

Using Dustmon to measure dust concentration in livestock feed additives

Dust cloud analysis can be used to characterise the physical and behavioural properties of a pulverulent product in the same way as particle density, grain size analysis, etc. Until recently, the Heubach method was considered the benchmark technique for this “behavioural measurement”. The limitations of this method have been comprehensively discussed (i'Tec_Q5). The last few years have seen the development of other (all fairly similar) methods based on light obscuration analysis. Tecaliman has conducted this study on one of these methods in order to assess its potential.

1. Principle

The equipment consists in a Microtrac brand Dustmon LS. The Dustmon LS characterises dust clouds by measuring the light obscuration of a product specimen dropped down a tube.

2. Equipment and apparatus

The apparatus consists in a stainless steel tube topped by a sample beaker used to introduce the product specimen, and a measuring chamber (Figure 1). A known quantity of product (that fits the volume of the apparatus) is dropped down the tube into the measuring chamber; the drop height is 75 cm. A computer-controlled system linked to the apparatus opens the butterfly valve, allows the product to drop down the tube (time 0) and records the light

obscuration measurement. The measurement is taken over a period of 30 seconds with readings recorded at intervals of 0.003 s. There is no measurement unit for the readings as they relate to obscuration of the light source projected through the dust cloud in the measuring chamber.

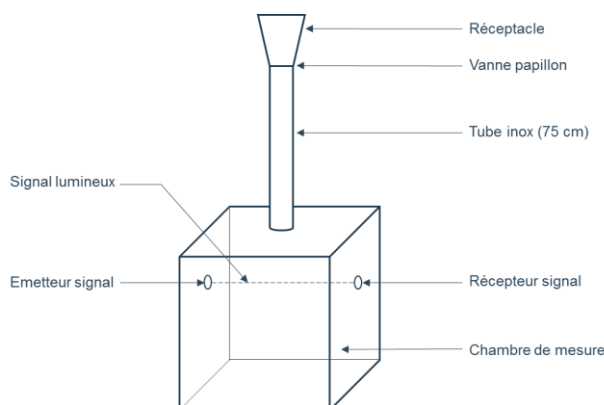


Figure 1: Diagram of the apparatus

The apparatus seals in the dust cloud. The higher the value of the reading, the larger the dust cloud. The measurement results (Figure 2) reveal a peak that corresponds to the moment the product is dropped, after which the readings decrease in relation to changes in the rate of sedimentation of the dust cloud in the chamber*.

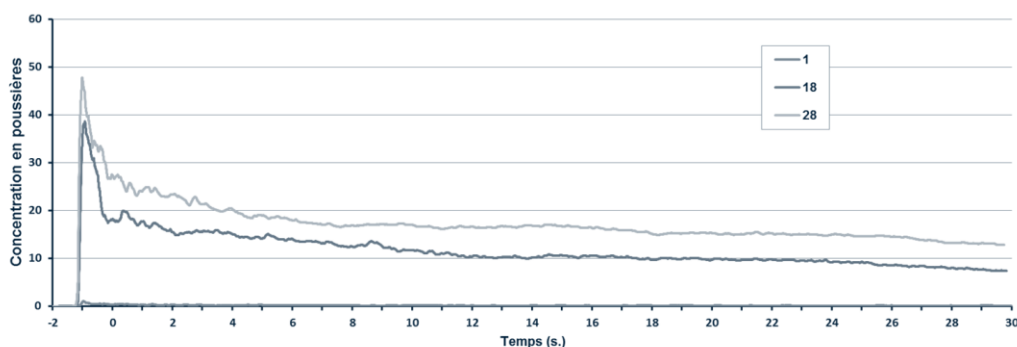


Figure 2: Recordings of 3 different products

The software records or computes several different parameters such as maximum value, dust area, readings at 5, 10, 15 s, end value, etc.

The raw data can also be used for the analysis.

3. Methods

3.1. Study of the effect of sample sizes and number of repetitions

This step is designed to determine the usefulness of the readings transmitted by the device, the size of the samples and the number of repetitions required to obtain a repeatable measurement.

The study initially uses three additives from the additive range used in the 1990s study and stored in a cold room (report N° 10). These products, coded 1, 18 and 28 respectively, are selected based on variances in their dust emitting capabilities.

3.1.1. Principle

The measurements are carried out on 3 test samples for each of the 4 masses (25 g, 50 g, 75 g and 100 g). The measurement period is 30 s, initially taking readings at 5-second intervals. The order in which the 36 measurements (3 products x 4 masses x 3 repetitions) are taken is entirely random.

3.1.2. Result

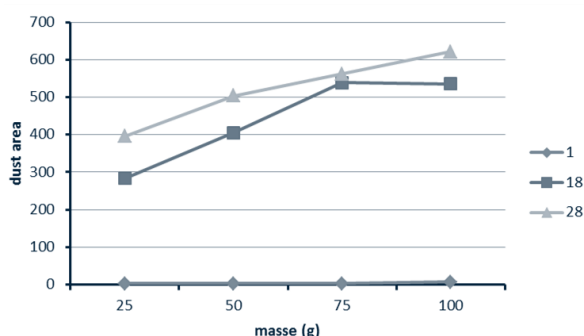


Figure 3: illustration of changes in dust area values (Dustmon) in relation to sample mass for 3 products

The observations indicate that:

- Depending on the density of the tested products, the volume of the chamber may be too small for the introduction of 100 g of product.
- The 75 g mass does not differentiate between products 18 and 28 (Figure 3).
- Whichever criterion is used, the 50 g samples always give readings that are higher than, but not double, the readings for the 25 g samples. As with the Heubach method, dust behaviour is not linear with or proportional to the mass of the sample.

This indicates that the **50 g mass** is more discriminating than the 25 g mass and can be used for all the products, as well as for comparative assessments with the Heubach method. It was therefore decided to use the 50 g mass in the further

study.

The means and standard deviations derived from measurement repetitions for 3 products using a 50 g mass were recorded and used to determine the **number of measurements per product** (Table 1).

	Sample	Mean	Standard deviation
Dust Area	1	3.3	2.2
	18	405.0	71.1
	28	504.0	26.7
Max. value	1	0.5	0.15
	18	35.7	3.07
	28	35.2	5.85

Table 1: Examples of means and standard deviations for the 50 g readings

Logic suggests a variability between the repetitions. Statistical analysis demonstrates that this variability decreases with the number of repetitions.

Due to the time required to perform the measurements each day, and the quantity of product available for the next study phase, it was decided to keep the number of repetitions at 3.

3.2. Study of measurement criteria and selection of 5 products

3.2.1. Objectives and principles

This study is used to identify which dust behaviour characterisation criteria to select from those derived from the raw measurements, and to choose 5 products with varying behaviours from an updated group of additives. This makes it possible to create a “sample library” containing 68 additives currently used in livestock feeds supplied by several different premixers. These additives are tested in the device according to the conditions determined during the first study (50 g mass, 3 repetitions per product).

3.2.2. Result

Analysis of the various usable parameters (peak value, dust area, readings at 5-second intervals, etc.) demonstrates that the majority are correlated and therefore redundant. Curve analyses suggest that the dust area (dust cloud) and the gradient that follows the initial peak (sedimentation rate) provide for greater product discrimination. These two discriminating and non-correlated criteria are therefore selected. The values are based on the mean of the 3 repetitions performed using the 3 test samples.

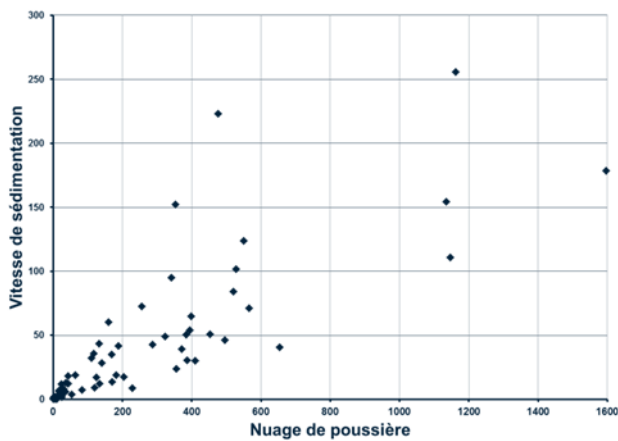


Figure 4: Distribution of the 68 products of the new collection according to the means of the two selected criteria

The criteria used for further study are (Figure 4):

- **Size of the dust cloud.** This parameter corresponds to the area under the curve (Dust

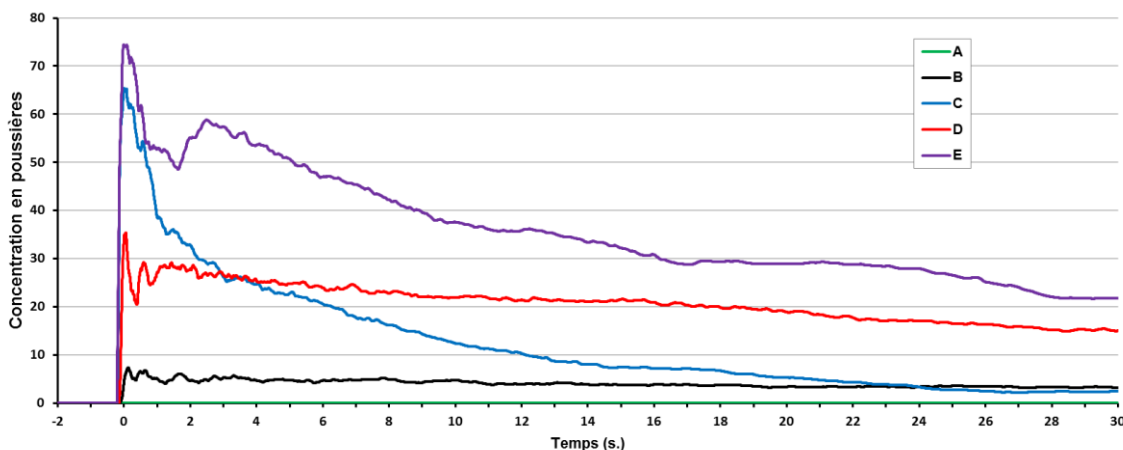
Area). The readings for the tested additives range between 0.6 and 1597.2

- **Dust sedimentation rate.** The absolute value of this parameter is the delta between the readings recorded at 15 s and 5 s divided by 10 (number of seconds between these 2 times). This parameter is then multiplied by 100 for ease of interpretation and data editing, giving values for the tested additives of between 0 and 256.

The mean values for each product and each criterion are used to group them into quartiles around each median (Table 2). Analysis of the curves (Figure 5) suggests that it may not be possible to use the sedimentation rate criterion for products with low dust emission. If these criteria are selected for further use, it will most likely be necessary to identify a threshold value below which the sedimentation rate is not to be taken account of due to the flatness of the curve.

Dust cloud					Sedimentation rate				
Percentage of the total population					Percentage of the total population				
Min.	Median			Max.	Min.	Median			Max.
⇒25%	⇒50%	⇒75%	⇒100%		⇒25%	⇒50%	⇒75%	⇒100%	
0.6	16.4	129.5	375.4	1597.2	0	3	18	49	256

Table 2: Ranking of criteria in quartiles



The products are divided into 10 separate groups using this 2-criteria method (Table 3). Ranking the results in terms of the number of additives in each quartile segment demonstrates a possible relationship between cloud size and sedimentation rate. It is interesting to note, however, that a certain number of additives deviate from this behavioural trend (quartile segments containing 1 or 4 additives).

		Sedimentation rate			
		⇒25%	⇒50%	⇒75%	⇒100%
Dust cloud	⇒25%	16	1	0	0
	⇒50%	1	12	4	0
	⇒75%	0	4	9	4
	⇒100%	0	0	4	13

Table 3: Distribution of additives into quartiles

The product ranking performed here concerns the additive collection provided for this study. For products in the upper quartiles, this ranking may not be used to draw conclusions on potential drawbacks for operators or on increased risks of carry-over, which will require further studies.

An overall variance analysis is carried out on all products and the 3 repetitions for each of the studied criteria. This makes it possible to separate the 68 products into groups (Student's t-test).

Dust cloud	26 groups
Sedimentation rate	22 groups

Table 4: Number of groups significantly different according to Student's t-test

The large number of groups confirms the discriminating power of the two criteria.

This analysis is used to select the 5 products targeted for further study (i'Tec_Q11). Each of the selected products belongs to a significantly different class. The following tables and diagrams show these classes according to a fixed colour code. The emphasis is on non-irritant and non-toxic products.

		A	B	C	D	E
Dust cloud	Mean	0.6	120.3	353.5	654.4	1162.9
	Standard deviation	0.8	8.8	41.4	71.2	175.6
Sedimentation rate	Mean	0	9	152	40	256
	Standard deviation	0	4	16	8	62

Table 5: Characteristics of the selected products

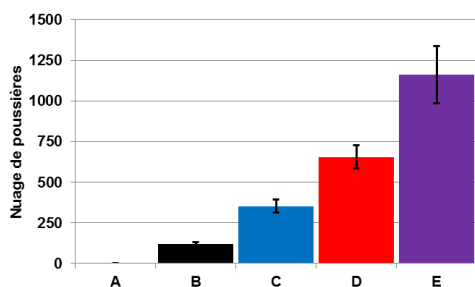


Figure 6: Dust cloud for the 5 selected products

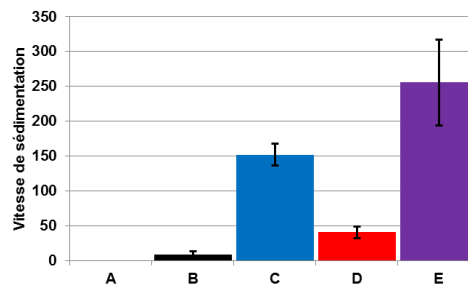


Figure 7: Sedimentation rate for the 5 selected products

		Sedimentation rate			
		⇒25%	⇒50%	⇒75%	⇒100%
Dust cloud	⇒25%	A			
	⇒50%		B		
	⇒75%			C	
	⇒100%				D E

Table 6: Ranking of the selected products

4. Conclusion

This study facilitates our understanding of how the Dustmon device works and enables us to identify the most important components of the protocol :

- 50 g mass
- Three repetitions per product (this protocol component will be reviewed at a later date)
- Dust behaviour assessment criteria: dust cloud in terms of the dust area; sedimentation rate in terms of the gradient between 5 s and 15 s.

Lastly, the 5 selected products will be used for further study into measurement repeatability and reproducibility and the potential preservation of discriminating power (i'Tec_Q11). The study will also investigate a possible correlation with the measurements taken using Heubach method.

5. Bibliography

i'Tec_Q5: Using the Heubach method to measure the emission of dust in animal feed additives **Report N° 10, 1998**. Comparison of laboratory methods used to characterise animal feed additives in terms of measurement ranges, discriminating powers and redundancies - Phase 2b.