# Ink Jet Pigments: The Triple S Concept

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## Abstract

*For ink jet grade pigments the Triple S concept became well accepted. Besides chemical constitution the solid state parameters size, shape and surface properties ("Triple S") are the key design elements.*

*Furthermore the "hidden pigment properties" have to be controlled. One example is the dynamic surface tension measurement (DSTM). Depending on the pigment and the associated dispersing or wetting agent, the DSTM can be modified in a wide range. This is important for the various fast wetting processes during ink jet printing.*

*In a similar way the pigment conditioning has a significant influence on viscosity and on viscosity over shear rate.*

*Applications: for each application further demands have to be fulfilled. Office and desk-top application need high transparency, good optical density and the desired photorealistic quality.*

*Wide format printing requires high light-, weather- and water fastness and sometimes more opaque pigments.*


## Introduction

The term colorants comprises pigments and dyes.

Dyes are soluble in the applied vehicle, while pigments are small solid particles with a distinct crystal structure. As shown in Figure 1. pigments can be segmented into three classes. This paper focuses on organic color pigments

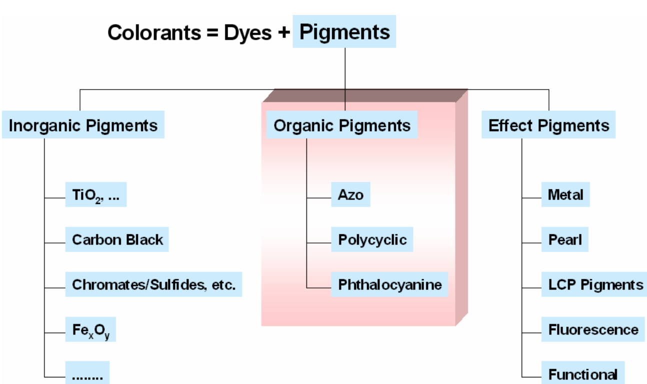


***Figure 1:*** *Pigments can be segmented into three main classes. This paper focuses on the organic color pigments*

From a chemical viewpoint the three groups of organic color pigments are the dominating azo-pigments, followed by polycyclic- and phthalocyanine.

Each main group has various chemical subclasses (see Figure 2)

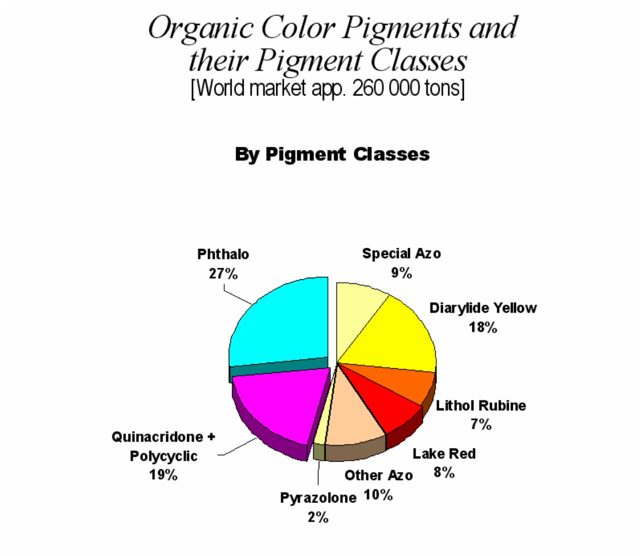


***Figure 2:*** *Classification of organic color pigments according to chemical classes*

Core properties of organic color pigments are shade, color strength (or optical density), light-, water-, weather fastness, hiding power, transparency and gloss to name the most relevant ones. [1] Key to achieve the full properties of a pigment is the optimum dispersion quality.

Pigments form agglomerates and aggregates which have to be dispersed into primary particles, typically in the nano-meter-range, in order to achieve the full pigment power. Pre-dispersions (also called color concentrates or masterbatches) are used for optimum dispersion quality.

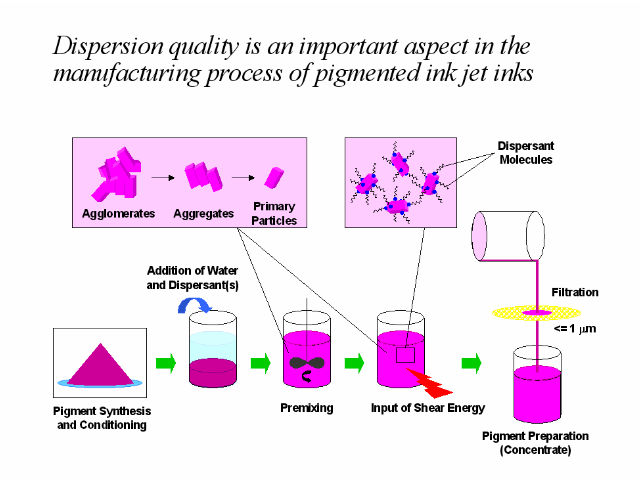


***Figure 3:** Optimum dispersion quality is the key for pigment properties. As powder, pigments have a size in the micro-meter-range. Only when dispersed do they achieve the nano-meter-size.*

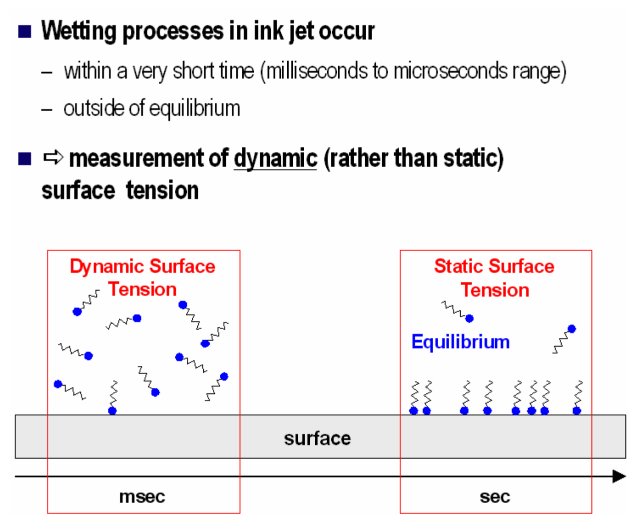


***Figure 5:** For fast ink jet wetting processes the dynamic surface tension provides information before equilibrium*

## The Triple S concept

As reported recently [2] [3] with a sophisticated combination of particle size, shape and surface almost all requirements for ink jet can be covered. Figure 4 explains some details for these parameters.

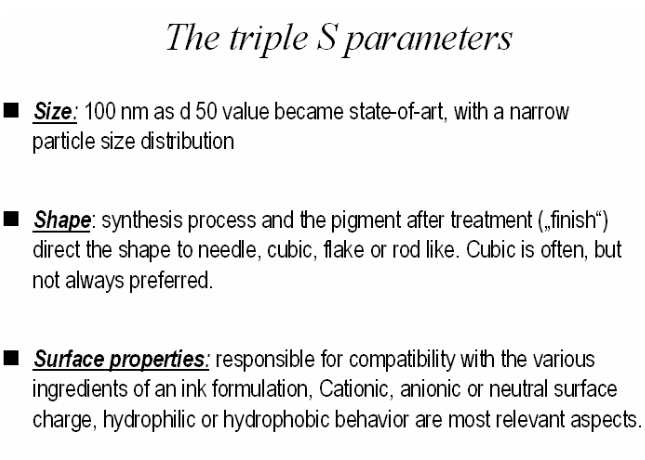


***Figure 4:** State-of-art ink jet pigments are designed with respect to size, shape and surface properties.*

## Aqueous inks

Aqueous pigmented ink jet inks for office applications have become increasingly successful in recent years. With the 100 nm pigment grades, the desired coloristic properties can be achieved. Size, shape and surface properties are relevant keys for the ink performance.

Fast wetting processes are typical for ink jet printing. Such wetting processes occur in the milli- and micro second range during nozzle wetting, droplet formation and substrate interaction. Figure 5 shows that such wetting processes take place before the equilibrium is reached.

The DSTM (dynamic surface tension measurement) method provides detailed insight into the interaction between pigment surface and the surrounding ink system [4].

The rate of the surface wetting and the change of surface tension over time show specific characteristics for each system. Figure 6 shows for a given pigment the extent to which the DST changes with the system: The upper line shows a slow surface wetting with a head-tail surfactant due to their micelle formation. With a Gemini surfactant the wetting is fast. After approx. 100 ms the competition between Gemini and head-tail surfactants starts.

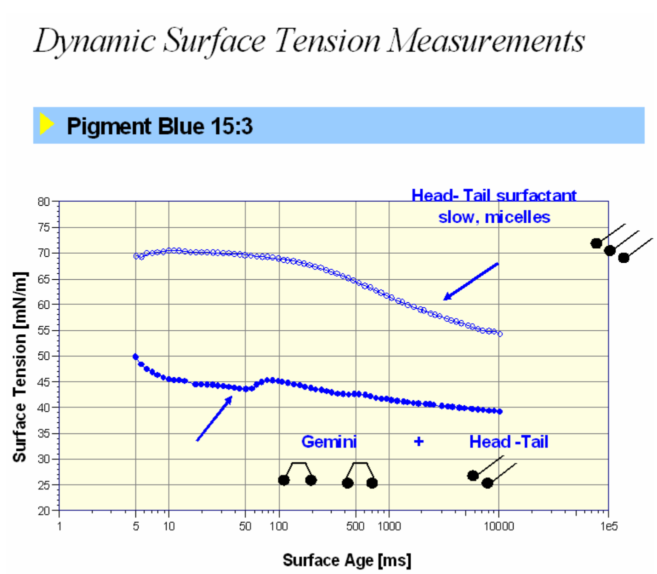


***Figure 6:** Gemini type surfactants show much faster surface wetting at the given pigment. At the lower line the "bump" indicates when the head tail surfactants start to replace the Gemini ones.*

In Figure 6 it is shown how for a specific pigment the surface wetting can be directed. In a similar way, the pigment properties can be modified to achieve the required wetting behavior for a given ink system. For example, anionic and cationic pigment surfaces require different surfactants. Once the surface properties are designed, they must be identical lot by lot.

## Solvent based inks

For a wide and grand format, typical substrates are paper, plastics, like PVC, and many others. The ink vehicles are organic solvents with good substrate interactions and fast drying times [5].

For wide format outdoor application the pigments need excellent light-, and weather-fastness.

This requires pigment classes with highest fastness properties, like polycyclic pigments and often leads to higher pigment $d_{50}$-values (200 – 300 nm) to further enhance stabilities.

Figure 7 shows the influence of the pigment design on the ink viscosity. A sharp viscosity increase at low shear forces is undesirable. Only stable viscosity guarantees optimum ink flow properties.

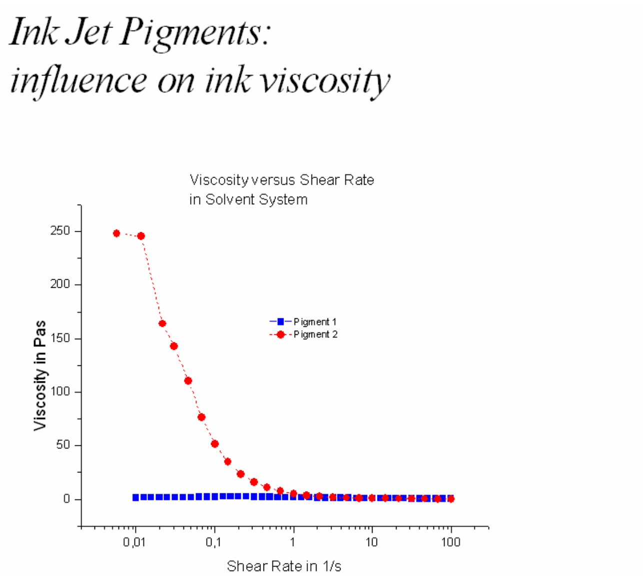


***Figure 7:*** *Viscosity over shear rate is strongly influenced by the pigment grade. Two different grades of P.Y. 120 (Benzimidazolone ) show significant different viscosity behavior. Pigment 1 received a specific surface after-treatment, pigment 2 is the standard coating grade.*

The wide format ink jet printing segment is becoming increasingly successful. Some of the trends are summarized as follows:

- UV ink jet becomes more and more popular
- Exchange of ecologically problematic ingredients
- Increase of print speed
- Better resolution
- New markets (e.g. packaging)

## Conclusions

Modern chemistry allows for the design of pigments according to the needs of ink jet. The specific modification of surfaces through functional groups or by specific after treatments provides unlimited opportunities.

With this, ink jet printing will steadily have opportunities for new markets and new applications.

## References


[1] "Industrial Organic Pigments", W. Herbst, K. Hunger, Verlag Chemie, Weinheim (Germany), 3rd edition, 2004.

[2] "From Ink Jet Dyes to Ink Jet Pigments", H.-T. Macholdt, 7th International Symposium on Functional pi-Electron Systems, May 15-20, 2006, Osaka; proceedings p.56.

[3] "Nano Approach for Ink Jet grade pigments" H.-T. Macholdt, Nanoscale Ink and Pigment Technologies , Pyra Conference, September 27-28, 2006, Chicago; proceedings.

[4] "Dynamic surface tension: A modern method to enhance performance of pigmented inks for ink jet", K.-H. Schweikart, B. Fechner, H.-T. Macholdt, Ink Maker August, 2005, pp 21-23.

[5] "Wide format Ink Jet Approach", S. Schneider, 3rd European Congress on Printing Inks, Ink Maker Forum, April 17, 2005, Nuremberg; proceedings, pp 143-150.

[5] Typical organic solvents or solvent combinations for wide format printing are cyclohexanone CAS# 108-94-1;butyl-glycol-acetate CAS#112-07-1;tetramethoxy-ethane ( ® Highsolv P) CAS#2517-44-4;diethylene-glycol-diethylether CAS#112-36-7; typical pigments for wide format outdoor use are P.Y.120 Benzimidazolone;P.Y.139 Isoindoline; P.Y.150 Metal Complex;P.Y.151 Benzimidazolone; P.Y.213 Monoazo/Chinazolondion; P.V.19 Quinacridone; P.R.122 Quinacridone; P.R. 254 DPP-Piigment: various P.B. 15 grades Cu-Phthaloblue; for further details see brochure " The Source of Ink Jet Printing Excellence" Clariant Edition 2007/2008, DP8518E_05/07.


## Author Biography

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