24th INGEDE Symposium
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Common INGEDE/DPDA Project: DPDA Ink Study

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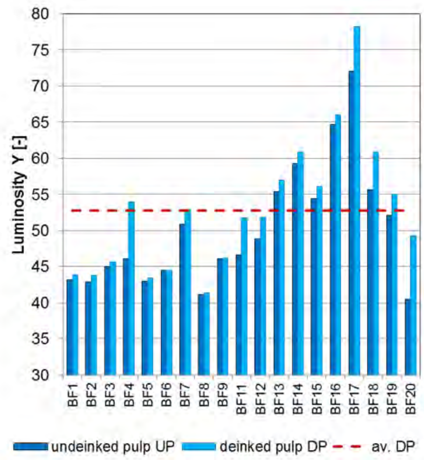
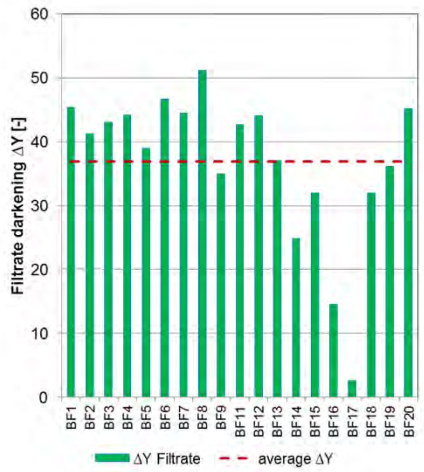
DPDA & INGEDE Ink Study

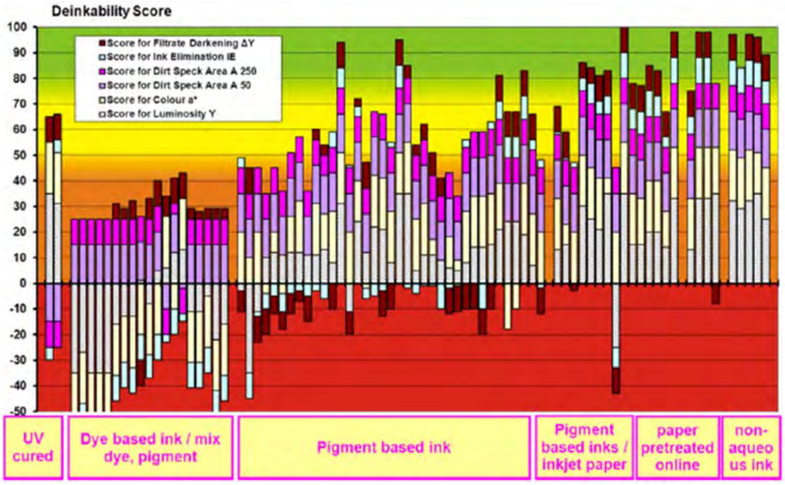




Content

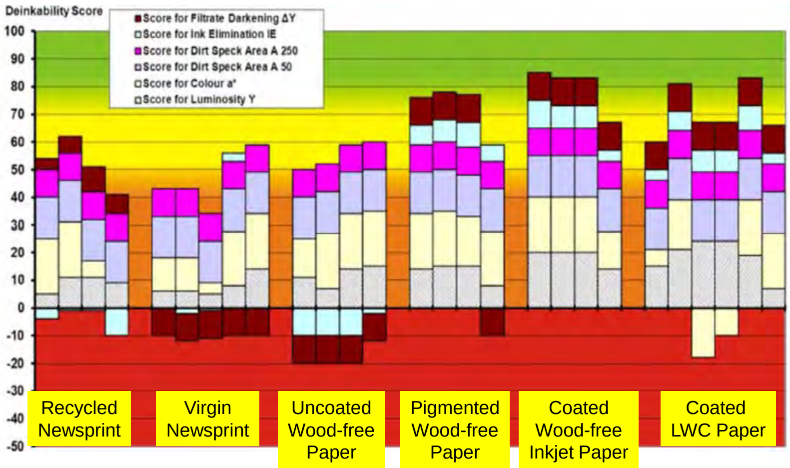
- Current situation and research program
- Pre-tests for comparability
- Test procedure
- Results of ink variation
  - Impact of surface tension and viscosity
  - Impact of pigment type
  - Impact of additive addition

Deinkability of Inkjet Prints (INGEDE Deinking Data)



Source: A. Faul, INGEDE, 10th Research Forum on Recycling 2013
Laboratory deinking according to INGEDE Method 11 (flotation deinking)

INGEDE-DPDA Benchmark Study



Background

- Several previous studies have shown that uncoated inkjet-optimized papers with cationic charge on paper surfaces can lead to positive deinkability results
- INGEDE and DPDA data show that uncoated, non-inkjet optimized papers are the largest challenge concerning deinkability with water-based pigment inkjet inks
- INGEDE and DPDA benchmark study show similar behavior of all DPDA member water-based pigment inks on uncoated papers
- Based on benchmark study results, any of the DPDA pigment inks could be used as the reference ink formulation
- Canon/Océ pigment inks chosen as the commercial reference for logistical simplicity reasons

Project Team

Dr. David Croll (Speaker)	OCE Printing Systems
Georg Besold	Kübler & Niethammer
Andreas Faul (Speaker)	INGEDE
Holger Hampel	Schönfelder Papierfabrik
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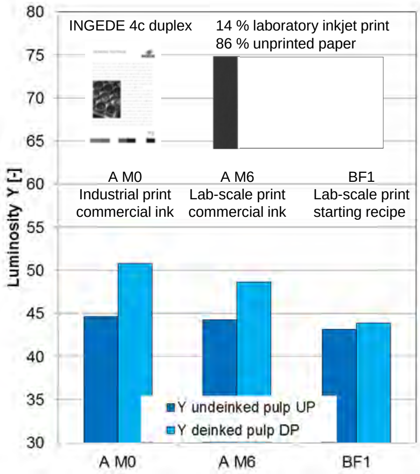
Andreas Steenbock	Steinbeis Papier
Institute:	PTS München
Project Manager	Dr. Elisabeth Hanecker

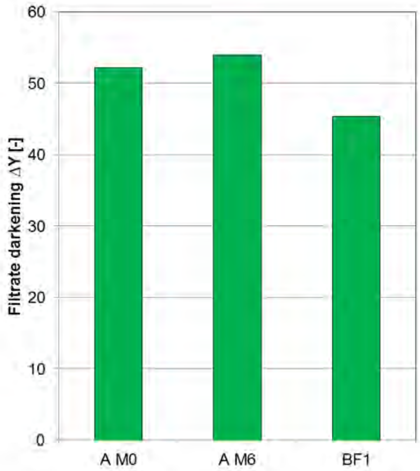
Research Programm

1. Pretests for comparability of industrial inkjet prints with laboratory test prints
   - Preliminary tests for determining the required quantities of test prints and unprinted papers to obtain comparability in terms of deinkability of industrial inkjet prints
   - Definition of the required quantities for comparison to industrial print
   - Definition of test procedure for further investigations
2. Impact of properties of aqueous inkjet inks on deinkability
   - Impact of surface tension and viscosity
   - Impact of pigment type
   - Impact of additive addition

Results of pretests for comparability – Luminosity and filtrate darkening

➢ Definition of the required quantities for comparison to industrial print





Test procedure

- Preparation of laboratory inkjet inks (defined recipes)
- Preparation of test prints
  (laboratory printing with ink applied to the paper surface via laboratory rod coating with different inkjet inks on defined copy paper)
  - Accelerated aging of test prints
- Proportions of printed and unprinted materials for deinkability test
  - 14 % laboratory inkjet print (accelerated aged)
  - 86 % unprinted paper (unaged)
- Deinkability test according to INGEDE Method 11
  Chemicals: 0,3% NaOH, 0,9% sodium silicate, 0,7% peroxide, 0,8% oleic acid

- **Ink Trial Points**
  - Variation of surface tension and viscosity
  - Variation of inkjet pigments
  - Addition of additives (wax particles, binders)
- **Laboratory test prints**

- **Deinkability Evaluation**
  - Luminosity of undeinked and deinked pulp
  - Ink Elimination IE
  - Filtrate darkening ΔY
  - Dirt specks when visually observed

Ink Trial Points

BF 1 Starting "neutral" recipe

- **Variation of surface tension and viscosity**

  BF2 Reduced surface tension to ~20-25 g·cm/s²

  BF3 Increased surface tension to ~45 g cm/s²

  BF4 Increased viscosity of ink by thickener addition (highly viscous polyvinyl alcohol)

- **Variation of inkjet pigments**

  BF5 Use of pigments which are stearically dispersed

  BF6 Use of "self-dispersing" pigments

  BF7 Use of cationically dispersed pigments

  BF8 Use of pigments with a significantly larger average particle size

  BF9 Use of pigments with a significantly smaller average particle size

Addition of additives

- **Wax particles**

  BF11 Low melting point wax particles (95ºC)

  BF12 Medium melting point wax particles (125ºC)

  BF13 High melting point wax particles (155ºC)

- **Binder (binder : pigment = 1 :1 dry)**

  BF14 Soft SB latex binder (Tg~0ºC)

  BF15 Hard SB latex binder (Tg ~30ºC)

  BF16 Water soluble, non-cross-linking polyurethane binder

  BF17 Water soluble, cross-linking polyurethane binder

  BF18 Styrene acrylate (Tg~-13ºC)

  BF19 Polyvinyl acetate (Tg~-6ºC)

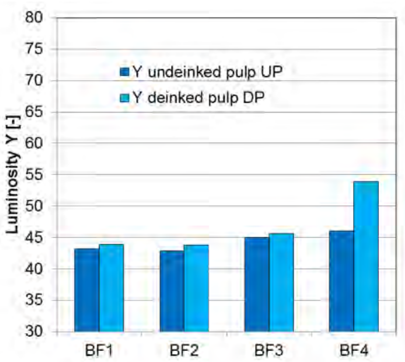
  BF20 Partially saponified polyvinyl alcohol

Impact of surface tension and viscosity

Luminosity

➢No significant impact of surface tension

➢Increase with increased viscosity



Filtrate Darkening

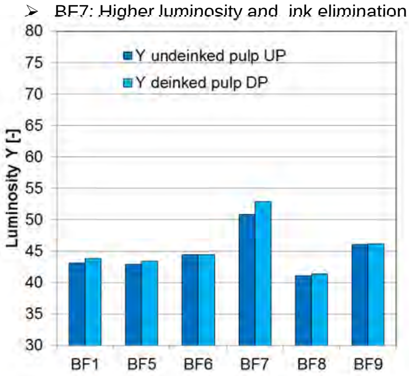
➢No significant impact

BF1: Standard „neutral" BF2: ↓surface tension BF3: ↑ surface tension BF4:↑ viscosity

Impact of Pigments

Luminosity

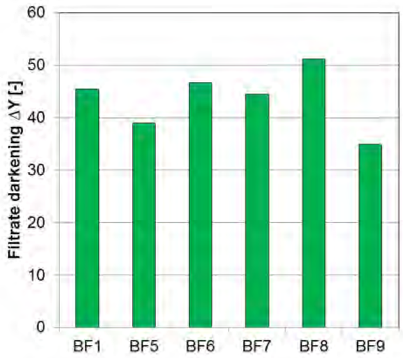
- ➢ No significant impact
- ➢ BF7: Higher luminosity and ink elimination



BF5 – BF7: Type of pigment dispersing

Filtrate Darkening

➢No or low impact

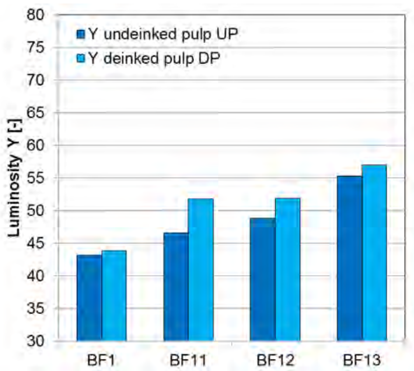


BF8 – BF9: Av. particle size of pigments

Impact of wax particles

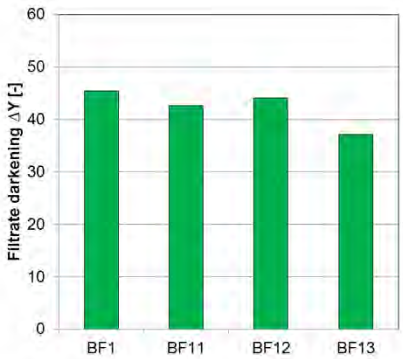
Luminosity

➢Impact of melting point of wax particles



Filtrate Darkening

➢Low impact of melting point of wax particles



BF1: Standard „neutral“ BF11: low melting (95°C) BF12: medium melting (125°C) BF13: high melting (155°C)

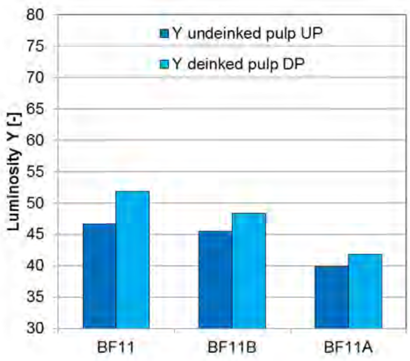
Impact of wax particles – Impact of drying after printing

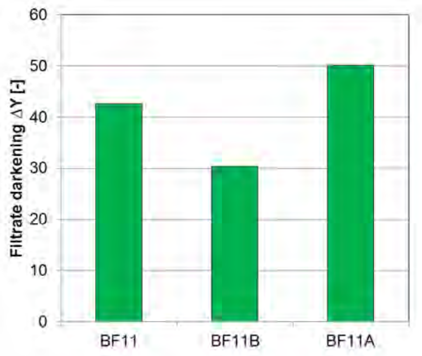
Luminosity

➢Impact of drying temperature

Filtrate Darkening

➢Low impact





BF11: drying after printing accelerated aged

BF11B: drying after printing 1 month storage

BF11A: no drying after printing 1 month storage

Impact of binder addition: Ink formulations

Use of different pigment types

No	Binder	Pigment
BF1	no	1-BF1
BF14	soft SB latex binder	1-BF1
BF15	hard SB latex binder	1-BF1
BF7	no	4-BF7
BF16	non-cross-linking PU binder	4-BF7
BF17	cross-linking PU binder	4-BF7

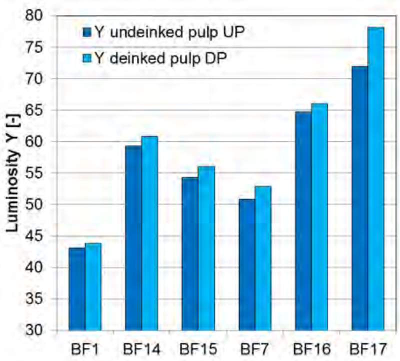
Use of standard pigment 1-BF1

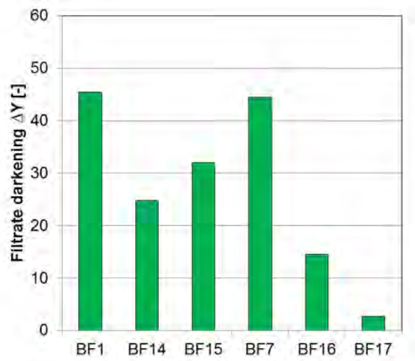
No	Binder
BF1	no
BF14	soft SB latex binder
BF15	hard SB latex binder
BF18	Styrene acrylate
BF19	Polyvinyl acetate
BF20	Partially saponified polyvinyl alcohol
BF4	Highly viscous polyvinyl alcohol (thickener)

Impact of binder addition (different pigment types)

➢ Significant impact of binder addition on ink particle size

- Increase in luminosity
- Reduction in filtrate darkening

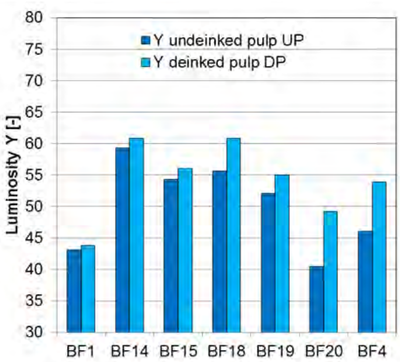




Impact of binder addition (Use of standard pigment 1-BF1)

➢ Impact of binder addition

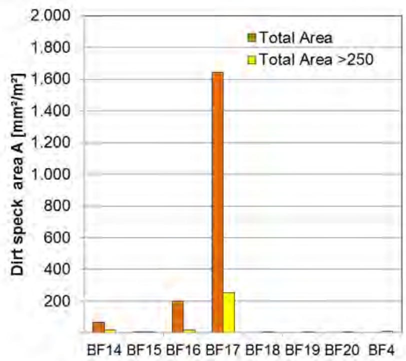
- Impact on luminosity
- Impact on filtrate darkening



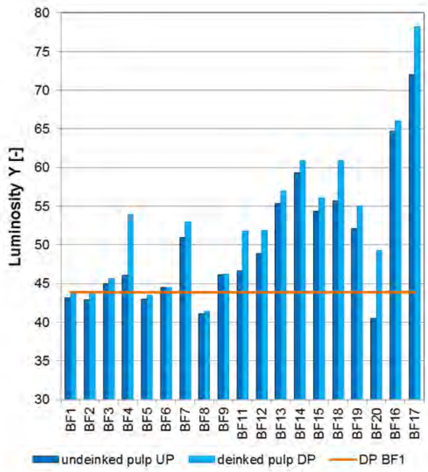
Impact of binder addition

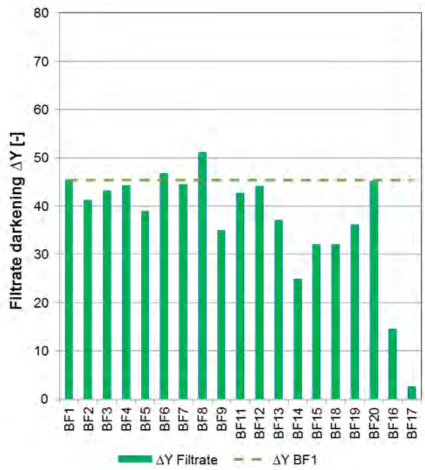
- **Significant impact of binder addition on particle size**

- Increase in luminosity
- Reduction in filtrate darkening
- Increase in dirt speck area (not critical)



Total Results





Summary of Results

	Impact on	Luminosity	Ink elimination	Filtrate darkening	Yield
Surface tension	reduced	o	o	o	o
	increased	o	o	o	o
Viscosity	increased	+	+	o	o
Type of pigment dispersing	stearically	o	o	o	↓
	"self-dispersing"	o	o	o	o
	cationically	+	o/+	o	o
av. particle size of pigments	larger	-	o	o	o
	smaller	o	o	o	↑
Addition of wax particles	low melting point	+	+	o	o
	medium melting point	+	+	o	o
	high melting point	+	o/+	o	o
Addition of binder	soft SB latex binder	++	o/+	+	↑
	hard SB latex binder	+	o/+	o/+	o
	styrene acrylate	++	+	o/+	o
	polyvinyl acetate	+	+	o	o
	polyvinyl alcohol	o/+	+	o	↓
	non-cross-linking PU *)	++	o/+	++	o
	cross-linking PU *)	+++	++	+++	o dirt specks

*) pigment type BF7

o no significant impact
o/+ low impact
+ positive impact

Summary

The investigations regarding the effects of some ink design changes on the deinkability of inkjet inks showed:

- No impact of surface tension
- Increase in luminosity and ink elimination by addition of polyvinyl alcohol to increase viscosity, but no impact on filtrate darkening
- No significant impact of pigment type, but slight increase in luminosity with cationically dispersed pigment
- Improvement of luminosity and ink elimination by addition of wax particles and impact of wax particle melting point and drying temperature on improvement, but no impact on filtrate darkening
- Notably improved deinkability by the addition of binder like soft SB latex binder, soft styrene acrylate binder and mainly by polyurethane binder.

Conclusions and Next Steps

- Improvements seen in some of the model inks verify recent the mechanisms of improvements in the deinkability of some DPDA commercial inkjet inks
- Results of this study are currently being reviewed by DPDA member company ink chemists to determine the extent to which the individual strategies could be further implemented
- The most promising results were seen using the cationic pigment in combination with self-cross-linking polyurethane, but this combination appears to be the most challenging recipe for commercial implementation
- The positive effect using a cationic ink formulation is consistent with effects seen with a cationic paper surface
- The next INGEDE-DPDA study is planned to focus on paper recipe and raw material impacts on deinkability
- The final solution to obtaining the optimum deinkability of water-based inkjet inks is expected to be a combination between paper and ink improvements