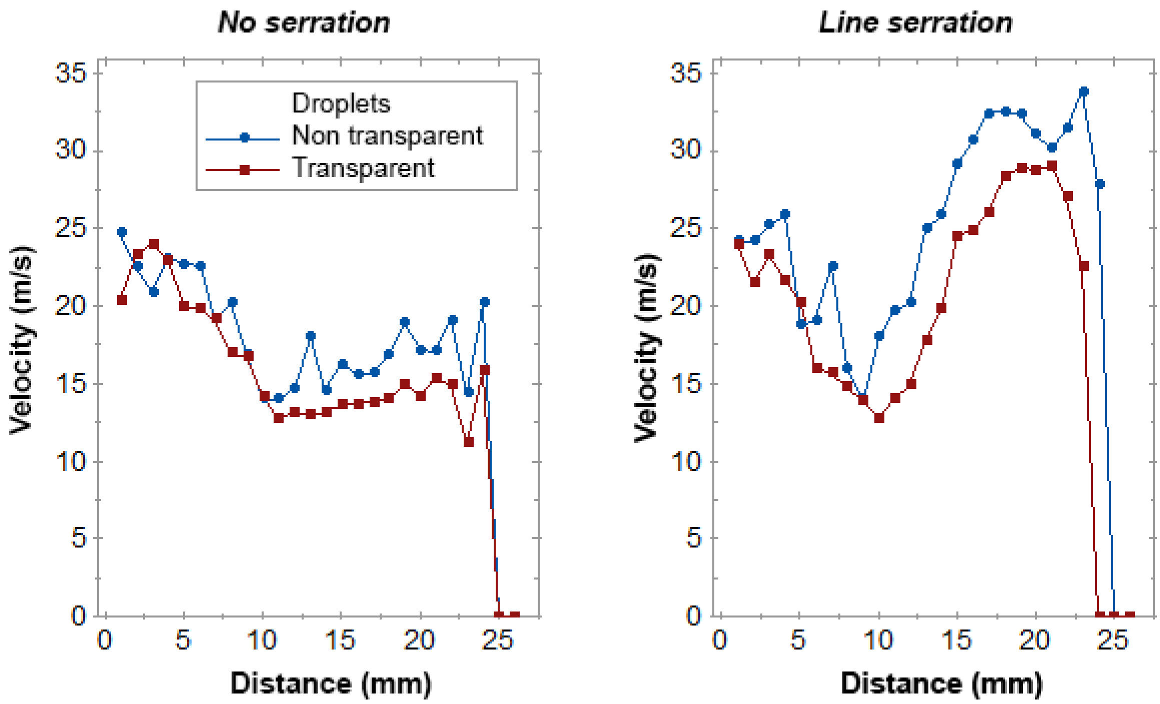


Figure 5: influence of bell serration on the spatially resolved drop velocities for a selected WBL

Conclusion:

The results show that SpraySpy® is an easy-to-use measuring system that can be used in daily application to measure and characterize spray cones during the application of automotive coatings. The features allow a very detailed view into the atomization process and provide information about the spatially resolved drop size, drop velocity and the type of drop (transparent vs. non-transparent). The instructed user can obtain reproducible results relatively quickly. Under standard measuring conditions (one atomizer, one specific measuring position), SpraySpy® thus offers promising approaches to differentiate between different paint systems and to further understand the atomization process more precisely. With knowledge of the surface properties, the application parameters can be optimised for them in a next step. In the technology management of BASF's coatings division, i.e. where new paints and coating processes are developed and tested, SpraySpay® serves as a key technology in measuring processes to be able to clarify complex cause-and-effect mechanisms in an even more targeted manner in the future.

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