Application of Nano-Fibrillated Cellulose as a Paper Surface Treatment for Inkjet Printing

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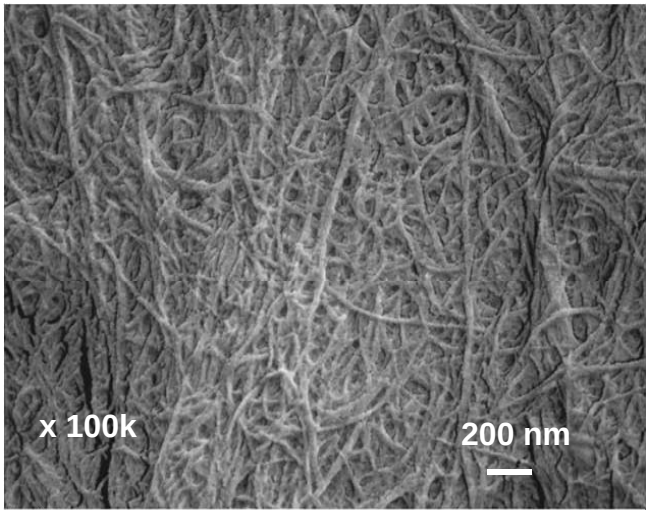
Motivation

- Nano-fibrillated cellulose (or micro-fibrillated cellulose) should be possible to produce on site at low costs.
- By putting this fine material at paper surface, we may be able to improve the print quality of paper.



Objective

- To explore the potential of nano-fibrillated cellulose (NFC) as a coating material to improve inkjet print quality of woodfree fine papers

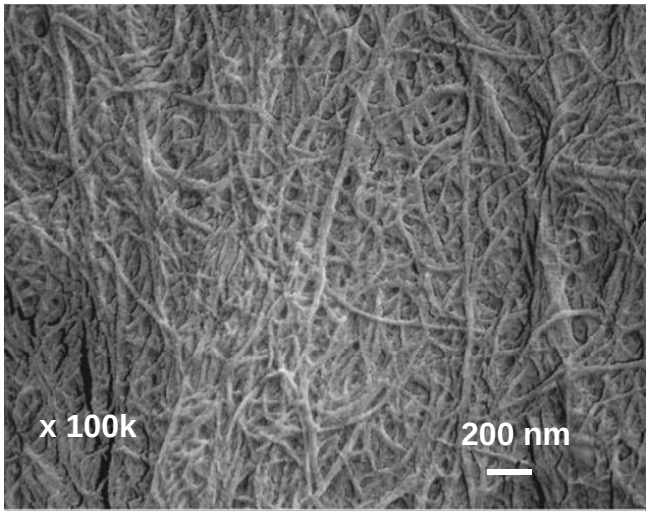
Key Questions

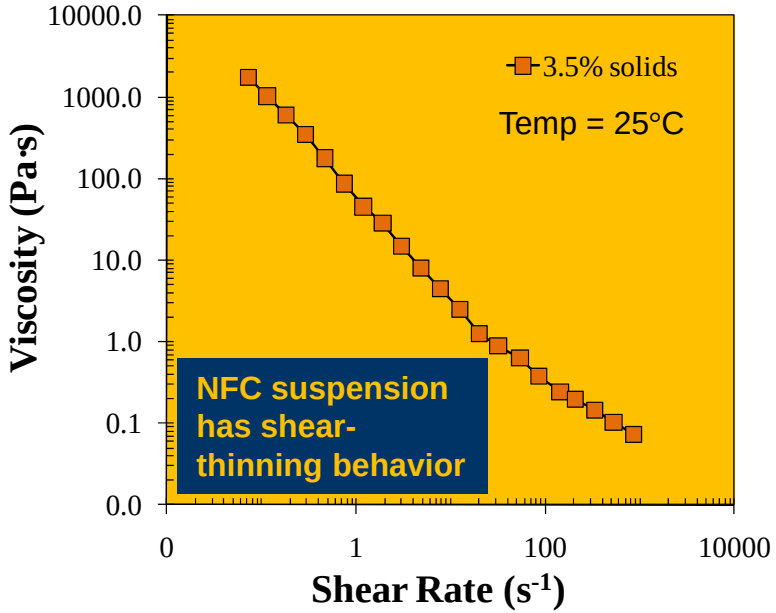
- What influence does the combination of NFC and alkyl ketene dimer (AKD) have on absorption and spreading of inkjet inks on uncoated papers

- What influence does NFC have on dye based vs. pigment based inks

Nano-fibrillated Cellulose

- NFC suspension – bleached softwood kraft fiber
- Initial solids content – about 3.5%
- Prepared by mechanical treatment with pilot-scale refiner, University of Maine



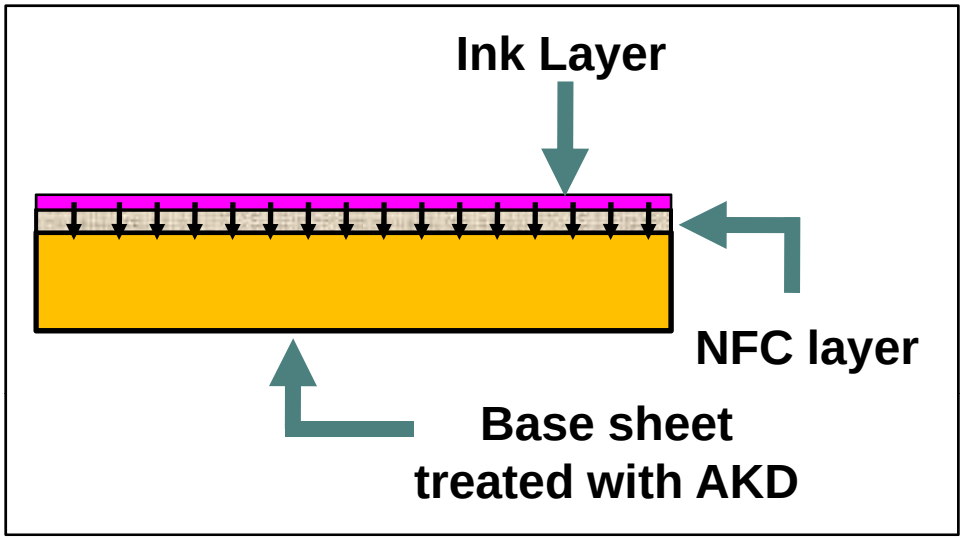


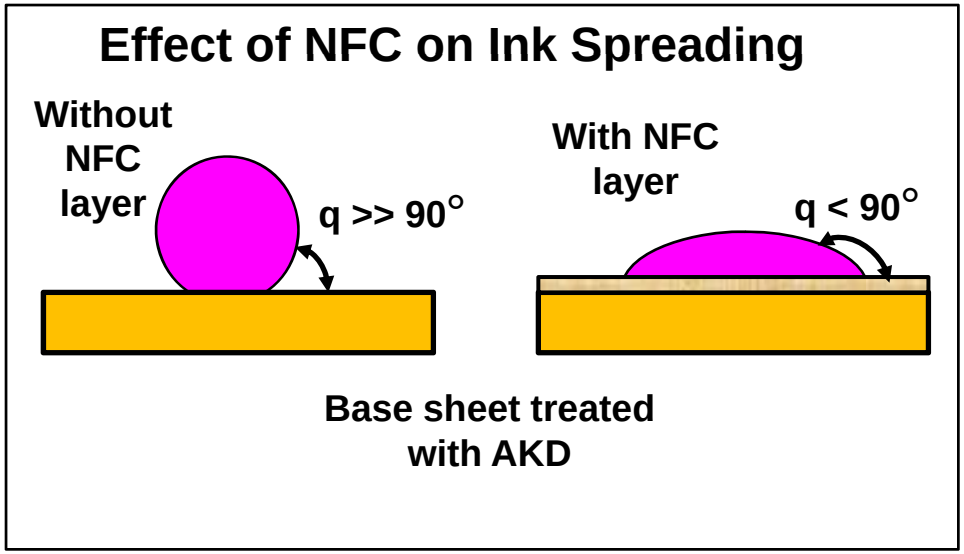
FE-SEM image of NFC and its viscosity curve provided by Hamada and Bousfield

Procedure Outline

1. Uncoated woodfree fine paper – immerse in 1% solution of AKD wax in hexane, allow hexane to evaporate, and oven cure at 105°C for 5 minutes.
2. Coat papers with NFC at different coat weights using a wire-rod coater.
   - NFC coat wt. ranged from 2 to 5 g/m^2
   - Calender samples at 50°C and nip load of 100 kN/m
3. Print samples using desktop inkjet printer.
   - Dye and pigment-based magenta inks
4. Measure print density.

Procedure Outline – Coating with NFC

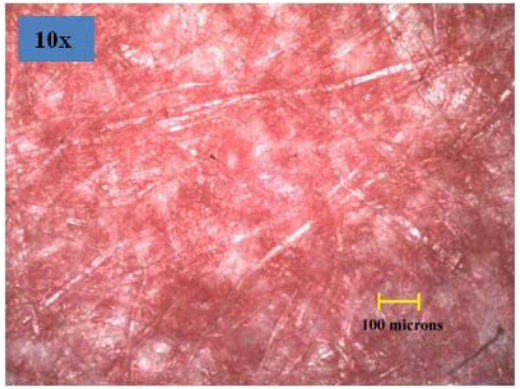




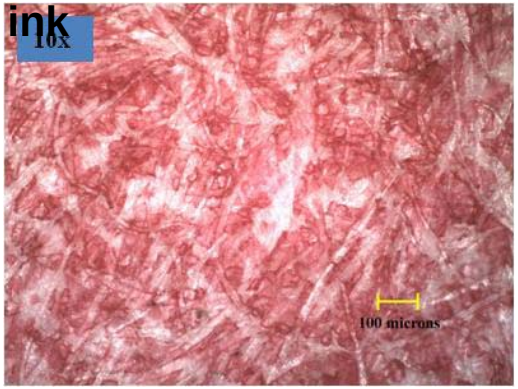
- Proposed Mechanism:
  1. Hydrophobic base paper treated with AKD limits or prevents fluid penetration into the sheet.
     - Reduces print-through
     - Ink drops contact on hydrophobic surface, giving low coverage and low print density
  2. Hydrophilic NFC layer helps ink spread on the AKD-treated paper.
     - Ink drops spread more, giving higher coverage and high print density
     - NFC layer may also filter pigments on paper surface

Results – Effect of AKD only on print quality

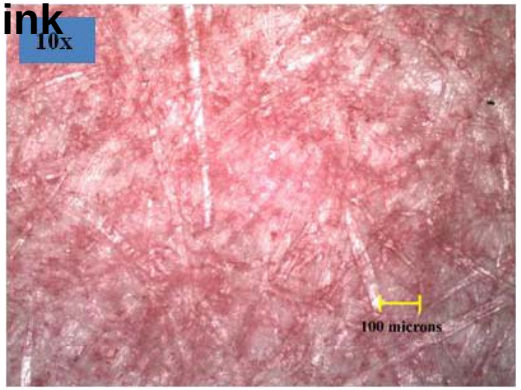
No AKD, dye-based ink



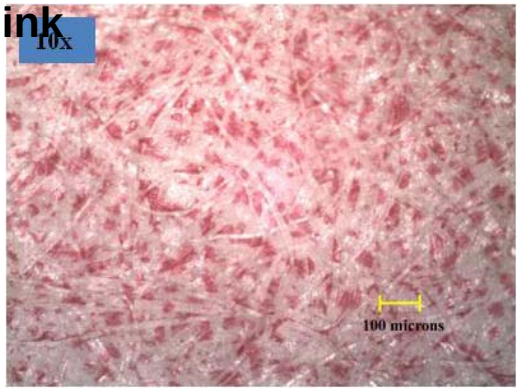
With AKD, dye-based ink



No AKD, pigment-based ink



With AKD, pigment-based ink



- Solid areas printed on base paper before and after AKD treatment
- Higher coverage for base paper *without* AKD
- Ink drops contract on AKD-treated paper, giving poor coverage and low print density

Results – Effect of AKD only on print quality

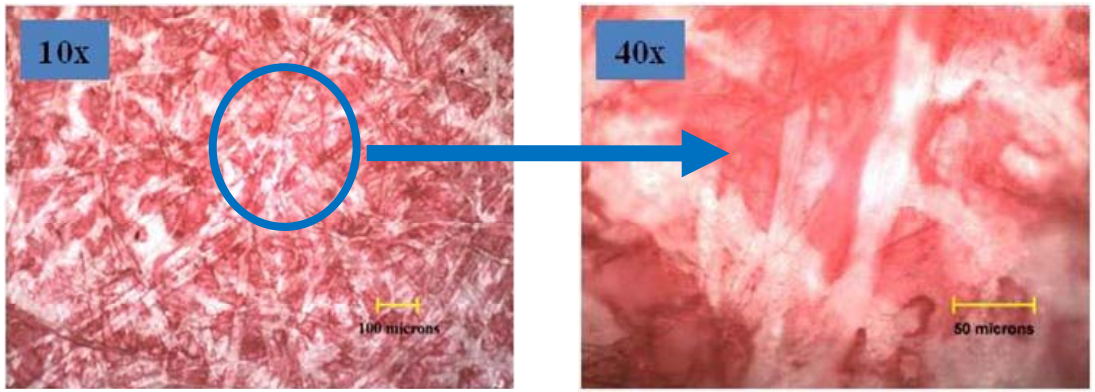
Print density of samples before and after AKD treatment

Sample	Dye-based	Pigment-based
No AKD	0.71 ± 0.01	0.43 ± 0.01
With AKD	0.59 ± 0.02	0.33 ± 0.01

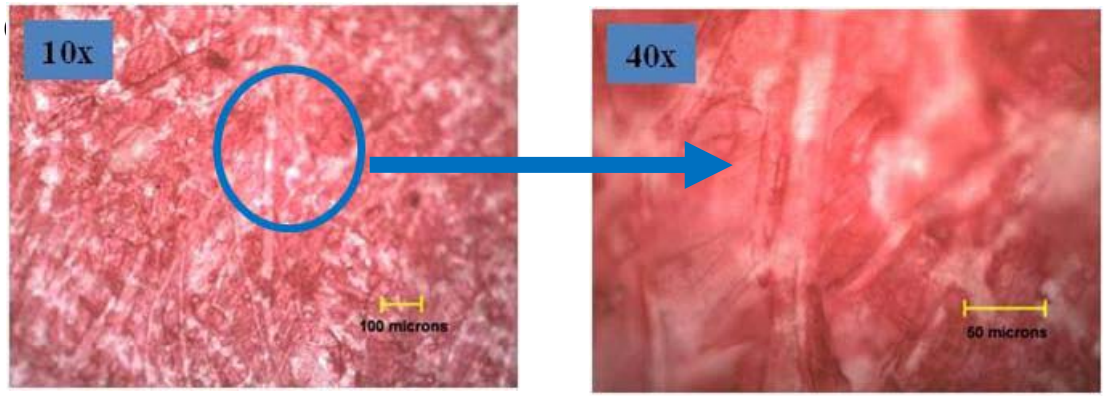
Decrease in PD for both inks after AKD treatment

Results – Effect of AKD and NFC on print quality (Dye-based ink only)

AKD, no NFC,



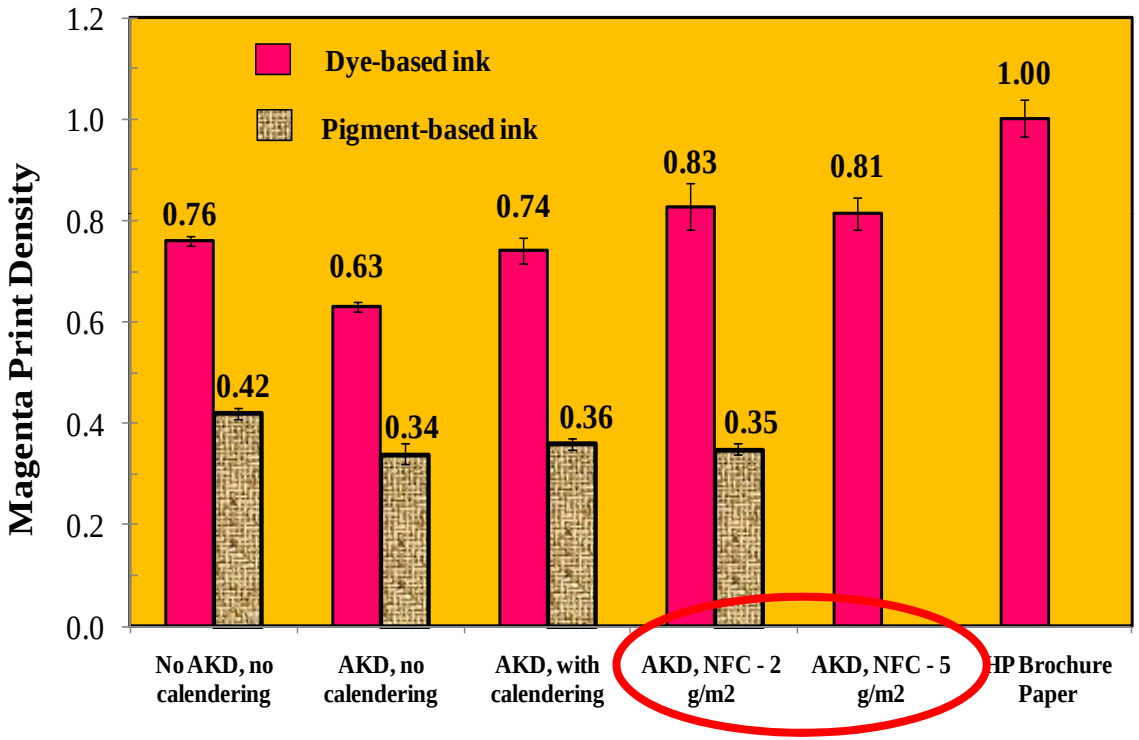
AKD with 2.0 g/m^2,



Coat AKD base sheet with NFC

NFC layer improves ink spreading and gives higher print density

Results – Effect of AKD and NFC on print density (printed side)



- Dye-based ink - print density increased after applying NFC
- Pigment based ink – no change in PD after NFC treatment
  - Possible that pigments are immobilized or trapped on the NFC layer

Additional NFC may not increase PD

Results – Effect of AKD and NFC on print density (reverse side)

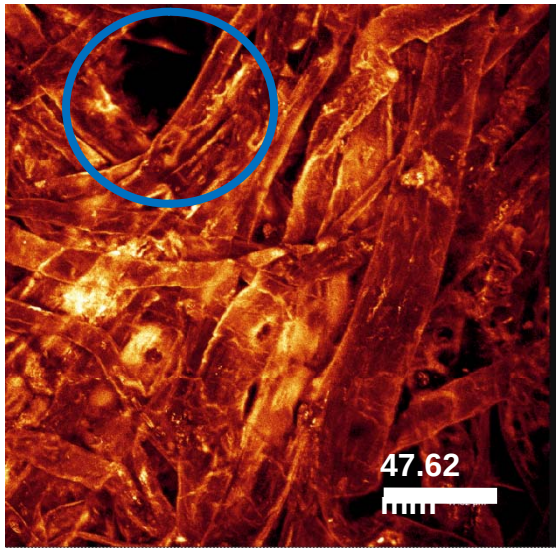
Sample	No AKD, no calendering	With AKD, no calendering	With AKD, calendered	With AKD, 2.0 g/m^2 NFC, calendered
Printed Side	0.76 ± 0.01	0.63 ± 0.02	0.74 ± 0.03	0.83 ± 0.05
Reverse Side*	0.041	0.019	0.021	0.017

**Standard deviation of the reverse side PD ranges from ± 0.007 to 0.009*

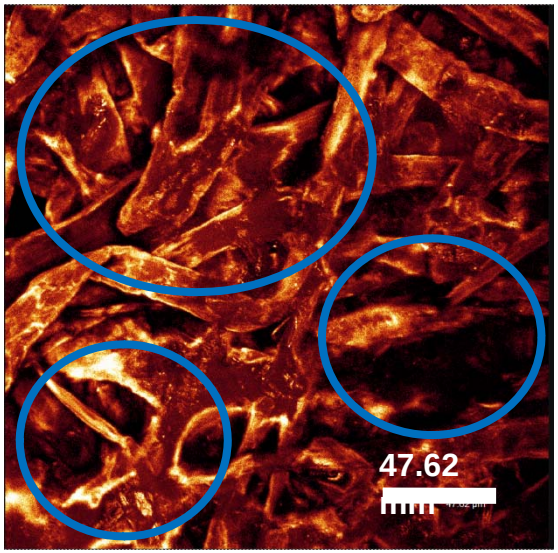
Combination of NFC & AKD increases PD while reducing print-through

Results – Confocal Laser Scanning Microscopy (Dye-based ink)

Uncoated woodfree paper (Before AKD treatment)



Uncoated woodfree paper (After AKD treatment)



- **Sample with no AKD** – ink spreads on low contact angle surface, giving a high PD
  - Only with a few areas where the ink did not cover
- **Sample with AKD** – ink drops contract on hydrophobic surface, giving poor coverage
- **Pigment-based inks** – similar trends were observed

Concluding Remarks

- Combination of AKD and NFC increase print density for dye-based inkjet inks. No differences observed for pigment inks.

- AKD treated fibers limit fluid penetration. Ink drops contract on AKD base paper

- Both types of inks spread on hydrophilic NFC layer. Give higher print density for dye-based inks.

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