Novel Inkjet Coating Alumina

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Abstract

Controlling alumina aggregate particle shape strongly influences production processing and resulting print quality for glossy inkjet. Especially primary particle size and specific surface area influence the paper and film coating processing related features as well as the resulting print result. AEROXIDE® Alu C, AEROXIDE® Alu 65 and the developmental grade VP Alu 3 are examples how to design particles for specific coating and printing needs.

Introduction

Alumina [1] is widely used as an inkjet coating pigment, preferably talking about coating for photorealistic imaging on polyethylene coated paper, so called RC(resin coated) paper. It meets the needs for coating formulation and processing as well as for high quality prints:

- easy to disperse and to stabilise in water
- acceptable binder demand
- high absorption capacity
- large colour gamut
- high gloss

To achieve this, three different kinds of alumina products were developed for use in inkjet coatings:

- AEROXIDE® Alu C
- AEROXIDE® Alu 65
- developmental product VP Alu 3

The purpose of this comparative study is to show the effects on the inkjet coating formulation make-down procedure, the coating process and finally the resulting print quality.

	AEROXIDE® Alu 65	AEROXIDE® Alu C	VP Alu 3
BET Surface Area	**65 m²/g**	**100 m²/g**	**130 m²/g**
Primary Particle Size	~20 nm	~13 nm	~10 nm
X-Ray Form (app.)	τ and δ, little γ	33% δ, 66% γ	γ

Figure 1. Alumina: Physico-chemical data

Primary Particles and Specific Surface Area

All three alumina products are made according to the Degussa fumed oxide process [2]. The commercial grade AEROXIDE® Alu C is flanked by AEROXIDE® Alu 65 and a developmental grade with lower and higher specific surface areas, respectively. In contrast to wet processed oxides, especially silica, the specific surface of a fumed grade is a function of the primary particle size and their corresponding aggregates. Primary particles do not exist as discrete entities. However, due to their loose aggregation they do not have internal surface area resulting from pores but have only external surface area. Specific surface area is a function of primary particle size. The ready access to the external surface area makes fumed alumina an ideal pigment to fix inkjet dye on the particle.

Aggregates and Pores

Although not porous as such, alumina particles do form pores because there is space left in between adjacent single primary particles. This space forms intraaggregate pores.

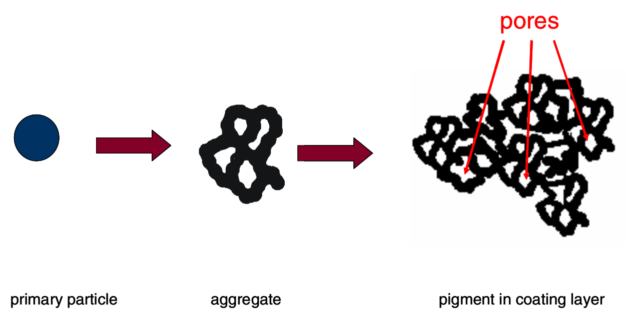

Figure 2. Microporous coating layer

These pores are needed to create absorption capacity. In contrast to classical impact printing, e. g. off-set or rotogravure where the ink carrier is mostly organic solvents, which is either absorbed by the paper or evaporated in the print shop, the solvent of the inkjet ink must be absorbed within the coating layer. In general this solvent is water. In case of RC paper with a polyolefin layer or a film, there is a complete lack of absorption capacity. But even for inkjet coating on paper absorption capacity is needed in the coating layer in order to secure a fast print drying. Mercury porosity has proven to be a good means to measure the pore volume of a coated inkjet sheet [3].

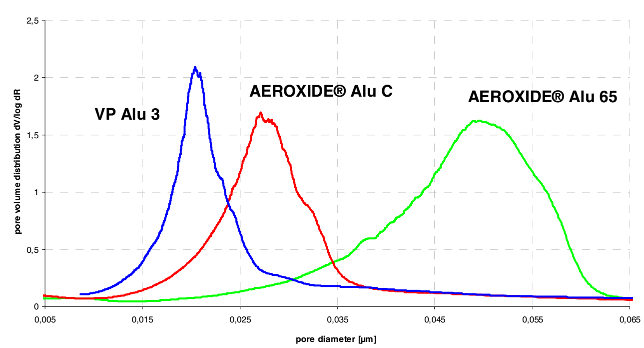

Figure 3. Inkjet Sheet: Intraaggregate pore distribution, AEROXIDE® Alu C / Alu 65; VP Alu 3

The line on the right shows the pore volume distribution of AEROXIDE® Alu 65, the product with the largest primary particle size and, hence, the smallest specific surface area. The line on the left, alumina VP Alu 3, is at the low pore diameter side of the pore size distribution having the smallest primary particles and the highest surface area. AEROXIDE® Alu C occupies the room in between. In short, AEROXIDE® Alu 65 forms the largest pore volume when used as coating pigment, and Alu 3 the smallest one.

Inkjet Application Test Results

Based on the particle knowledge, the effects for the make-down of inkjet coating formulation, its coating processing and finally the print results have been studied. Coated sheet is a PET film. For the make-down procedure all pigments were added to the PVA binder solution as dispersions in water [4].

These were the parameters tested for each glossy inkjet coating:

- formulation
  binder content
  flow properties, indicated as runnability
- sheet and print
  gloss (60°)
  colour quality
  resolution

The binder content was optimised individually for each pigment. It was regarded as minimised as soon as cracking after drying had disappeared. The Brookfield viscosity of the coating formulation was the means to judge its runnability during the coating process, considering also the respective solid content. The sheets were printed on an Epson Stylus Color 980. Colour was measured with a spectrophotometer. The line sharpness of image analysis gave the resolution and, hence, indirectly the absorption ability of the coating layer.

A normalised diagram shows the performance of AEROXIDE® Alu C as reference, setting each feature as one. Values greater than one show advantages compared to the reference and values less than one disadvantages.

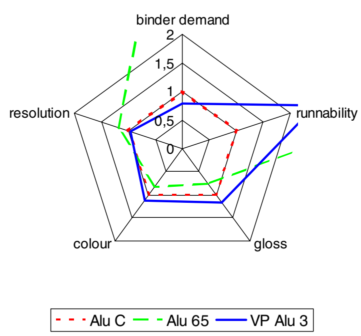

Figure 4. Performance rating: AEROXIDE® Alu C / Alu 65 / VP Alu 3

AEROXIDE® Alu 65 reduces dramatically the binder demand und improves strongly the runnability of the formulation during the coating process. Resolution is also improved. This occurs, however, at the expense of colour quality, both colour density and gamut, and gloss. VP Alu 3, on the other hand, improves both gloss and colour quality without giving up resolution when compared to AEROXIDE® Alu C. Runnability is still much better compared to the reference, although due to lower solids level. More binder, however, is needed.

How do these application results link to the physico-chemical data, namely primary particle size and specific surface area?

Particle Feature		Resulting Physicochemical Effect	Application Effect	
primary particle size ↑	⇒	pore volume ↑	resolution ↑	
surface area ↑	⇒	interacting ability ↑	colour quality ↑	binder demand ↑
surface area ↓	⇒	interacting ability ↓	runnablility ↑	
primary particle size ↓	⇒	pore diameter ↓	gloss ↑	

Figure 5. Physico-chemical features and resulting application effects

- Higher primary particle size leads to a higher pore volume, hence a higher absorptivity with better print resolution.
- Higher surface area increases the possibility of the particles to interact with the environment that leads to a better dye fixation that improves the colour. Because of smaller particle size, there is also a higher transparency that boosts full colour density. On the downside, a higher surface area raises the need for binder.
- When reducing the surface area we reduce the interacting ability, improving at the same time the runnability of the coating formulation on the coating machine.
- Smaller pore diameters due to smaller primary particles reduce light scattering. This raises the gloss.

There is one exception within this well fitting explanation pattern: It is the improved runnability of VP Alu 3, compared to AEROXIDE® Alu C, although it has a higher surface. This is due to a lower solid content in the coating formulations, lower by 10% (20.6% vs. 23.7%). The concentration that can be achieved with VP Alu 3 as dispersion in water is lower than with AEROXIDE® Alu C.

Conclusions

- Alumina AEROXIDE® Alu C meets the needs of both imaging quality and good coating processing.
- Should superior image quality and gloss be needed, VP Alu 3 is an attractive alternative alumina. Formulation and coating may be more challenging with especially higher drying capacity needed.
- If gloss and the colour part of the imaging can be compromised AEROXIDE® Alu 65 is the pigment of choice. It offers low binder demand, good runnability and even improved resolution.

Regarding the conclusion for imaging, this is based on a printer with dye only ink and high ink volume to be absorbed. The broad variety of inkjet printers may lead to modified conclusions. This requires individual judgment. All the more the link of application features to physicochemical parameters in the case of alumina helps to choose the right pigment for a needed inkjet coating.

References

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[2] Technical Bulletin Pigments No. 11, Degussa AG (2001)

[3] K. Werner, Felix Schoeller, private communication (2004)

[4] Technical Information (TI) 1212, Degussa AG (2004), „Degussa Synthetic Silica for Inkjet Media"

Author Biography

Arnold Storeck holds a diploma in chemistry from the University of Bonn, Germany, (1978) and is a Doctor of Science earned at the Institute of Technology, Aachen, Germany (1980). He has worked in R&D departments of fast moving consumer goods companies before he joined Degussa, Hanau, Germany, in 1989. Since then he was assigned to several application areas for the use of synthetic silica and silicate.