



***Stability Properties of Electrically Conductive Ink, Filled Metallic Nano Size Silver Filler for Ink Jet Printing Technique.***

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# The Major Ink Requirements for Ink Jet Dispenser Technique



## **DISPENSING POSSIBILITIES AND LIMITATIONS:**

*Single drop volume: 30 – 500 picoliters with variation ~ 1%*

*Droplet diameter: 30 – 100  $\mu\text{m}$*

*Drop rate: 0 – 2000/sec.*

*Fluid viscosity range: 0.5 ~ 35 mPas. (unheated)*

*Drop acceleration: 100 000 g (during each shoot)*

<b>Number of components</b>	<b>One</b>
<b>Consistency</b>	<b>Very low viscous fluid</b>
<b>Percentage of silver filler</b>	<b>40 - 60 %</b>
<b>Viscosity limit</b>	<b>Up to 35 mPas</b>
<b>Thixopropy index</b>	<b>~ 1.0</b>
<b>Surface tension value</b>	<b>28.5 - 34 dynes/cm</b>
<b>Specific gravity</b>	<b>1.3 - 1.6 g/cm<sup>3</sup></b>
<b>Electrical conductivity</b>	<b>( 1 – 3 ) 10<sup>-5</sup> <math>\Omega\text{cm}</math></b>

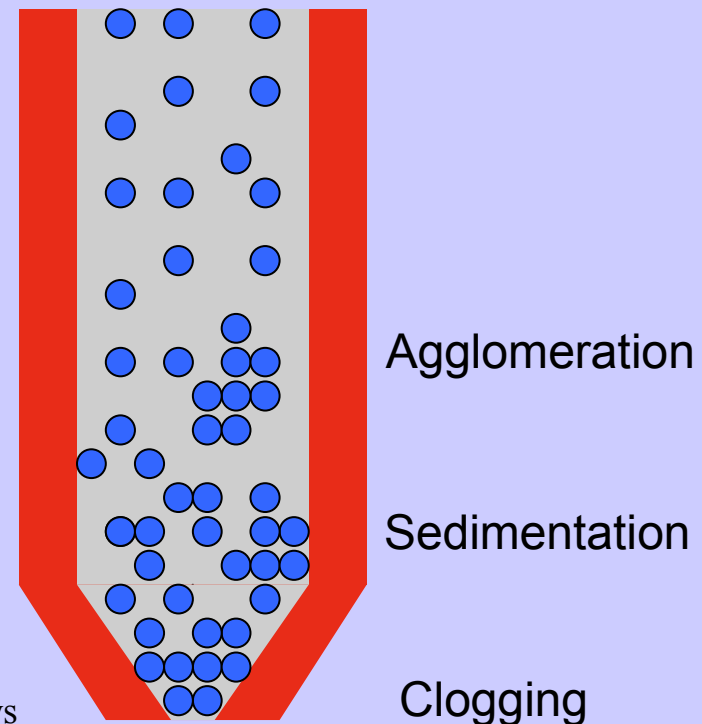
## Metalic Nano Silver as a Filler for Ink Preparation



*All formulation types which are the mixtures of fluid binder and solid fillers will have this same major problem - filler sedimentation.*

### Very low binder viscosity plus:

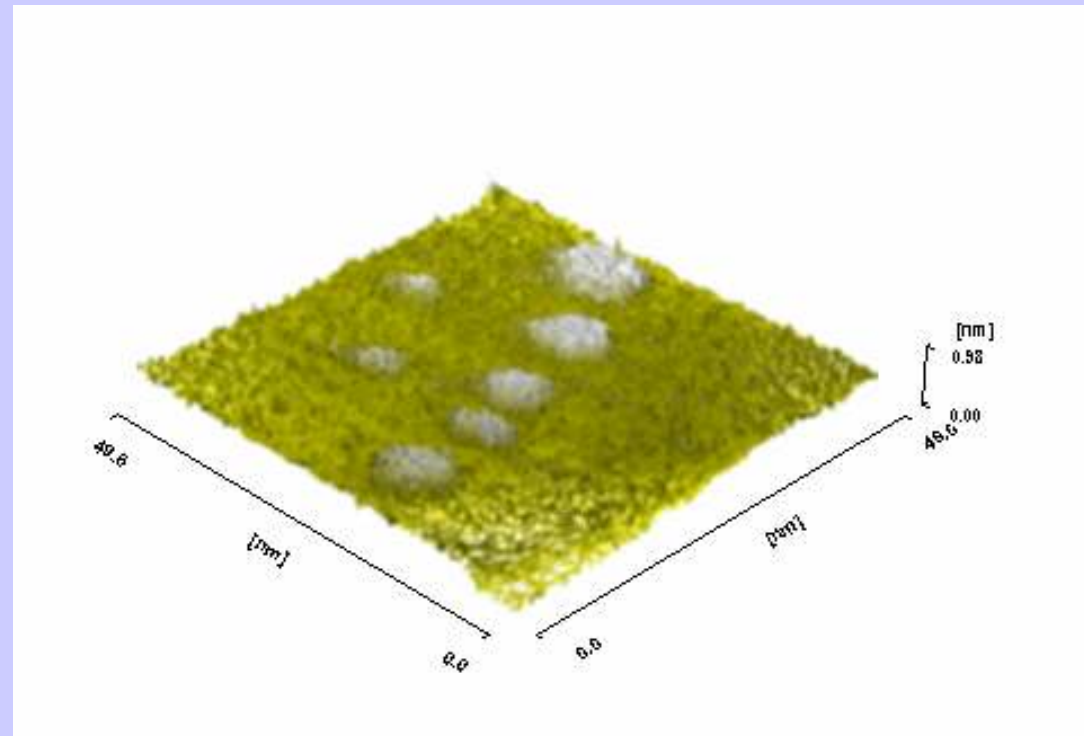
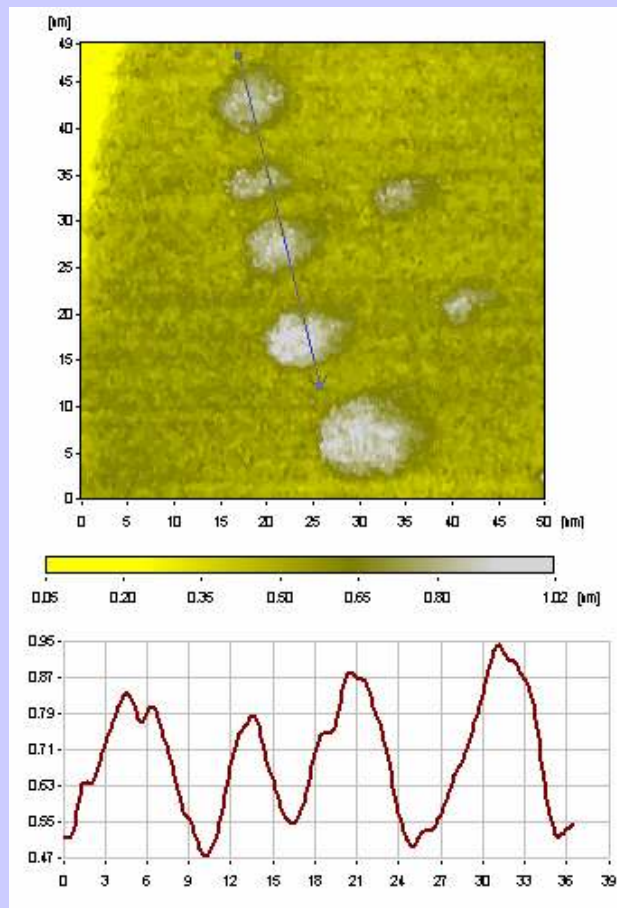
- filler which has much higher specific gravity as fluid binder,
- high % of filler inside formula



## Metallic Nano Silver as a Filler for Ink Preparation



*Different situation is when conductive filler has diameter less 10 nm. Than formulation is very uniform and has properties similar as a „true fluid”.*

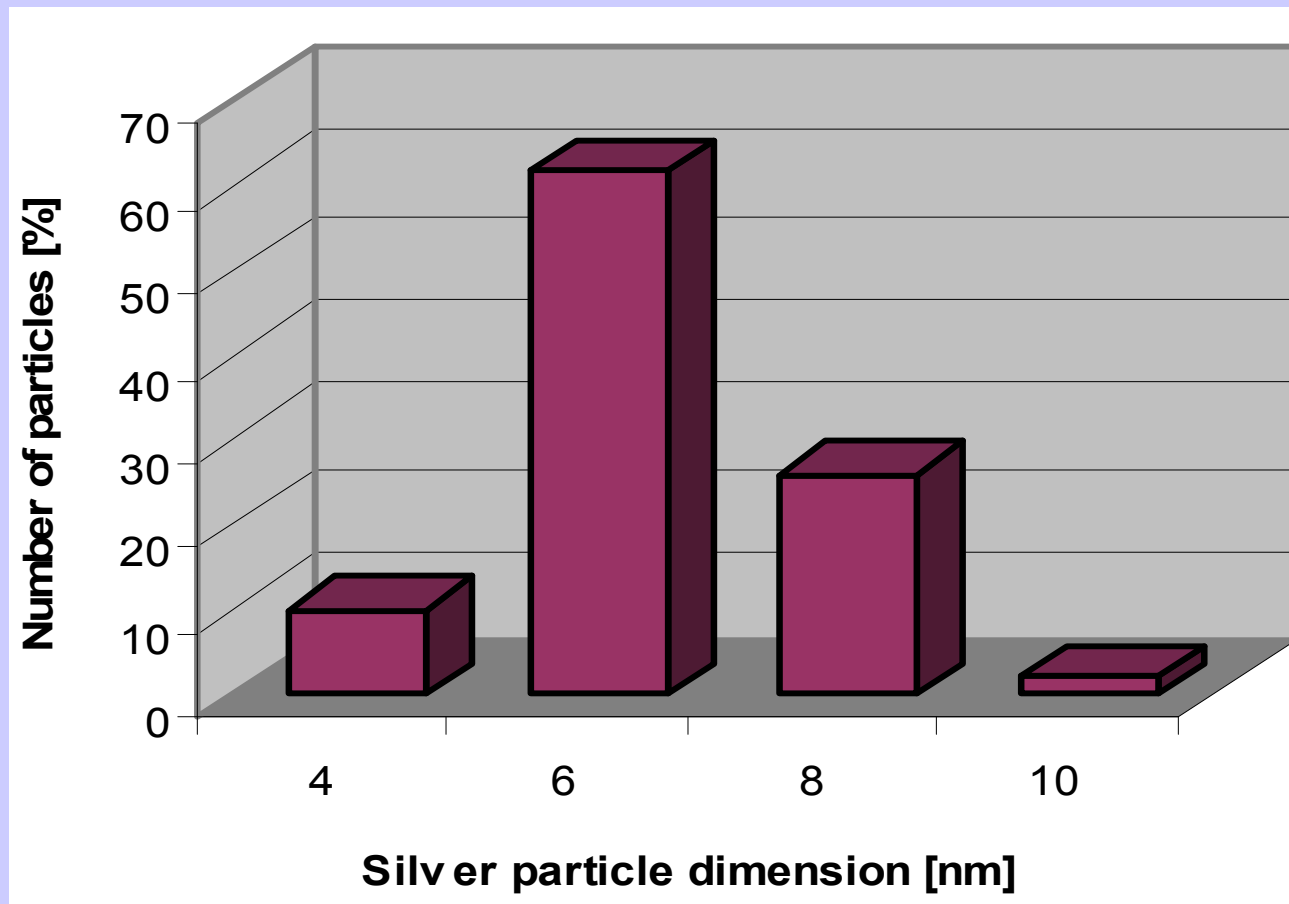


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# Metallic Nano Silver as a Filler for Ink Preparation



*Histogram for particles size of Amepox nano Ag*



# Nano Ink Stability Tests



## **TEST CONDITIONS:**

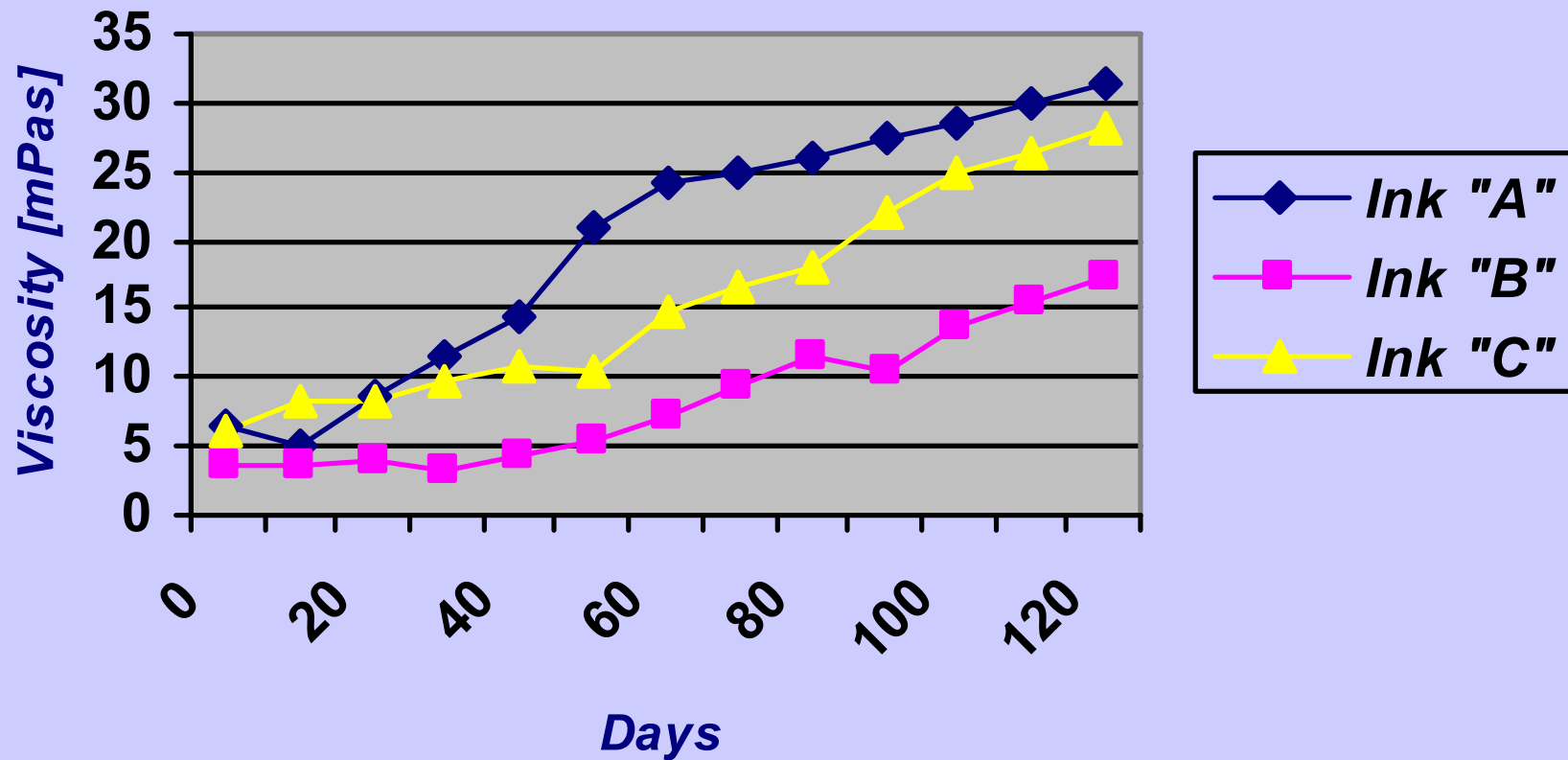
1. Equipment: Brookfield type LVDVII + CP (Cone & Plate)
2. Rotor (Cone) speed: 100 rpm
3. Storage temp. = 23 °C
4. Test temp. = 25 °C

<b>Sample #</b>	<b>Ink A</b>	<b>Ink B</b>	<b>Ink C</b>
Percentage of nAg [b.w.]	50%	48%	50%
Initial Viscosity [mPas]	6.5	3.66	6.1
Thixoprophy index	~1.0	~1.0	~1.0

# Nano Ink Stability Tests



## *Ink Viscosity versus Time*

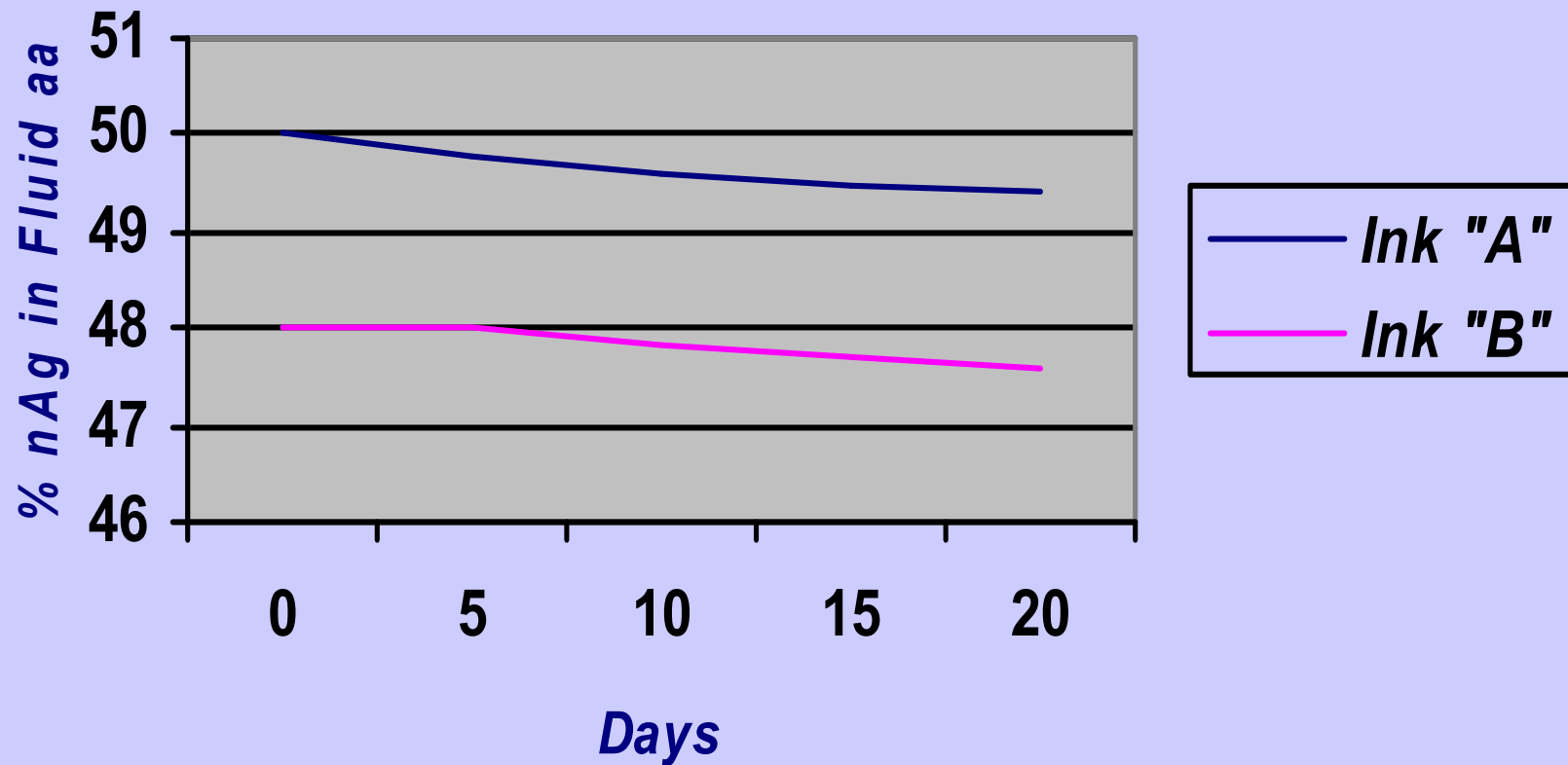


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# Nano Ink Stability Tests



## Silver Sedimentation versus Time

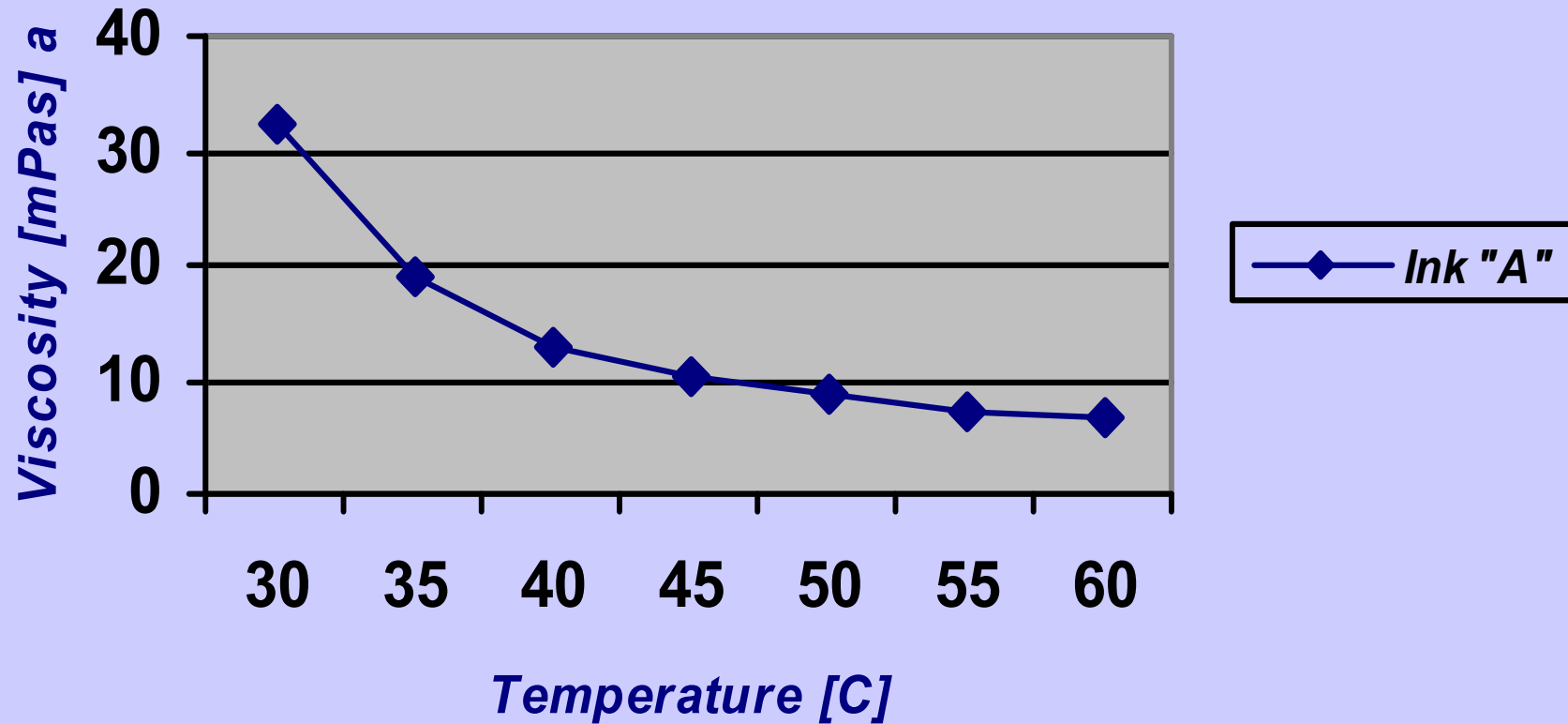




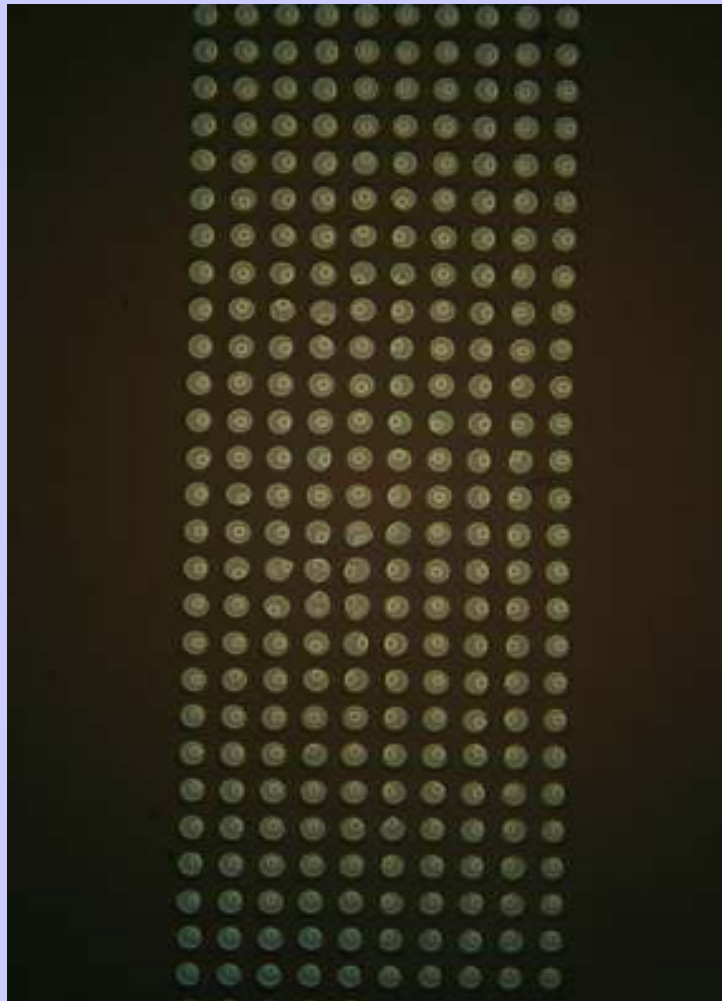
# Nano Ink Stability Tests



## *Ink Viscosity versus Temperature*

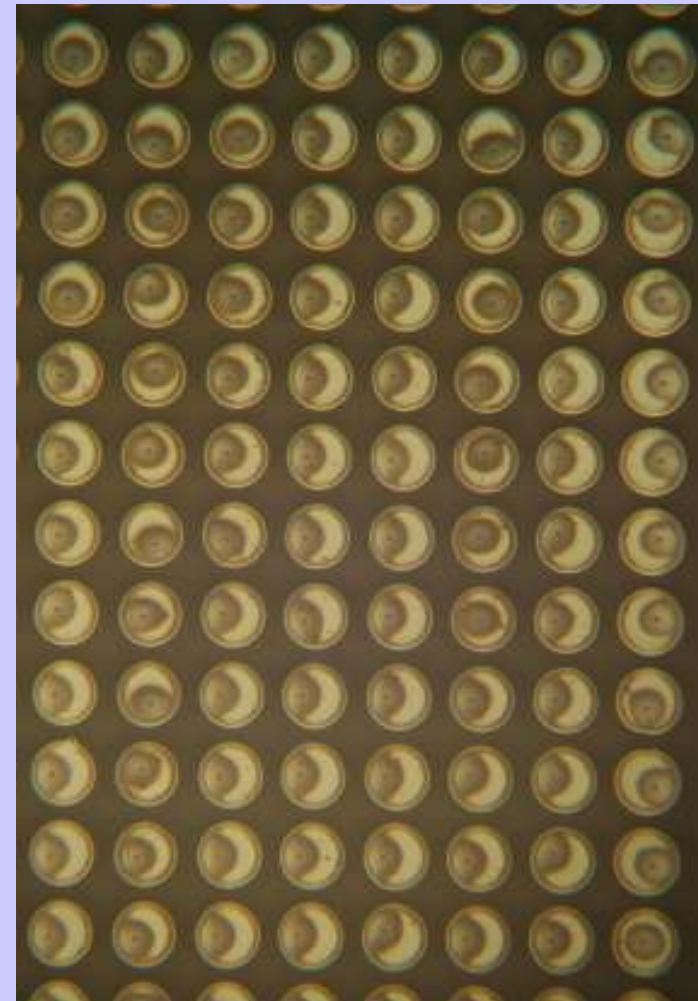


# Samples of Dispensed Ink by Ink-Jet dispenser



**Nozzle  $\Phi = 34 \mu\text{m}$**

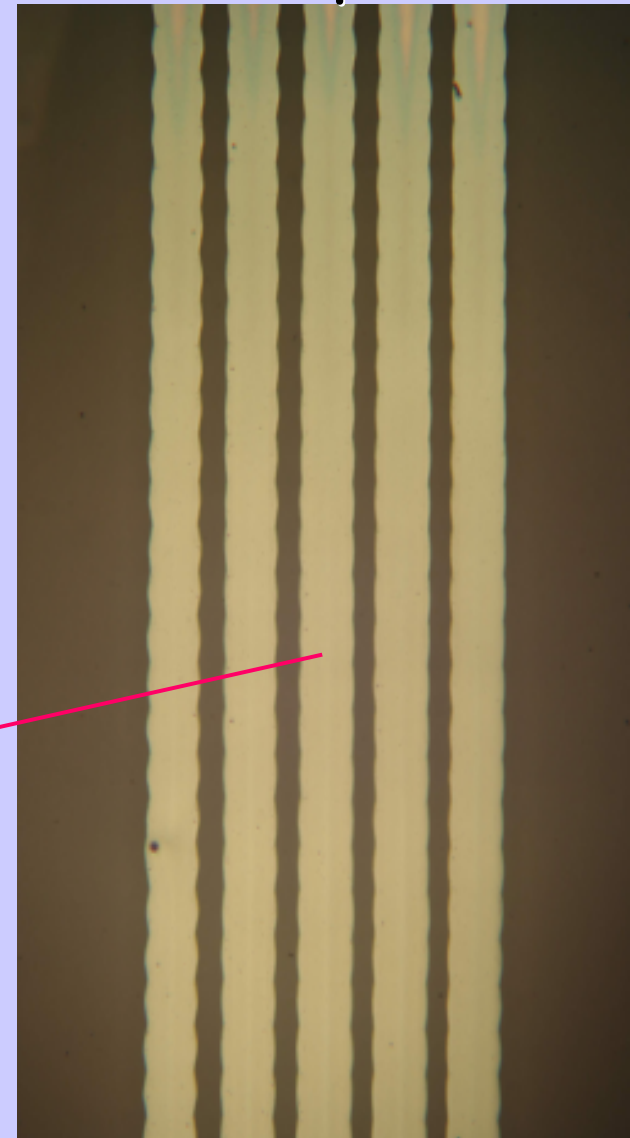
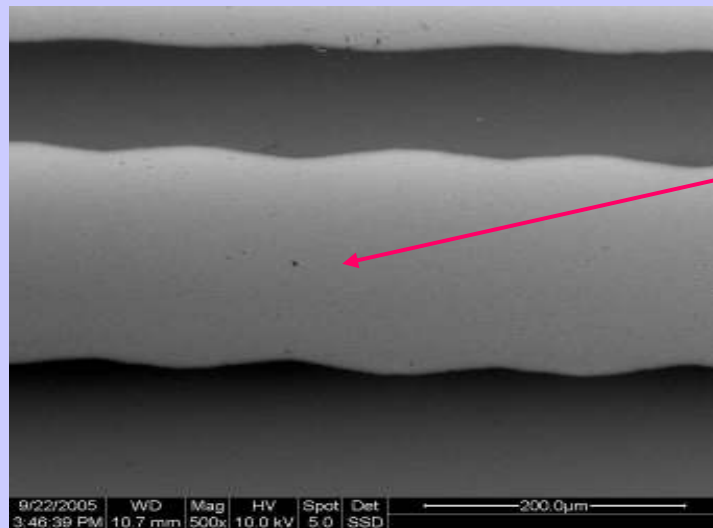
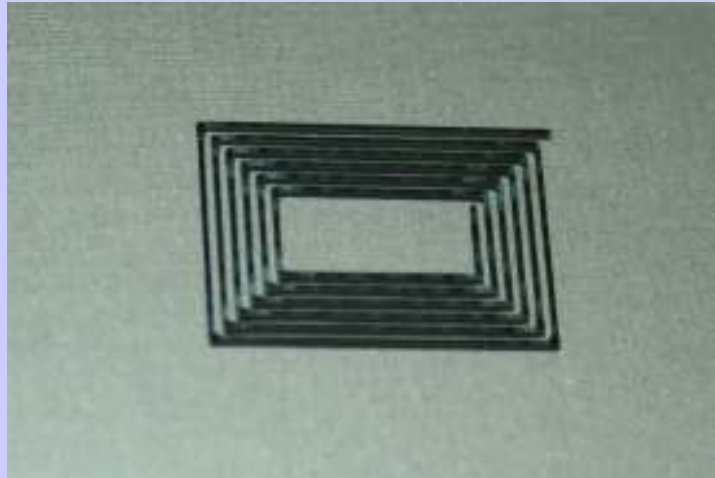
*Courtesy of Microdrop Technologies GmbH*



**Nozzle  $\Phi = 66 \mu\text{m}$**

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# Samples of Dispensed Ink by Ink-Jet dispenser



Courtesy of Microdrop Technologies and TNO Industrial-Eindhoven

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## Summary:

- The studied inks show properties similar to true fluids
  - Nano silver filler with so small size has the main influence for practically no sedimentation phenomena.
  - Obtainment of the large concentration of nano silver filler without the significant inks viscosity growth is a result of using small silver particles size.
- Stability of ink properties, especially with viscosity point of view is extremely important from print head safe work and repeatability of printed structures.
- Ink with nano size silver filler, after sintering process has highly uniform structure similar like in case of metal wire.