DoDxAct

Technical Consulting Services for Industrial Inkjet

IMI EUROPE

Ink Jet Fluids for Industrial Printing

An Application Viewpoint

WHY INK MATTERS

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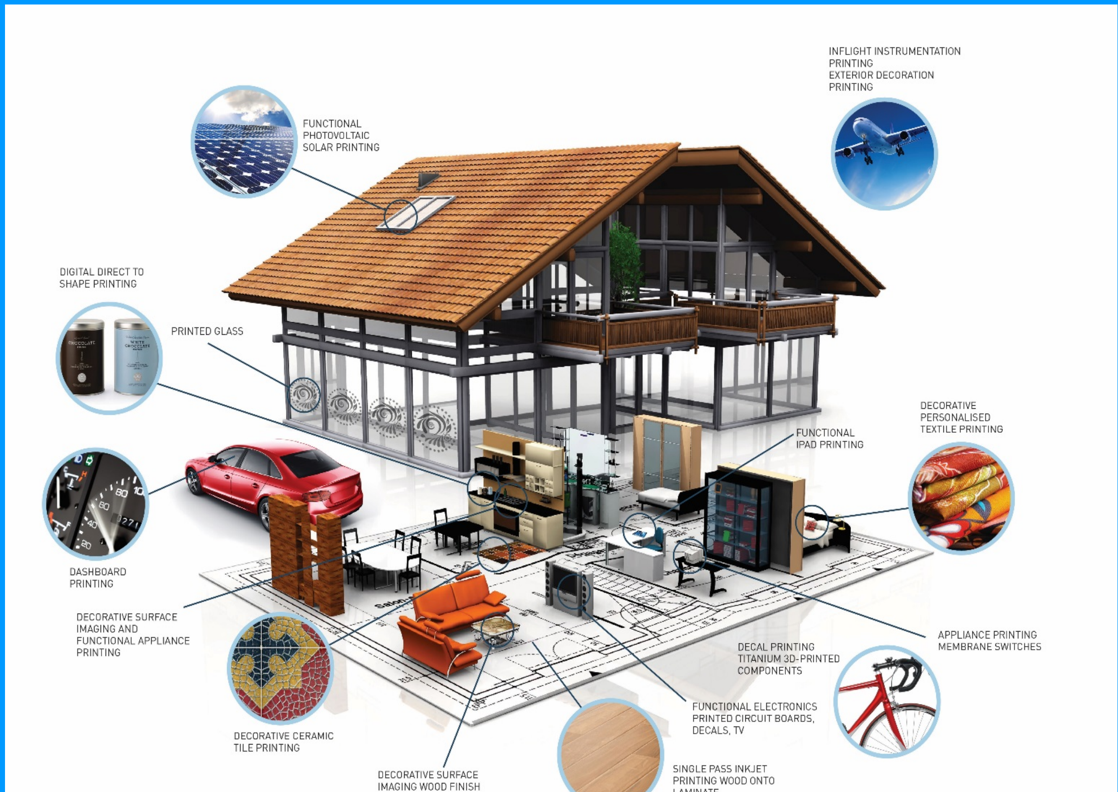
- Industrial Print = Function as well as appearance



Source: InPrint

- Adhesion
- Heat resistance
- Conductivity
- UV lightfastness
- Flexibility -> Hardness
- Compatibility with other processes

➔ As a result the fluids are often highly specific

DR MARK BALE
- VARIED BACKGROUND

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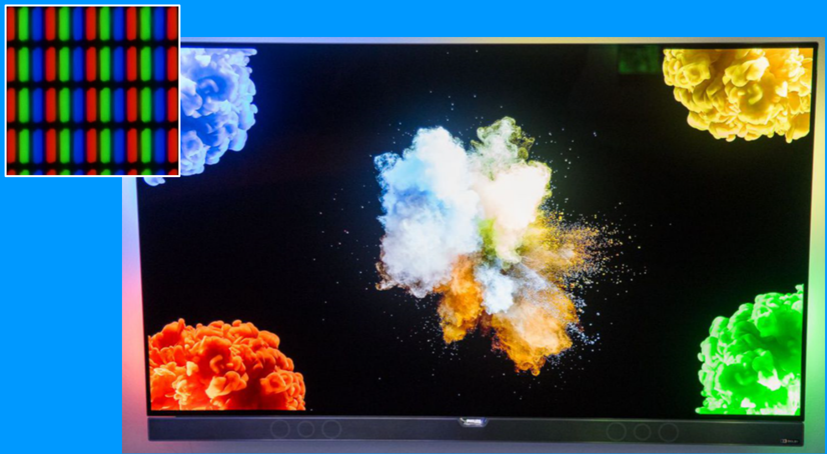
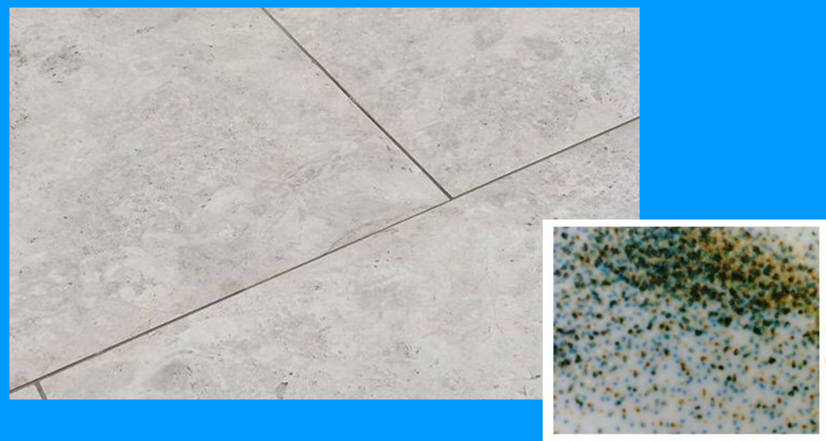


RGB AM-OLED TVs

Corrugated Boxes

Ceramic Tiles



Solar Cells

WHY APPLICATIONS DRIVE INK CHOICES

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The end use demands the specific performance

		Ink Type					
		Aqueous	**Solvent**	**Oil**	**Hot Melt**	**Energy-cured**	**Hybrid**
Materials used in formulating	Base material	Water Co-solvents Humectants	Organic solvents (ketones, alcohols, esters, glycols)	Petroleum distillates, plant extracts	Waxes	Acrylate & vinyl monomers Reactive diluents	Water Solvent Monomer Waxes
	Active / functional material	Resins (optional) Waxes Pedot/PSS	Resins Nano-metals Organic semiconductors	Frits Nanometals	Resin (e.g. rosin)	Resins Oligomers Photoinitiators Silanes Iso-cyanates	Thermally or radiation-curable or cross-linkable materials
	Colorant	Organic dye or pigment Inorganic pigment (ceramics)	Organic dye or pigment + TiO2 (CIJ)	Organic dye/pigment Inorganic pigment	Organic dye or pigment	Organic dye or pigment +TiO2	Inorganic dye or pigment Inorganic pigment
	Additives	Surfactant, biocide	Surfactant, conductivity aid (CIJ)	Surfactant compatibilizer (ceramics)	Plasticizers Surfactants	Surfactants Stabilizers	Various from left (depends on system)
Usage	Drying Regime	Absorption / evaporation	Evaporation	Absorption	Phase change (freezing)	Phase change (cross-linking)	Combination
	Key Advantages	Low VOC Thin film Sustainable	High functionality Low Build	Shelf life Head stability	Long shelf life Head stability	Head stability Highly tunable High build	Best of both technologies (ideally)
	Main Challenges	Latency/drying Functionality (e.g. adhesion)	Latency High VOC	Low dry speed	Complex ink system	Film thickness Viscosity constrains functionality	Worst of both technologies (if unlucky)
	Applications	Paper Textiles Wide-format Graphics Décor Edible inks Electronics Coding & marking Ceramics	Wide-Format Graphics Coding & Marking	Paper Ceramics/Glass Coding Electronics	WF-Graphics Coding & Marking Electronics Manufacturing Edible inks	WF-Graphics Labels Glass Bottles / Shapes Packaging (LM) Manufacturing Ceramics Décor 3D printing	Graphics (Solvent-UV/Aq-UV) Packaging (S-UV/Aq-UV) Glass Edible inks (oil/hotmelt) Electronics manufacturing (hot-melt-UV)

Chemistry defines what is possible within process constraints

INK TYPES – WHAT'S INSIDE

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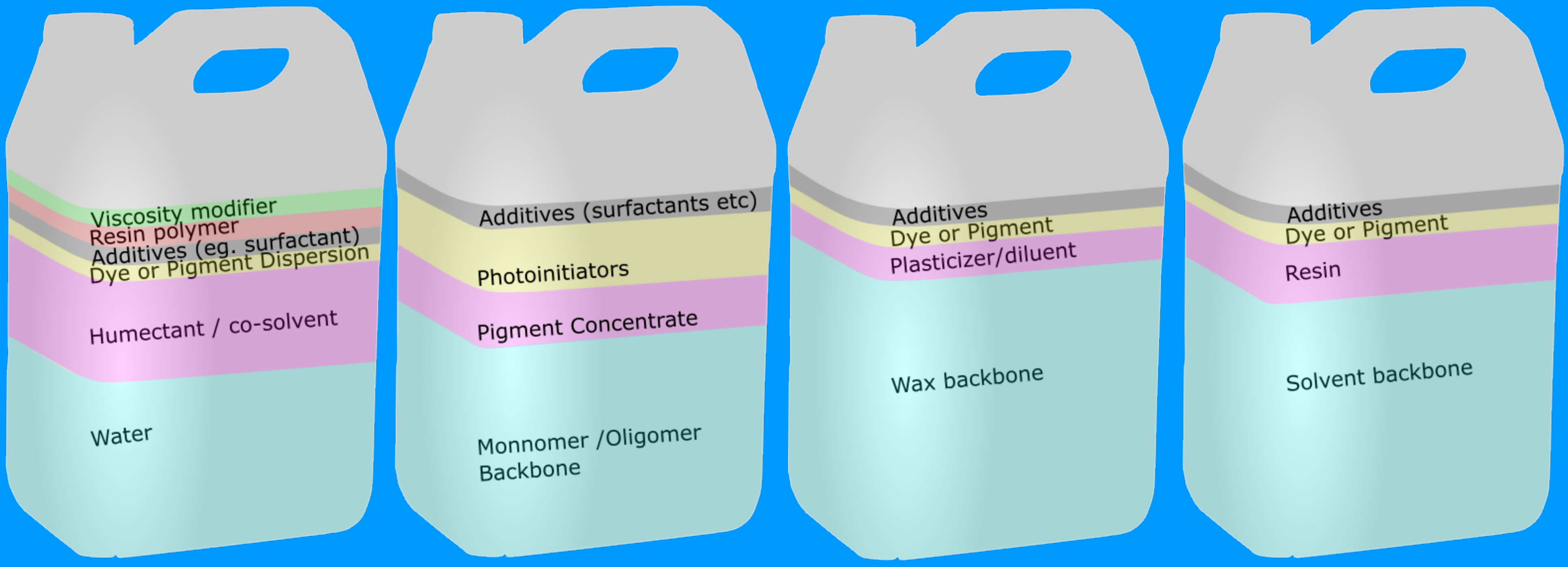
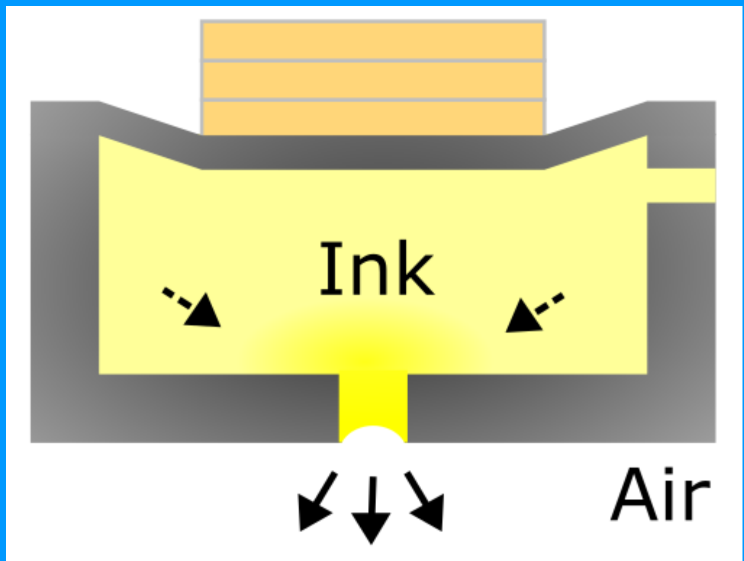
Complexity varies significantly depending on required balance o properties required. The following are non-definitive examples

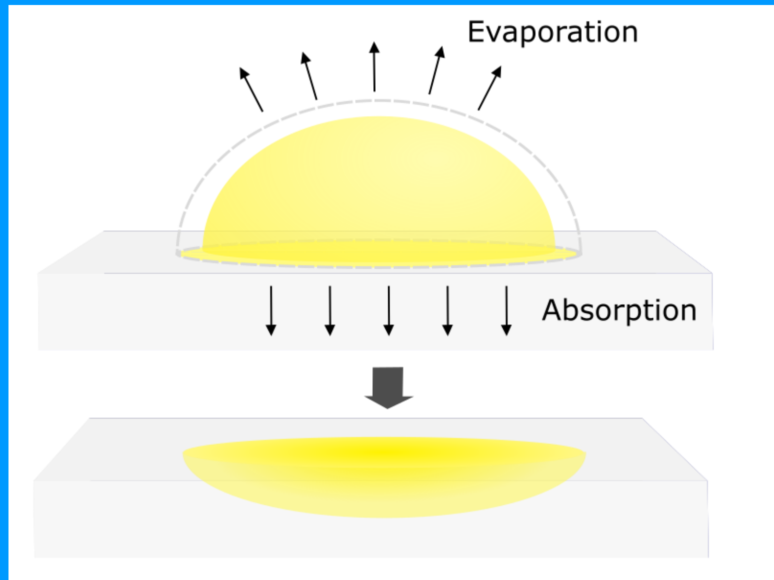


Aqueous UV-cured Hot-melt Solvent

AQUEOUS INKS
- FORMULATING PRINCIPLES

- Target 1: Balancing head performance with drying
- Target 2: Achieving film functionality with resin “binder”





- Latency effect is key reason for rise in recirculating print heads

AQUEOUS EXAMPLES - CO-SOLVENT SELECTION

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- Most office & production inkjet often use humectant like glycerol
- Not good for non-absorbing media (like packaging)

26.6 mass % of pigment dispersion
0.5 mass % of "Olfin (registered trademark) E1010"
5.0 mass % of 1,3-butanediol
5.0 mass % of triethylene glycol monobutyl ether
5.0 mass % of 2-pyrrolidone
15.0 to 30.0 mass % of glycerin
27.9 to 42.9 mass % of ion exchange water

Source: Kyocera Mita, US8444261

Ink Example	M1
Deionized water	44.0
TegoWet KL245	0.5
DPM	8.0 (n = 1)
PnB	2.0 (n = 2)
Propylene glycol (PG)	-
Neorad R441[a]	35.0
Aqueous Cyan Dispersion A[b]	10.0
Irgacure 2959	0.5
PI1	-
PI2	-

Source: Sun, WO2018/022590

- This Aq-UV ink uses much faster drying co-solvents so cure is achieved ➔

UV CURABLE INKS
- FORMULATING PRINCIPLES

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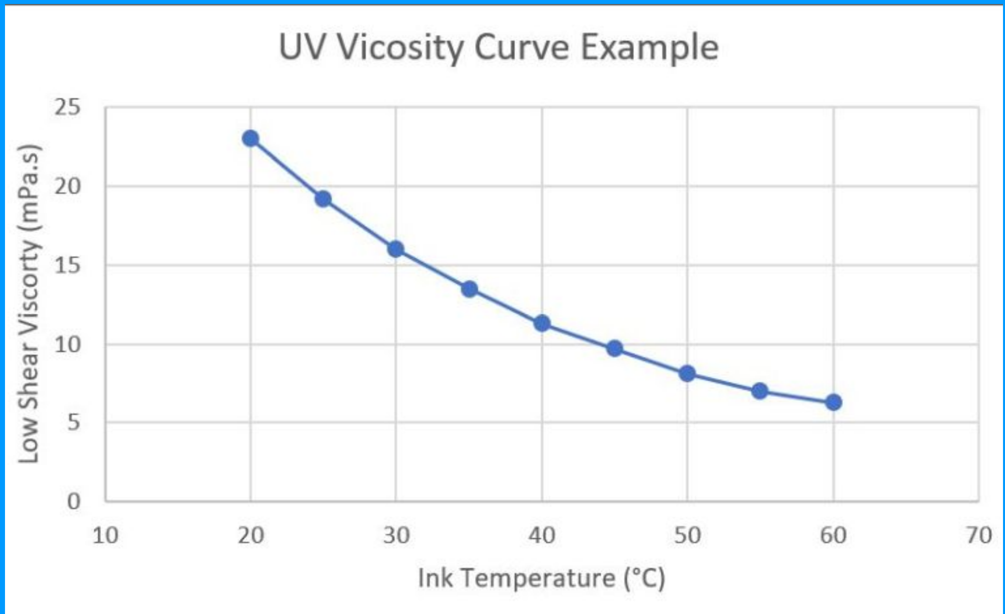
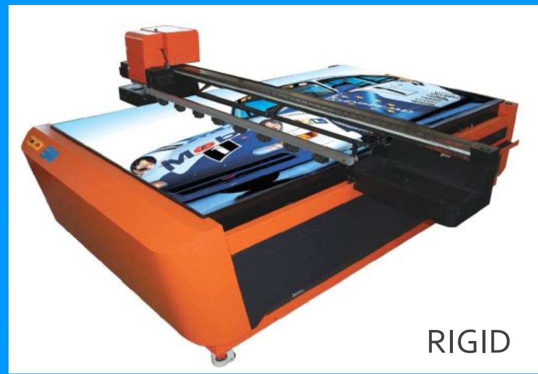
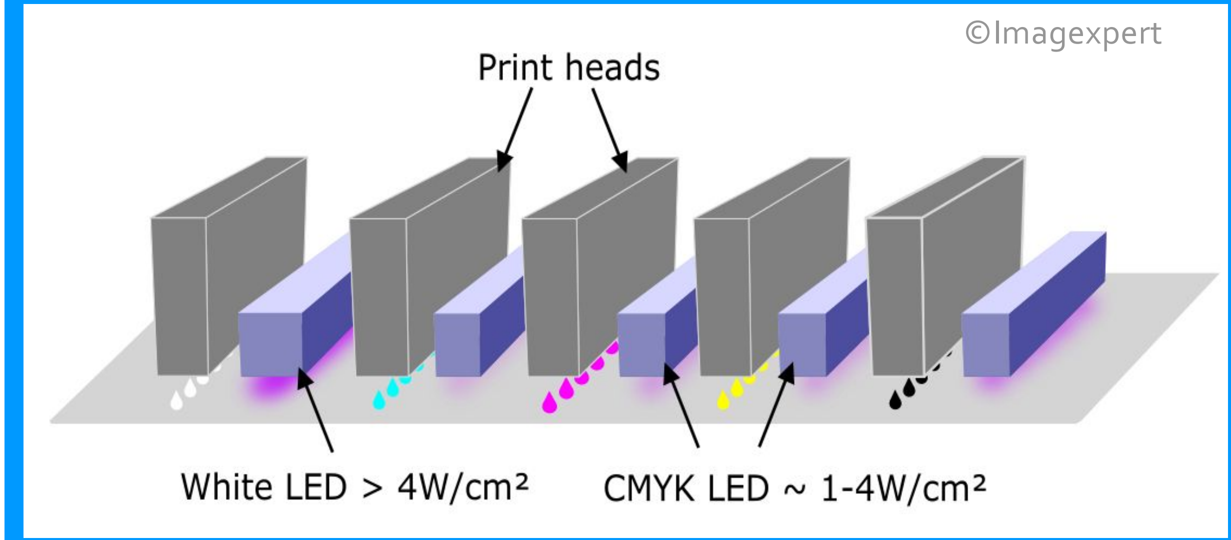
- Target 1 = Balance monomers and oligomers for viscosity / function
- Target 2 = Adjust surface tension for substrate / process



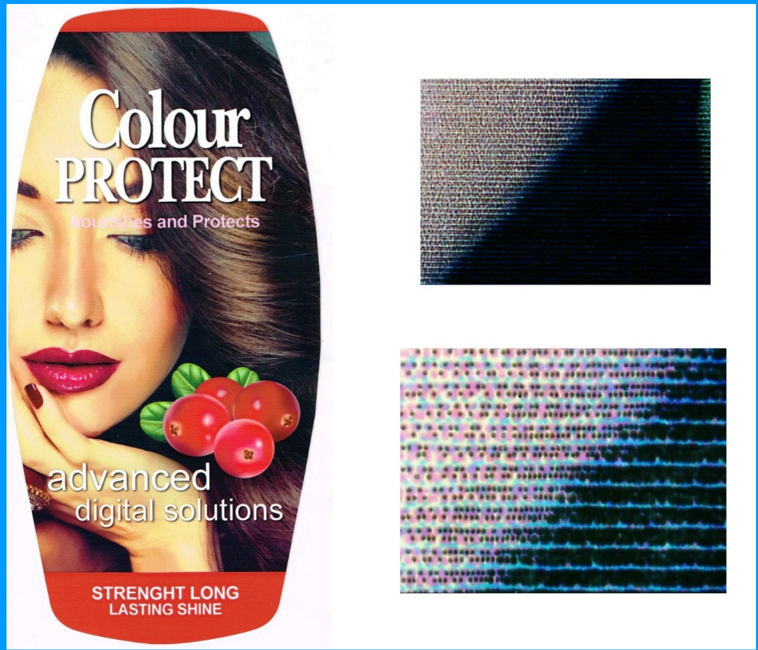


UV EXAMPLE
- NARROW WEB LABEL INK

UV-cured inkjet inks have seen steady growth over 10+ years



Ink-to-substrate wetting and ink-ink interactions are critical factors



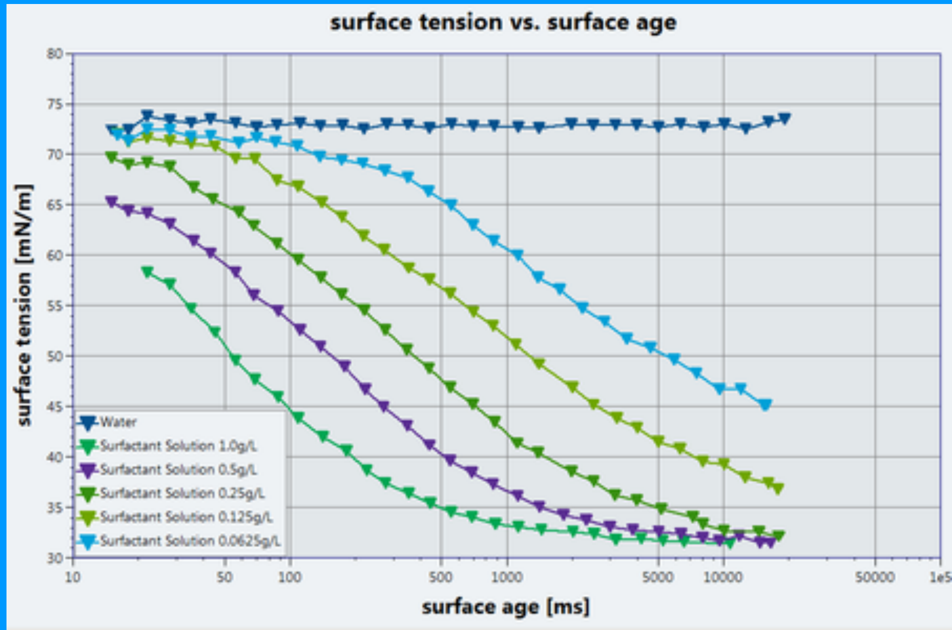
UV LABEL INK
- SUBSTRATE WETTING

- Wetting of media in required time depends critically on surfactant

TABLE 12

wt % of	C-4	M-4	Y-4	K-4
VEEA	61.44	62.55	62.69	61.44
DPGDA	12.56	14.60	11.31	12.56
M600	6.00	1.80	6.60	6.00
ITX	2.00	2.00	2.00	2.00
IRGACURE ™ 819	3.00	3.00	3.00	3.00
IRGACURE ™ 907	5.00	5.00	5.00	5.00
IRGACURE ™ 379	2.00	2.00	2.00	2.00
PB15: 4	3.00	—	—	0.80
PV19/PR202	—	3.50	—	—
PY150	—	—	2.70	—
PB7	—	—	—	2.20
SYN	—	0.05	—	—
S35000	3.00	3.50	2.70	3.00
INHIB	1.00	1.00	1.00	1.00
BYK ™ UV3510	1.00	1.00	1.00	1.00

Source: Agfa, US8646901



Source: Kruss

→ Key claim is the need to gain low surface tension quickly

UV LABEL INK
- INK WETTING

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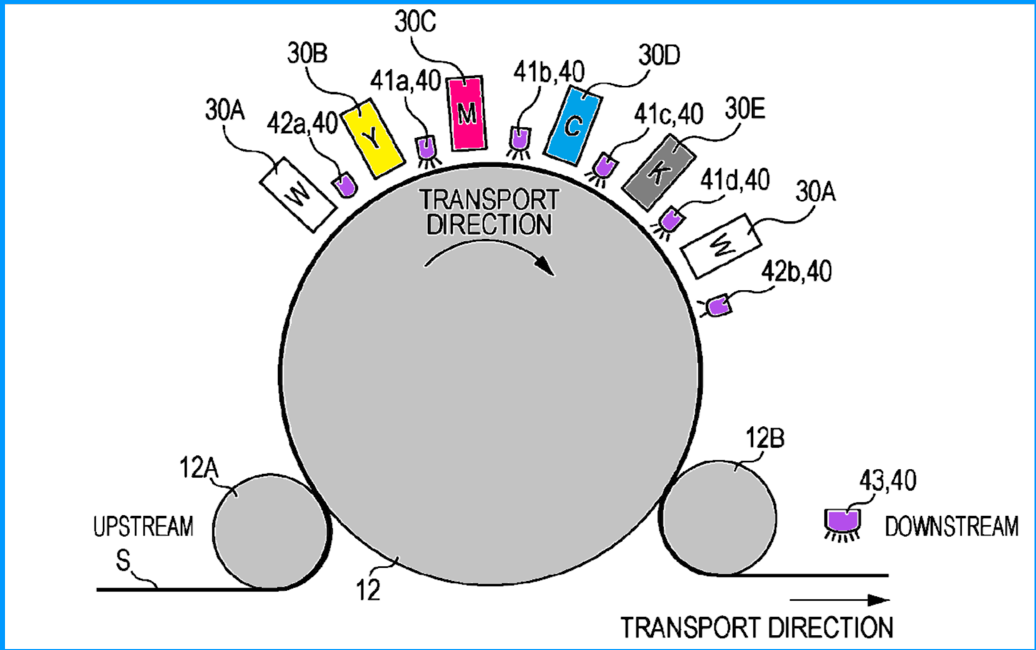
- Again it comes down to tuning surface tension with additives
  - Eg. white ink under/over CMYK print



	Example 1
Overcoating ink No.	Overcoat 1
Undercoating ink No.	Undercoat 1
Surfactant in overcoating ink	Silicone UV 3500
Surfactant in undercoating ink	Acrylic BYK 350
Undercoating ink γ-overcoating ink γ	10
VEEA (mass %) in overcoating ink	20
VEEA (mass %) in undercoating ink	30
Wetting/spreading properties of overcoating ink	A
Burying property of undercoating ink on recording medium	A
Ejection stability of overcoating ink	A
Ejection stability of undercoating ink	A
Curability of overcoating ink	A
Curing ability of undercoating ink	A

Source:us9243154

HOTMELT INKS
- FORMULATING PRINCIPLES

- Target 1 = Choose base wax for function
- Target 3 = Adjust viscosity and colorant for application

- Mixtures of different waxes are common to get correct property

HOTMELT EXAMPLE
- EDIBLE INKS

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First patented by Exxon in the early 1980s (US4390369)

Food compliance is critical factor

=> Carnuba wax and beeswax are common choices

=> Glycols can also be used but don't completely solidify:

Ingredients	Amount (% by weight)
Polyethylene glycol 200 molecular weight	65.95
Triacetin	20.00
Glycerol	10.00
*FD&C Blue No. 1	3.50
Polysorbate 80	0.50
Methylparaben	0.05

From Sun Chemical application GB2438197

Source: eatmylogo.co.uk

HOTMELT EXAMPLE - ETCH RESIST INK

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Freezes upon contact for line definition

= Reduced spread and increased layer thickness / resistance

Acid wax can be removed by base solution:

	Example 4	Comparative Example 1
Unilin 425 (2)		79.5
PEG 1000		
Myristic Acid		
Stcaric Acid	88.5	
Rosin Ester Resin (1)	10	19
Dye-Orasol Black RLI (3)	1	1
Tween 80 Wetting agent	0.5	0.5
Viscosity cps @ Temperature	12.4 75° C.	10.3 125° C.
Alkali Washability %	98	0
Water Washability %	0	0

Source:Sun Chem, us899185

+ Adding UV curable materials can improve resistance properties

SOLVENT INKS
- FORMULATING PRINCIPLES

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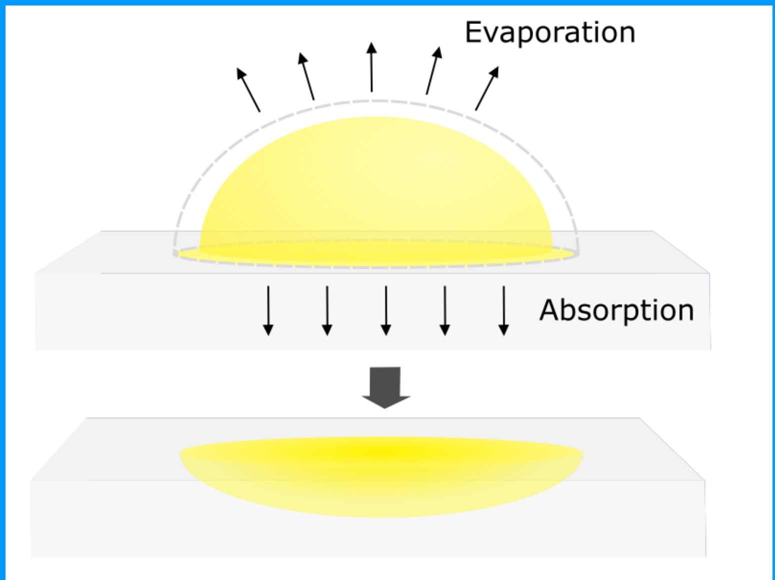
- Target 1 = Choose active material for function
- Target 2 = Adjust solvent blend for application / printing

=> like for aqueous depends again if media is absorbing or not



Source: Dip Tech

SOLVENT INK EXAMPLE - GRAPHICS INK

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Drying needs to be fast enough to prevent bleed

Blending solvents creates best balance of these needs

Non-aqueous ink composition			Examples 1	2	3	4	5	6	7	Comparative Examples 1	2	3
Pigment		PB-7	4	4	4	4	4	4	4	4	4	4
Pigment dispersant	Resin dispersant	Solsperse37500	4	4	4	4	4	4	4	4	4	4
	Pigment derivative	Solsperse12000	0.2	0.2	0.2	0.2	0.2	0.2	0.2		0.2	
		Solsperse5000										0.2
Organic solvent		Organic solvent A	20	20	20	40	35		45	20		20
		Organic solvent B						20				
		DPGmME	15	30	30	10	18	15		15	45	15
		TetraEGmBE	15				18	15		15		15
		DEGdEE	33.8	33.8	29.8	35.8	12.8	33.8	38.8	34	38.8	33.8
Surfactant		BYK340	2	2	2	2	2	2	2	2	2	2
Resin		HM515	4	4	8	2		4	4	4	4	4
		G-1000P	2	2	2	2	6	2	2	2	2	2
Total (mass %)			100	100	100	100	100	100	100	100	100	100
Evaluation result	Image quality	Uneven printing	5	6	6	6	4	5	6	5	2	5
		Glossiness	6	6	5	5	6	6	3	6	6	6
		Dot size	6	5	5	5	6	6	2	6	6	6
	Friction fastness		5	5	6	5	4	5	6	5	3	5
	Storage stability	Viscosity change	○	○	○	○	○	○	○	X	○	○
		Generation of foreign matter	no	no	no	no	no	no	no	no	no	yes

Source: Epson, US9725610

SOLVENT INK EXAMPLE
- OLED INK

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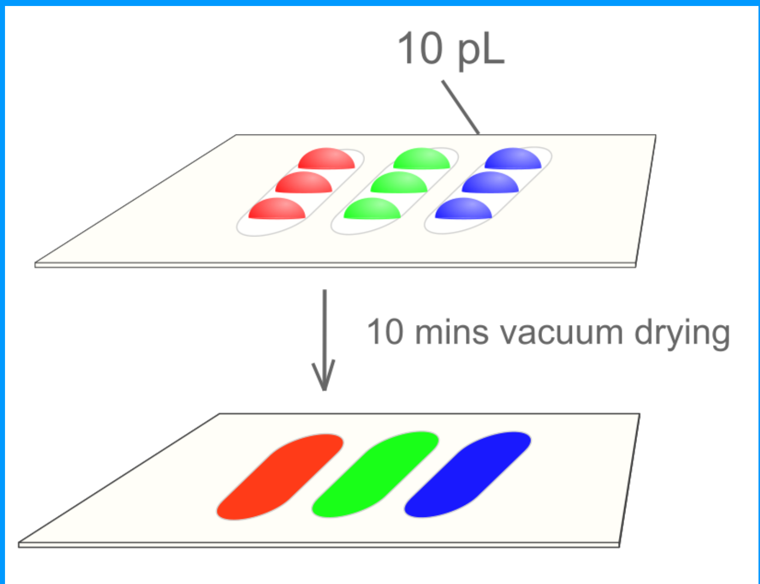
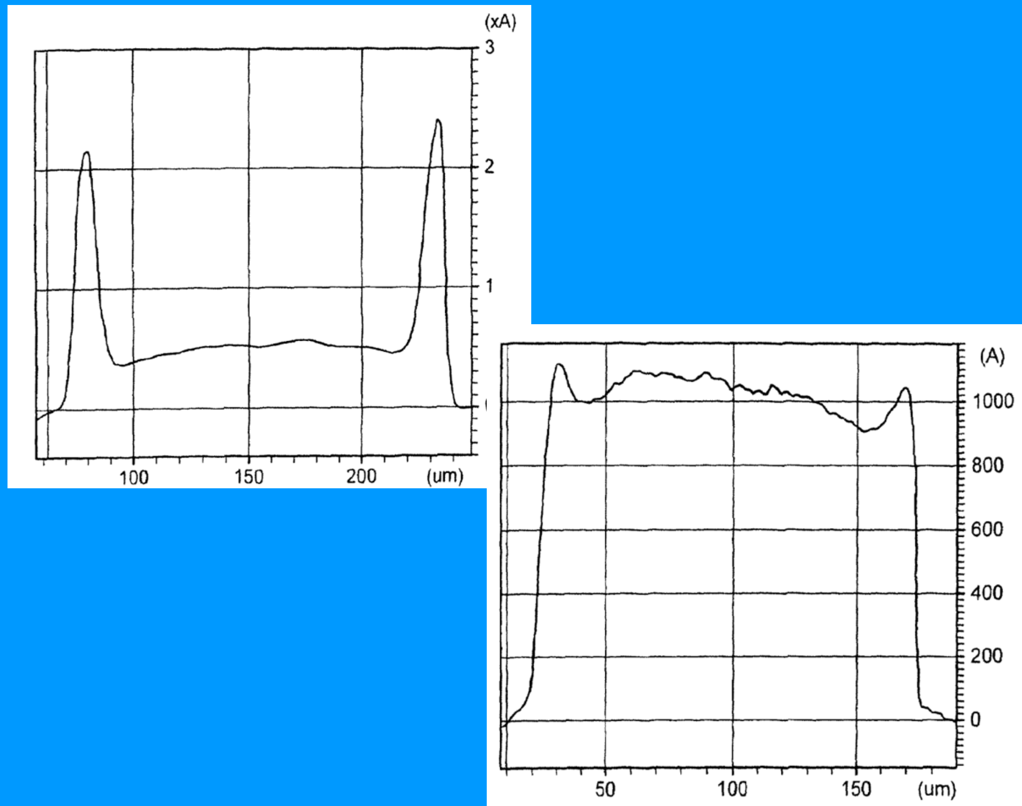
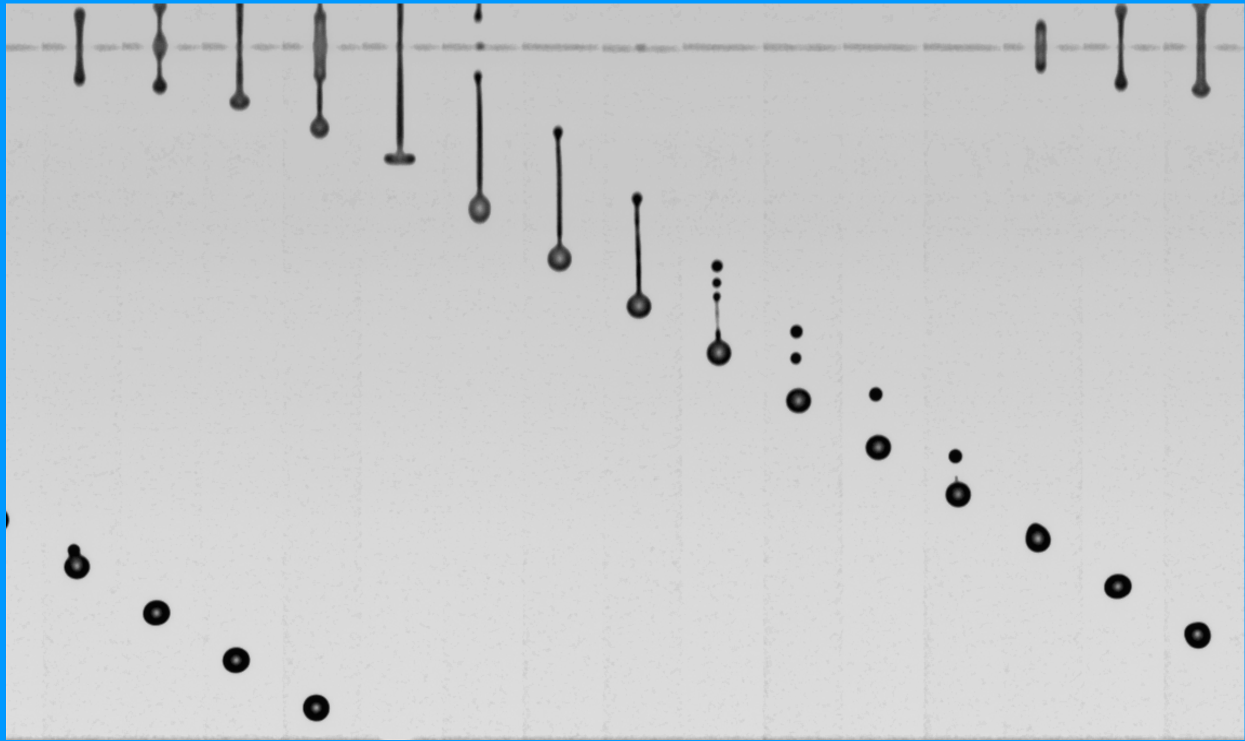
Quite unlike graphics inks, solid content is very low (<~1%)

Balance solvents to counter "coffee ring" effect





Source: Cambridge Display Tech, US7807070



Interested in learning more ?

We will be presenting at the IMI Winter Workshop in January 2020

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We make ink work – See us on stand 120