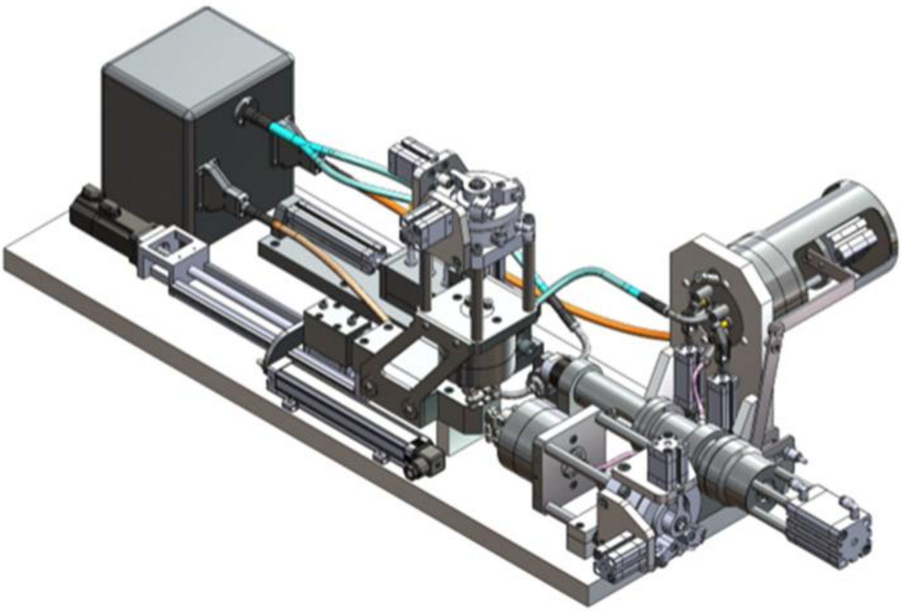
RMA

TECH

TRANSMICELL - The Technological Connection for the Paint Industries to Reach Industry 4.0



RMA TECH, through its founder, with decades of experience and patents in paint manufacturing processes, aware of the challenges that the paint segment faces, decided to explore new paradigms for this sector, through the creation of cutting edge technology that enable evolutionary leaps in this sector, following the other industrial segments that are in more advanced stages, such as the oil, petrochemical, paper and cellulose, pharmaceutical, automobile sectors, among others, where Industry 4.0 already has the necessary bases for establish yourself.

On the other hand, internationally, the Paint Industry, in practically all its manufacturing processes, presents a great technological GAP.

Commonly "automatizations", which translate into isolated mechanizations of industrial processes, are carried out in one or another unitary operation, basically motivated by a better balance of the production line.

These evolutionary mechanizations, commonly called “automatizations”, however, bring little in terms of effective gains to the business, since they do not alter the production dynamics in terms of their flow, integrating the various stages of the processes, until we reach a final product with low lead time, minimum variability and minimum cost, which, for example, that automotive industry has been practicing for decades.

It is easy to observe large stocks both in terms of raw materials and finished products in paint factories, which corroborates the thesis of the low manufacturing productivity of this segment.

Over decades, we have heard several theses and explanations about this, however, the real explanation is that the paint manufacturing processes, in most cases, are not capable, which implies that the "stock strategy" ends up being the adequate strategy to manage the lack of capacity, stability and productivity of the processes, however reducing the financial capacity and working capital of this segment.

Large stocks, in the final analysis, demonstrate only the fragility and low capacity of the manufacturing processes, in the face of market demand, a paradigm already surpassed by several industrial segments, through highly robust, flexible and lean processes, where the stock is treated as heresy.

In these segments, “industrial automation”, which is the result of the sum of “automatization” plus “integration” and “intelligence”, made possible real leaps in competitiveness through advanced strategies to control their 100% integrated processes.

“Intelligent” processes, integrated and capable, lead to optimal solutions where the business gain is then maximized.

The time has come when the paint industries, driven by high competition, low profit margins, high production costs, high inventories, resulting from low productivity, etc., change the manufacturing paradigm, using cutting-edge technological resources to win productivity and competitiveness in the international scenario.

In this sense, ***RMA Tecnologia Industrial Ltda*.,** focused all its expertise seeking to make the “intelligent automation” of the paint industries viable, where then, among other new concepts, the equipment called ***TRANSMICELL*** was born.

TRANSMICELL was conceived with the objective of measuring the most complex characteristic of the paint sector, which is the **"STRENGTH"** for colorants and bases.

This characteristic can take hours to be measured and even days to be adjusted for a batch in production, having great variability, which ends up being the determinant in the total lead time of production of these materials.

TRANSMICELL allows this measurement to take place in a matter of seconds, both in a laboratory and directly on the production line, maximizing the gains.

Measurement sensitivity and variability are far superior to conventional technique, which makes ***TRANSMICELL*** the new measurement and adjustment paradigm for this property.

TRANSMICELL, has an international patent filed in November 2018 and performs the measurement of the material ***"in nature"*** in liquid form, through the spectrophotometric technique by means of TRANSMISSION, unlike the conventional technique that uses an external standard for mixing, then performing the measurement of the Colorant Strength through REFLECTION spectroscopy, using a mixture between a standard base and the colorant under test, after the application and curing of this material on a test panel.

TRANSMICELL also measures, simultaneously with “STRENGTH”, also the “COLOR POSITION” and the “HIDING POWER”, for colorants and bases.

Associated with a Mass Flow Transmitter by “Coriolis” effect, ***TRANSMICELL*** also delivers other characteristics of the material, such as VISCOSITY and DENSITY, becoming a very powerful weapon in the automatic control of paint manufacturing processes and their correlates, enhancing the implementation of the long-awaited Industry 4.0 in the paint segment.

Hardware resources specially created for the equipment, combined with control software with artificial intelligence resources, make the equipment extremely flexible and easy to operate, intensifying its gains.

SUMMARY OF TRANSMICELL'S INNOVATIONS AND GAINS:

- Elimination of external standards to measure STRENGTH properties (external standards introduce great variability);

- 90% reduction in the measurement time and the adjustment cycle time related to the material (productivity gains);

- Elimination of human errors;

- Elimination of variability related to (weighing / application / drying / environment), arising from the conventional technique;

- Reduction of the cost of the formula (reduction of pigment / coating saturation);

- Allows 100% automated manufacturing for Bases and Colorants;

- Enables the pre-qualification of Color Bases for the production of “factory paints” (factory pack), through the use of INDUSTRIAL DISPENSING MACHINES, without the need for further adjustments, increasing productivity;

In order to facilitate the understanding of the technique used at ***TRANSMICELL***, we will develop a reasoning and considerations regarding the STRENGTH property:

What is the STRENGTH of a Colorant?

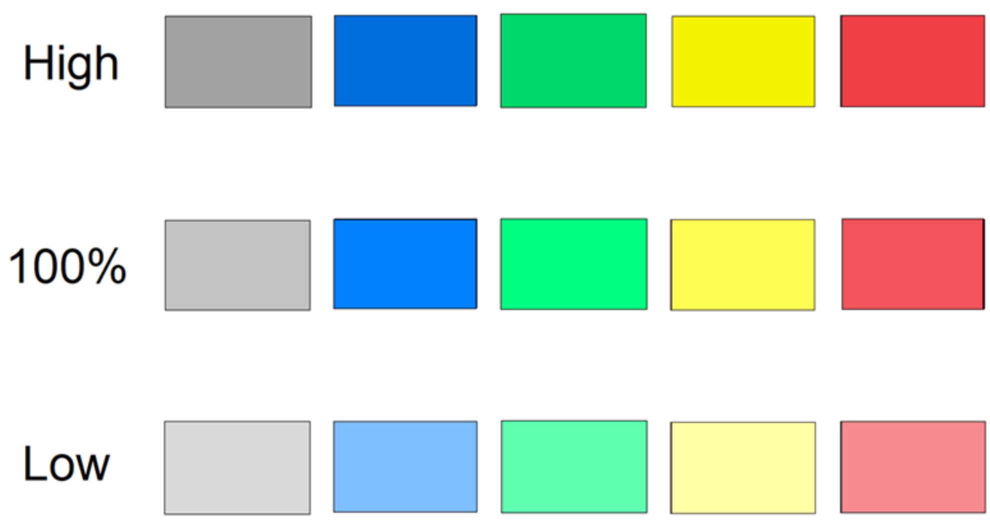
- The **Colorant Strength** is a measure that represents how strongly a given colorant affects another when mixed;

- This measure is essential to ensure that you have the right color when mixing colorants;

- Colorant strength is one of the main process quality tests carried out on automotive, industrial and decorative colorants;

- The Colorant Strength Force is also called the Colorant Power, with the English term “STRENGTH”;

- The following figure illustrates the variation of the STRENGTH for different batches of Colorants.



Why is Colorant STRENGTH important?

- The knowledge and control of the STRENGTH in colorants guarantee the delivery of consistent paints to customers in the mixing systems (automotive refinishing, industrial and decorative paints);

- A customer mixes several colorants, according to a formula, to obtain the paint of a car when making a repair or even when composing a color for the decorative painting;

- On the shop floor, the adjusted pigment bases and concentrates provide a fast and effective process for paint manufacturing, reducing cycle time and costs.

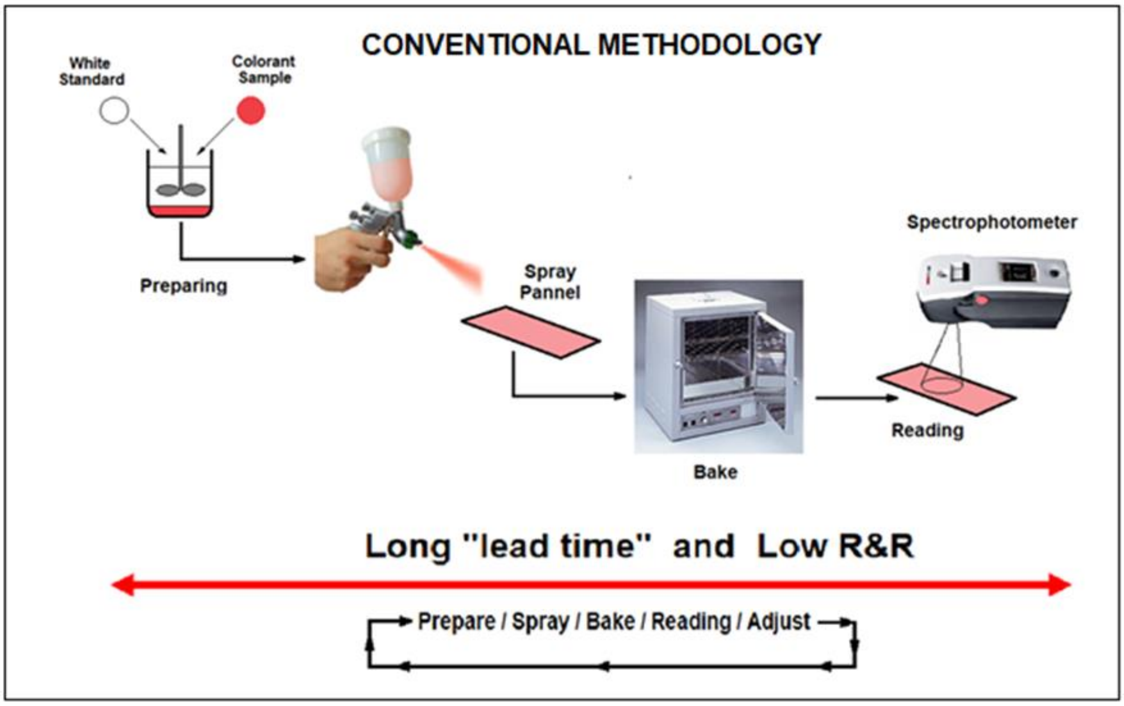
How STRENGTH is usually measured?

- The current method requires a small amount of colorant be mixed with a large amount of white base;

- The mixture is usually applied by spray gun on a panel that is dried / cured in an oven;

- After drying, the panel is measured on a spectrophotometer using the reflectance technique;

- The measurement is then compared to a measurement stored in a computer, specific to each colorant.



This technique of STRENGTH measurement in colorants and bases, is a methodology created decades ago, which presupposes the mixing of a certain amount of a base or colorant, with a certain amount of a Standard Pigment Base, which was previously standardized.

Usually a white pigment base, made from TiO_2 as a White Standard Paste, is used to measure the STRENGTH of colored pigments and a green or blue pigment base to measure the STRENGTH of bases or concentrates manufactured from white pigments.

In this methodology, spectrophotometry is used to measure the STRENGTH of the pigment under analysis, in the region of 400 to 700nm (visible spectrum), through reflection spectroscopy.

In this case, when a certain amount of a paste of a specific colored pigment is mixed with the Standard White Base, the STRENGTH is measured by observing the deformation generated in the spectral curve of the Standard White Base as can be seen below.

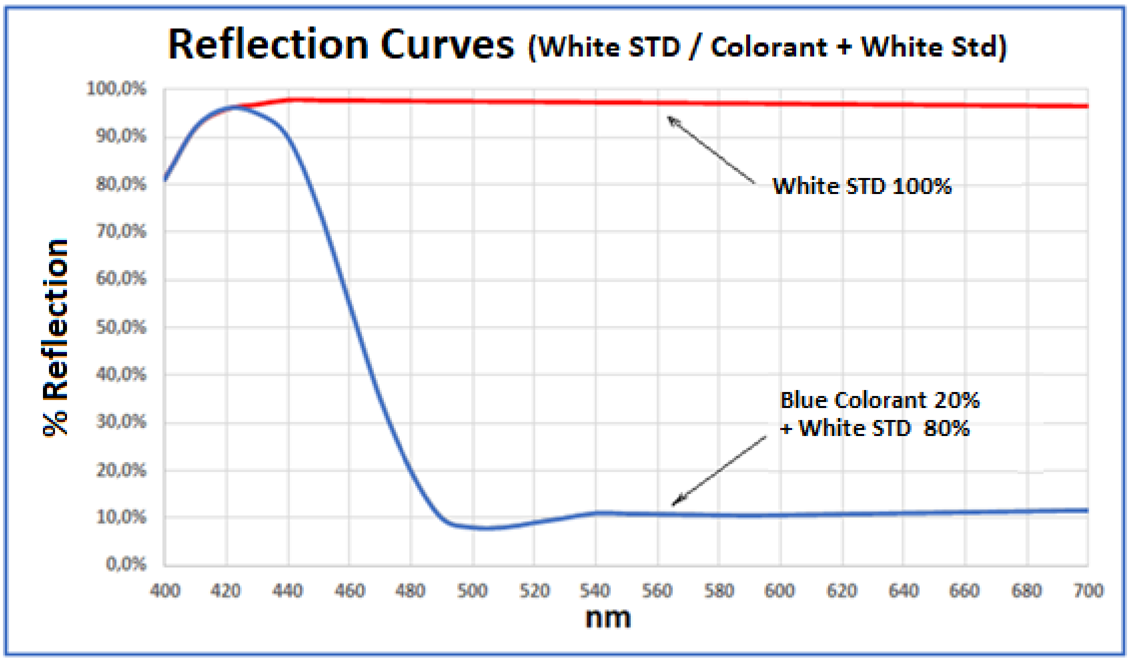


Figure 1

In this case, we can observe the reflection curve of the Standard White Base in its pure form (100%), represented by the red curve of the graph.

In the blue curve of the previous graph, we observe what happens with the reflection curve of the Standard White Base (red curve), when it is mixing a specific amount of a Blue Pigment Paste

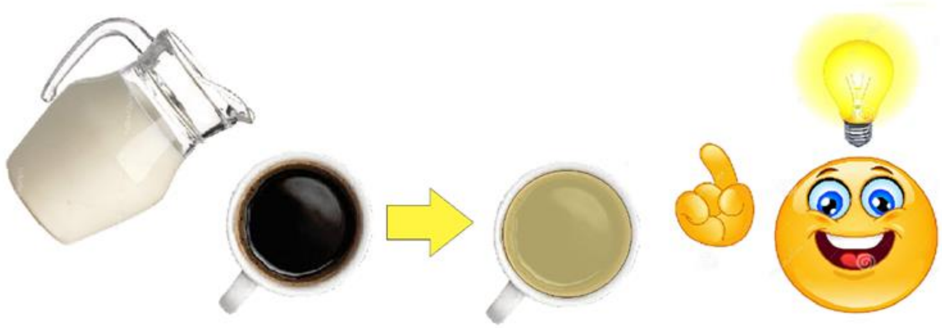
In this case, the Blue Pigment for having high reflection in the region of 400 to 450nm (blue color), presents high absorption of light in the wavelengths above these values.

It should be noted, however, that in this methodology, what is actually observed is an EFFECT and not a CAUSE because what ultimately results from this interaction is the deformation in the reflection curve of the Standard White Base and not a reading of the optical properties of the Blue Pigment, to which this new ***TRANSMICELL*** technology is proposed.

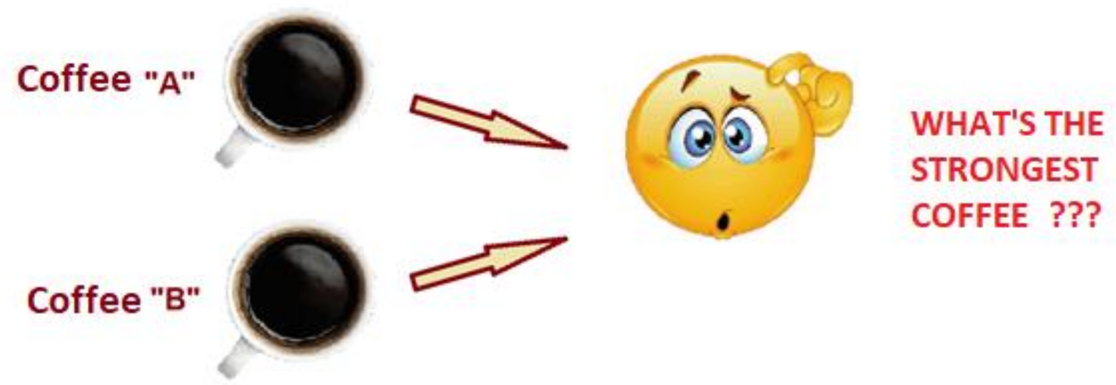
The main reason for not measuring directly the reflection spectrum of a panel applied with the BLUE Colorant, instead of mixing it with the Standard White Base, is that this colorant is found in what we call **"total saturation"** and in this case, there would be no significant differences in the direct measurement of their spectral curves even for a sample with 20% of the STRENGTH for another with 200% of the STRENGTH.

We can make a simple analogy to this effect, considering that we had a cup of coffee and observed the color of the coffee to identify how "strong" (concentrated) it is ...

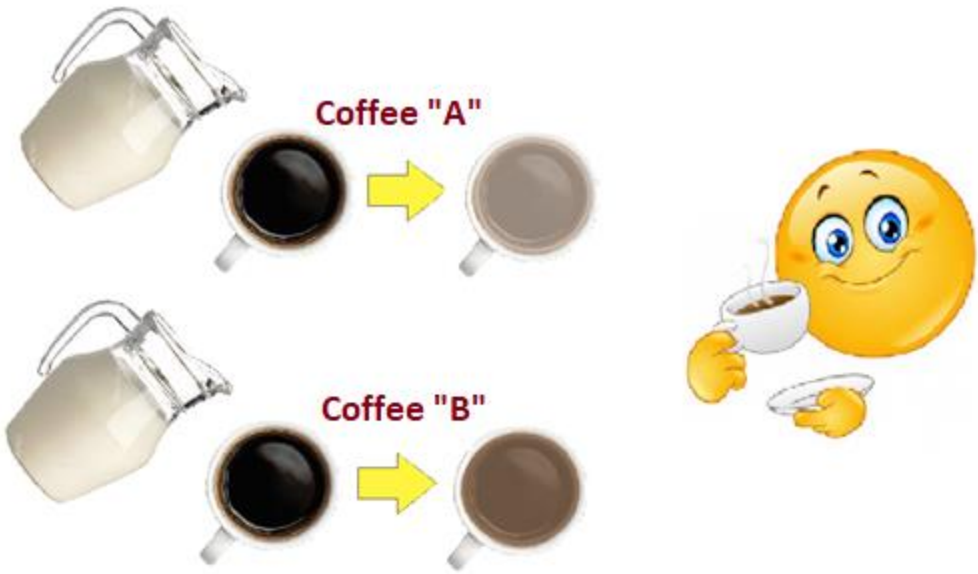
In this case, we could easily observe this property if we added a certain amount of milk to the coffee content in that cup, observing the color that would develop from that ...



This simple experiment could easily differentiate two cups of coffee, one made from stronger coffee and another made from softer coffee, which is exactly the principle that paint manufacturers use to measure the STRENGTH.



However, simply visually observing the coffee in the two cups, without mixing with a certain amount of milk, we could hardly say precisely which coffee is softer and which is stronger, as both are in the color stage that we know as “full saturation” , making it impossible for us to make any assumptions regarding its “strength” or intensity, just by visualizing its color.



The following is a representation of this in a comparison of two batches of a blue pigment, measured comparatively by the spectrophotometric method.

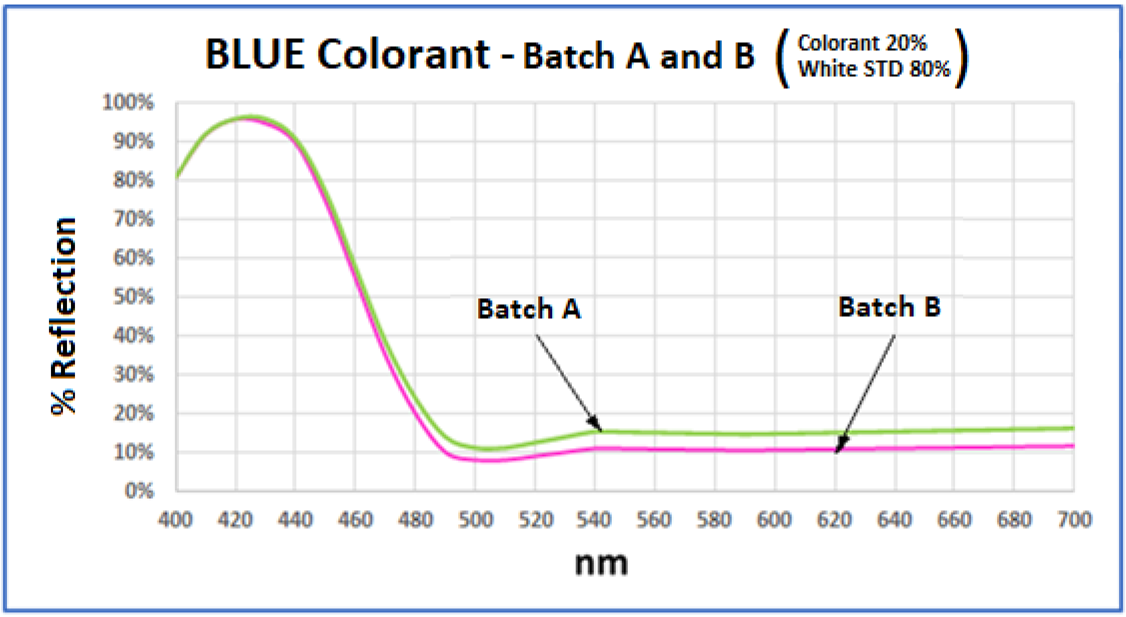


Figure 2

In the previous graph we see two curves related to the reflection spectrum of two batches of Blue pigment, properly mixed with the same proportion of White Standard Base, with **Batch (A)** represented by the green curve and **Batch (B)** represented by the curve in magenta.

Comparing the green curve with the magenta curve, we can say that the pigment **Batch (A)** was less efficient in causing a greater deformation in the spectral curve of the Standard White Base than the **Batch (B).**

Batch (B) in turn "deformed" the curve of the Standard White Base more, having in almost every spectral curve, lower values of% Reflection than **Batch (A).**

This clearly demonstrates that **Batch (A)** is "weaker" than **Batch (B),** which in the technical jargon of paint chemists, represents that the STRENGTH of **Batch (B)** is greater than that of **Batch (A).**

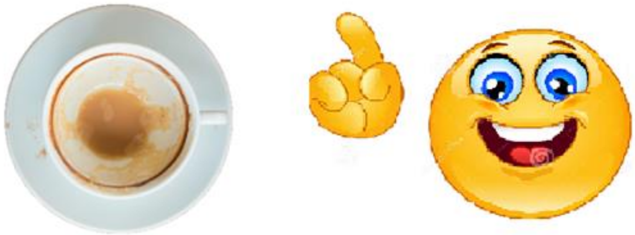
Well, this technique previously illustrated, as seen, has been used for decades and manages with reasonable precision to differentiate batches for colorants, bases, pigment pastes, etc., measuring and enabling adjustments in the STRENGTH of these materials.

Now, going back to the example of our coffee cups, in addition to the possibility of mixing milk, or even simply sipping a drink to differentiate between stronger and softer coffee, could we propose another way of conducting our comparison?

In this case, we will keep our reasoning in our coffee cups, additionally imagining that our two cups are made of white porcelain.

Following our reasoning, let's imagine that we are removing our black coffee from one of the cups until we can see the bottom of the cup through a certain layer (thickness) of coffee that covers the bottom of the cup.

At that point, the coffee at the bottom of the cup would no longer be at its "maximum saturation" and we would be beginning to notice a coloration similar to that obtained when adding milk to the coffee ...



From that point on, the more coffee we remove from the cup the thinner the coffee layer is on the bottom until the moment when there is no more coffee in the cup and we only see its white background ...

Continuing our reasoning, let's say that we establish a thickness of about 5mm of coffee above the bottom of the first cup, where in that thickness, the color we observed for our coffee is equivalent to the experiment that we had carried out in the original mixture with milk.

If we then use that same 5mm thickness of coffee for the other cup and observe the two cups comparatively, when looking at the coffee, looking at the bottom of the two cups, we would clearly see that in one of them the shade would be darker, which would indicate that in that cup the coffee would be stronger ...

Well, at this point, we have already managed to agree that the current method of paint manufacturers to determine the STRENGTH for colorants, pigments, bases and etc., by mixing with a Standard White Base, has similarity to the reasoning of the coffee cup with milk and also with this other supposed technique of "watching" our coffee in a certain layer (thickness), where it has a certain transparency that allows us to visualize the bottom of our cups ...

It is exactly on this concept that we base our research for the development of ***TRANSMICELL.***

This process, which allows us to see the bottom of the cup through a certain thickness of coffee, is called the “TRANSMISSION” method.

In this case, in order to be able to measure the “TRANSMISSION” spectrum of a given sample, light necessarily needs to pass through a certain thickness of the material under test, so that we can then observe the absorption effects generated in the light emerging from the sample, when across the entire visible spectrum.

Physically, when a certain amount of light energy in the visible spectrum region reaches a certain layer of material, part of that energy is absorbed and another part is transmitted.

The fraction of the absorbed light turns into heat, varying in intensity for each wavelength.

The fraction of light that can pass through (permeate) the material, emerging from the opposite side, then presents the colorimetric characteristics of the material "in natura", what we call the **"Transmission Spectrum"** of the material.

Our ***TRANSMICELL*** technology uses exactly that principle.

Our equipment is capable of measuring the “transmission spectrum” of a liquid colorant sample, in a fixed thickness, where the transmitted light (which passes through the sample) brings with it all the information of the material we are testing with greater sensitivity and less variability than the conventional method we previously described.

The reading of the “transmission spectrum” of a colorant sample presents its optical and colorimetric characteristics in the “pure” form, that is, we do not observe an “EFFECT” of the deformation of the “reflection curve” of a given material by the “addition / contamination” with another, rather the“ native transmission curve ”of the material, that is, ultimately we are observing the“ CAUSE ”.

This may seem irrelevant, but it is of great importance, considering that the conventional method requires the “interaction / interference” between the two actors (material to be tested and the “Standard White

Base”) to occur, and the resulting color of this mixing, after exposure to light from the spectrophotometer allows its measurement by the reflection method, in the region of the visible spectrum (400 to 700nm).

This interaction, resulting from mixing the material we want to test with the “Standard White Base”, ends up causing the great variability of this technique.

Note that if we have stability problems or still need to manufacture more “Standard White Base” for testing, we will certainly be introducing relevant variability into this form of measurement, which usually occurs.

But unfortunately the variability of this technique is not limited to this, because for the test to be carried out, we need to accurately weigh the colorant sample plus the “Standard White Base”, mix it under agitation, apply it on a panel, make it drying for only then, after all this, we can take this panel to a spectrophotometer and measure its “reflection curve”.

In this case, each step of this test adds variability that adds up, and it can still take hours until a result is obtained and with a very considerable variability.

For the method related to “TRANSMISSION”, there is no “second actor”, the interaction between the sample and the light irradiated by the spectrophotometer occurs directly through a fixed thickness of the material in its liquid form.

This makes a huge difference both in terms of the variability of the results, as well as in the time to perform the test, and at ***TRANSMICELL*** all analysis takes place in a fully automated way, taking about one minute.

Below we present the transmission spectra of the two blue colorant samples already illustrated in **Figure 2.**

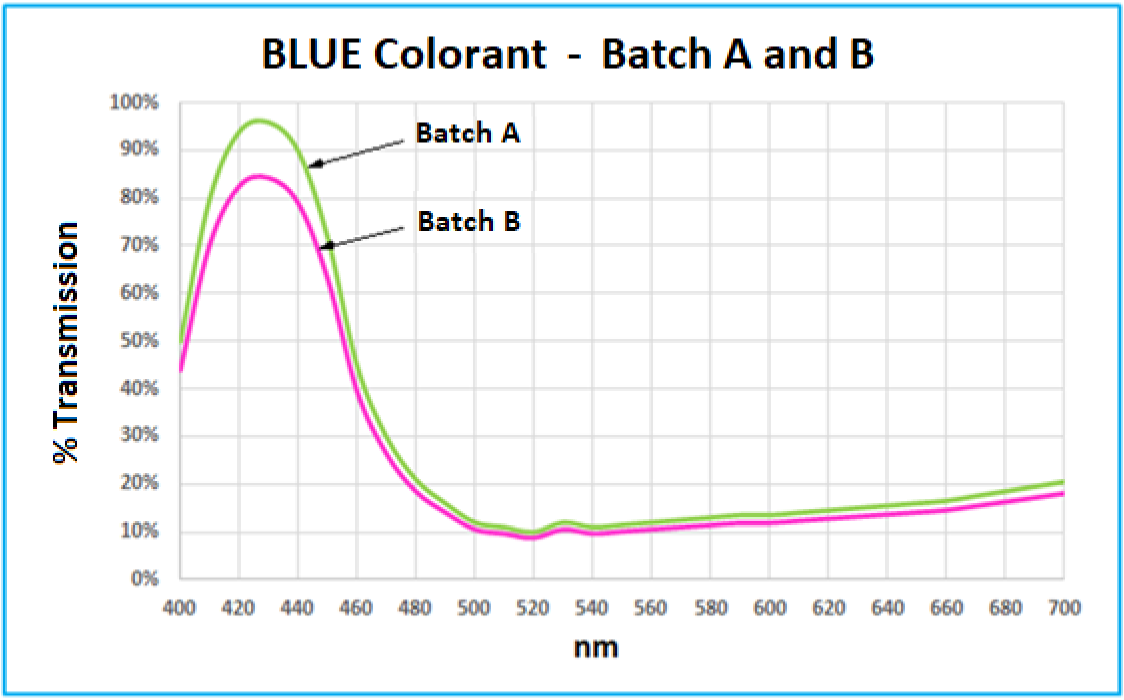


Figure 3

In the previous figure (Figure 3), the two curves represent the two blue colorant batches already presented in **Figure 2**, using the "Transmission Spectrophotometry" analysis technique in our ***TRANSMICELL*** equipment.

As we can see, the transmission curves of **Batch A** and **B**, specifically in the BLUE region (400 to 500nm), present a high differentiation having its maximum absolute difference in terms of% of Transmission, approximately in the wavelength of 430nm.

Physically we can interpret that the curve corresponding to **Batch B**, has greater STRENGTH because it was more effective in blocking the light that wanted to pass through it, when compared to the sample in **Batch A**, where the Transmission Level was higher in all lengths of wave.

We can observe, however, that in the traditional methodology, illustrated in **Figure 2**, that this region (400 to 500nm), is characterized by the region where less differentiation was obtained between the two colorants batches.

This is easily explained, given that the color Blue is characterized by the ability to absorb most wavelengths other than that of the region where most of the incident light is reflected (range 400 to 480nm).

When we mix a blue colorant on a "standard white base", which has the characteristic of reflecting a high level of energy approximately equal in all wavelengths, the blue colorant ends up causing the deformation of the curve of the "white standard base" in practically the entire region of the spectrum, except for the region of the color Blue (range 400 to 550nm) where it is also the peak of maximum reflection of this color, as can be seen in **Figure 2**.

Thus, it is easy to conclude why, in the conventional technique (reflection method), this region is not used to measure the colorant STRENGTH.

Several methodologies even use the "minimum reflection valley" to measure and differentiate the STRENGTH between two samples, which in **Figure 2**, would be around 500nm.

This situation is totally antagonistic when we measure the STRENGTH by the "transmission" technique in our ***TRANSMICELL.***

In this case, we use exactly the **"transmission curve peak"** to measure the STRENGTH, since that is the region that has the best "resolution" to differentiate between two different samples, as can be seen in **Figure 3**, around 430nm.

At this point in our thinking, you may be asking:

It makes perfect sense for the Transmission technique to be more efficient to be used for the measurement of the STRENGTH and with great advantages, but why has it not been used since forever?

The answer is a little complex, but let's try to explain it as simply as possible.

1. Colorants, pigment pastes, colored bases, etc. they have extremely high absorption and opacity and when "*in nature*" measures block practically all the light that the source of the spectrophotometer can provide. To have an idea of the opacity of pigmented colorants, in the case of inorganic pigments even with extremely low film thicknesses around 2 microns (0.002mm) the light block is almost complete;

2. Practically the vast majority of spectrophotometers that measure through the transmission methodology use “cuvettes” with optical paths (thicknesses) of the order of 10mm which, for 99.9% of the colorants and bases, would totally block the light, in a measure of transmission spectrum;

3. A large majority of the pigments adhere to the surface of the spectrophotometer transmission windows, staining them and falsifying later readings. Disposable plastic cuvettes still have limitations regarding the composition of solvents, due to their chemical resistance;

4. The light sources of the spectrophotometers have fixed power, not allowing us to increase their emission to seek a higher level of signal, which allows us to differentiate samples with an acceptable signal / noise ratio;

5. The spectrophotometers that operate by transmission and its accessories, were not developed for measurements in materials of high opacity. These equipment’s were basically designed to measure transparent colored solutions, where some colorants fit and following what the ***“Beer Law”*** postulates. In this case, the only expected effect between the incident light and the sample is its absorption, the behavior of which is described by the equation:

$$\mathbf{A = \varepsilon.b.c}$$

ε = molar absorptivity

b = length (thickness) of the cell path in which the sample is contained (optical path)

c = concentration of material under analysis

6. For pigmented materials such as paints, colorants, pigment concentrates, bases, etc., what we find are solid particles, finely divided, suspended in a liquid medium, unlike a solution. In this particular case, Beer's Law does not apply because, in addition to the simple absorption of light that passes through the material, another phenomenon occurs in a concomitant and extremely intense way, called ***"scattering".*** In this case the light that passes through the medium, collides with the particles in suspension, being part absorbed by the particle and another part reflected in multiple directions, causing the effect of "scattering", similar to a chain reaction.

This effect is extremely intense in inorganic materials (pigments and fillers) and less intense in organic pigments, although it occurs in both cases.

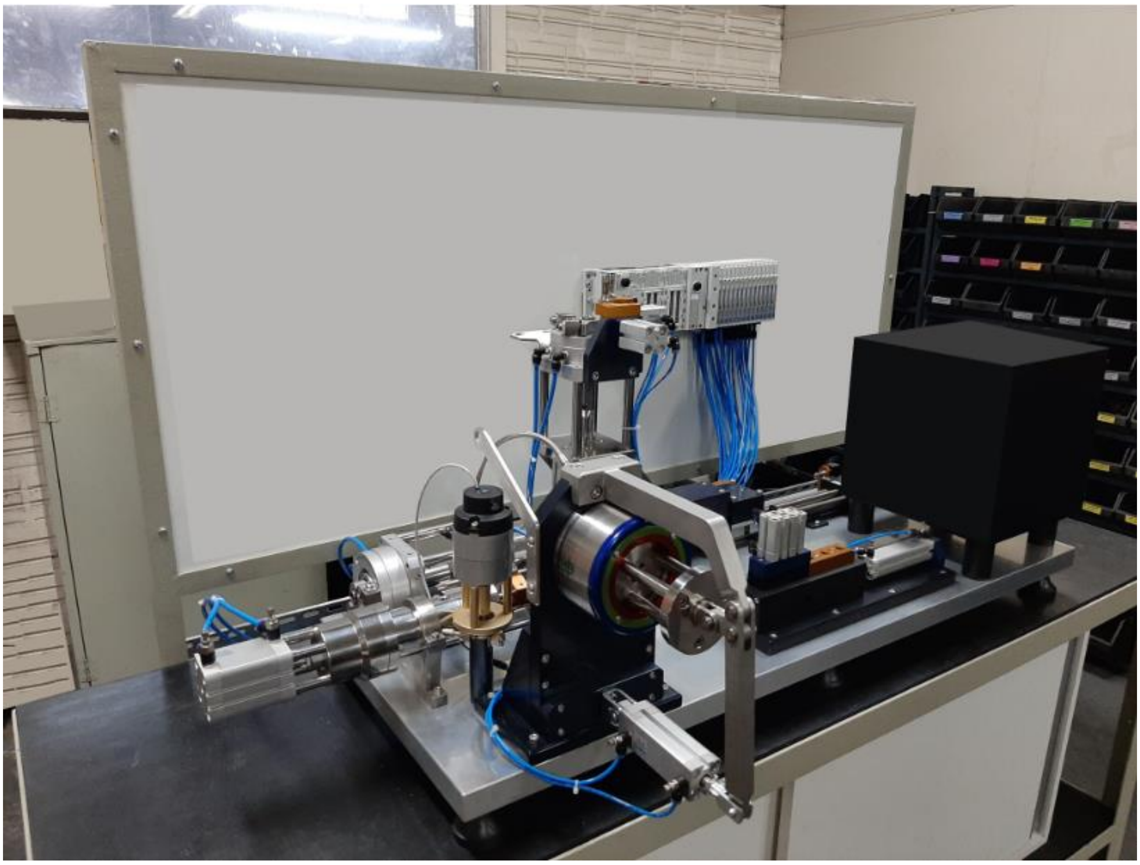
In this case, unlike what occurs in solutions, where Beer's Law applies, the amount of light absorbed by a given material does not vary in a linear way with the "optical path" (thickness) of the material, but suffers a decay exponential with this factor.

This scattering phenomenon is also directly linked to the size of the particles and their distribution in a medium, because as we know, the smaller the particle size of a given amount of material, the greater the sum of the surface areas of the particles present, which demonstrates yet another factor to be taken into account.

Based on all these theories and concepts, ***TRANSMICELL*** was then idealized, having its patent filed in November 2018 at the international level (PCT).

A pilot unit (Prototype) was then built, which has been operational since February 2020.

All these phenomena, related to interactions of light with particles (pigments) in a medium, were the object of study generating the **KUBELKA MUNK THEORY**, which in addition to the simple factor of absorptivity **"K"** incorporated the effects of multiple scatters **"S".**



OPERATIONAL DATA:

• Sample volume per analysis: **25 ml (max)**
• Analysis time: **1.5 minutes (max)**
• Exploratory Analysis Cycle: **5.0 min (max)**
• Spectrophotometer: **RMA - ESPECTRAMATIC**
• Sensor type: **CCD (1024 pixels)**
• Chemical Resistance: **Supports any combination of solvents**
• Material: **AISI 304 stainless steel**
• Reading window: **SAPPHIRE with dynamic cleaners**
• Communication: **PROFIBUS TCP / ETHERNET IP**
• Installation: **Classified Area with pressurized cabinet with N2**
• Pneumatics: **FESTO**
• Control System: **PLC + Supervisory System ELIPSE E3**
• Security System: **PLC interlock and primary protection systems**

- Patent**: BR 10 2018 0730223**

VÍDEO 1 - YOUTUBE

TRANSMICELL OPERATING PRINCIPLE SIMULATOR

https://youtu.be/F4uPsoqMwEg

VÍDEO 2 - YOUTUBE

FILM OF THE TRANSMICELL PILOT UNIT - (initial tests)

https://youtu.be/o-NYg1yY068