# INFLUENCE OF SURFACE ENERGY ON SETTING AND TRANSFER OF WATER-BASED SYSTEMS

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## Abstract

The setting and transfer of water-based flexographic inks is of critical importance for the print quality of uncoated papers and linerboards. While paper surface free energy is often of importance for print properties, ink chemistry such as binder type and its interaction with the paper is also known to influence ink transfer.

Four different base papers, a woodfree, newsprint, supercalendered (SC) and linerboard, were treated with a solution of alkyl ketene dimer (AKD) in hexane to change the surface energy without changing fiber pore structure. The properties are in Table 1. Water contact angles increased in all cases, in some cases to over $90^o$. The absorption rates of a water based ink into these samples decrease with treatment as expected. Figure 1 shows the absorption behavior of two ink types; one ink was based on an emulsion binder system and the other a solution polymer.

Table 1. Paper Properties .

| Paper Type | Basis Weight (g/m²) | Average Pore Diameter (μm) | Roughness (μm) | Darcy Air Permeability (m²) | Void Fraction |
|---|---|---|---|---|---|
| | | Control sample – as received | | | |
| Wood-free | 79.4 | 3.6 | 6.3 | $6.5 \times 10^{-15}$ | 0.36 |
| Newsprint | 52.3 | 3.3 | 7.9 | $7.5 \times 10^{-15}$ | 0.35 |
| SC | 48.8 | 0.9 | 1.23 | $3.8 \times 10^{-16}$ | 0.35 |
| Linerboard | 238 | 5.9 | 7.6 | $6.1 \times 10^{-14}$ | 0.35 |
| | | 1% AKD added by immersion | | | |
| Wood-free | 79.4 | 3.6 | 6.4 | $6.4 \times 10^{-15}$ | 0.36 |
| Newsprint | 53.2 | 3.6 | 7.9 | $7.6 \times 10^{-15}$ | 0.35 |
| SC | 49.1 | 0.9 | 1.21 | $3.4 \times 10^{-16}$ | 0.35 |
| Linerboard | 242 | 5.9 | 7.8 | $5.3 \times 10^{-14}$ | 0.35 |

The samples were printed with a laboratory flexographic proof press at a range of anilox volumes using two water-based inks. In this printing method, the amount of ink fed to the transfer nip is constant, but the amount of transfer can still be different due to the interactions of the ink and paper. The amount of transfer is measured by ink density measurements. However, gravimetric measures correlate well with the density measurements; this correlation

suggests that differences in ink density are not from the final position of ink pigments within the sample, but from the transfer event itself.

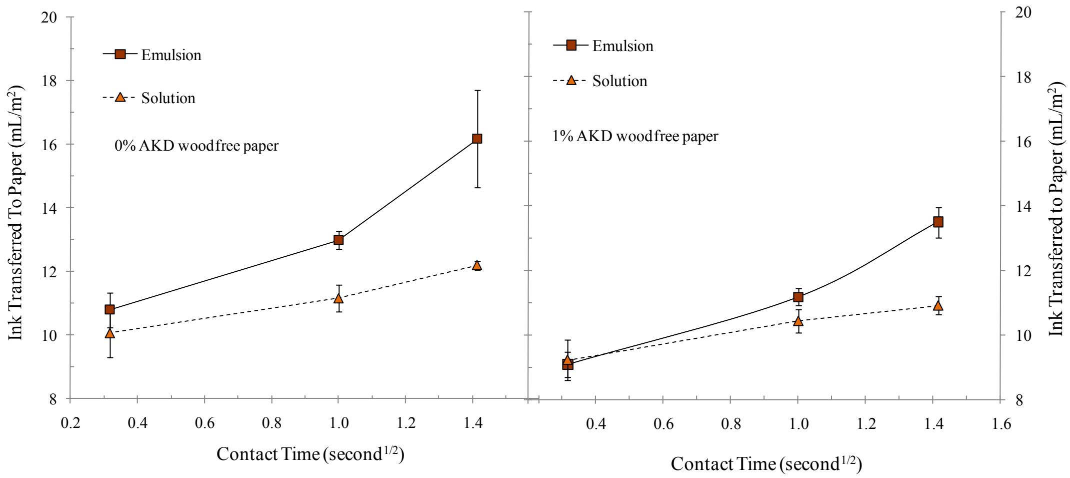


Figure 1. Absorption of ink into untreated (left) and treated (right) paper samples for the wood free base paper and the two ink types.

Figures 2 and 3 show the print density measured before and after treatment for the two inks for the wood free paper and the newsprint grade, respectively. While the surface tension and viscosities of the two inks are similar, their responses to the paper treatment are quite different: the emulsion ink had a lower ink density on the treated samples compared to the untreated samples at all anilox volumes while the solution ink had no difference in print density. This behavior was also seen for the other two types of papers studies.

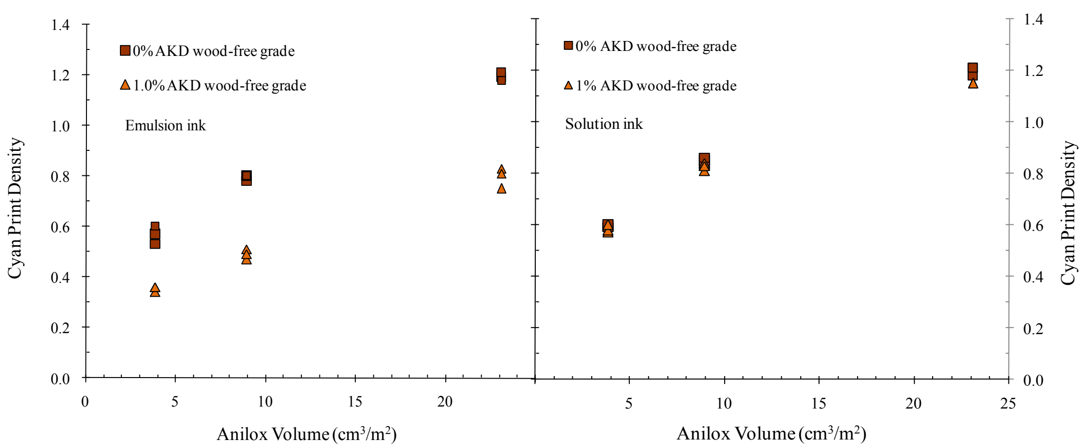


Figure 2. Ink density for the emulsion ink (right) and the solution polymer ink (left) for treated and untreated woodfree paper.

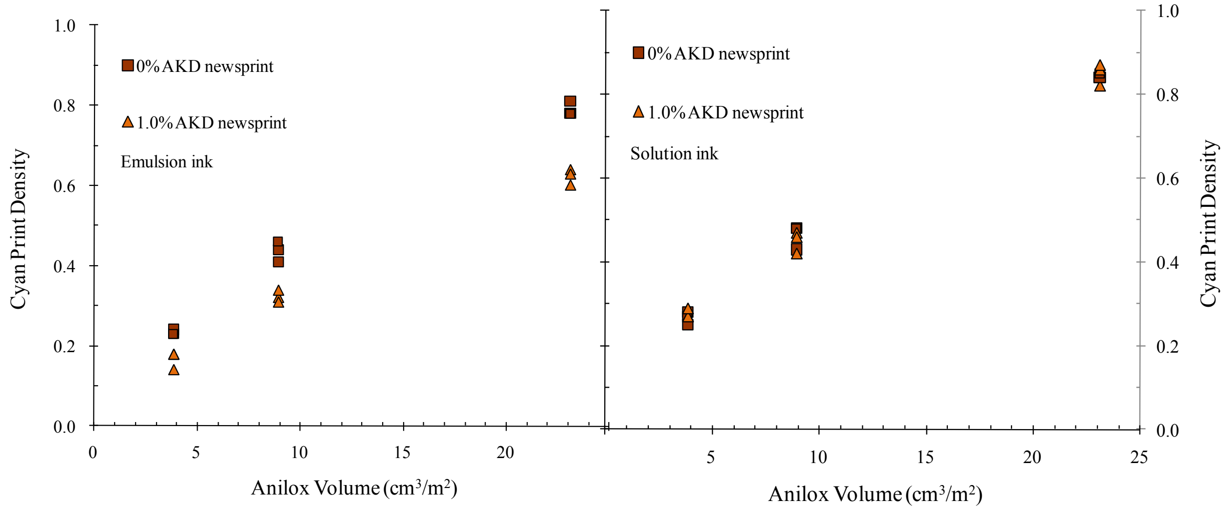


Figure 3. Ink density for the emulsion ink (right) and the solution polymer ink (left) for treated and untreated newsprint.

These results present a significant question: what is different about these two inks that cause one ink to be sensitive to the substrate surface energy while the other ink is not? The difference in behavior seems to be related to the filtercake resistance of the inks. Figure 4 shows the results of a filtration experiment done with the inks. The solution polymer ink that was not sensitive to the paper surface energy had a high filtercake resistance: this resistance may cause the ink transfer to depend on the ink film split, not the paper surface energy.

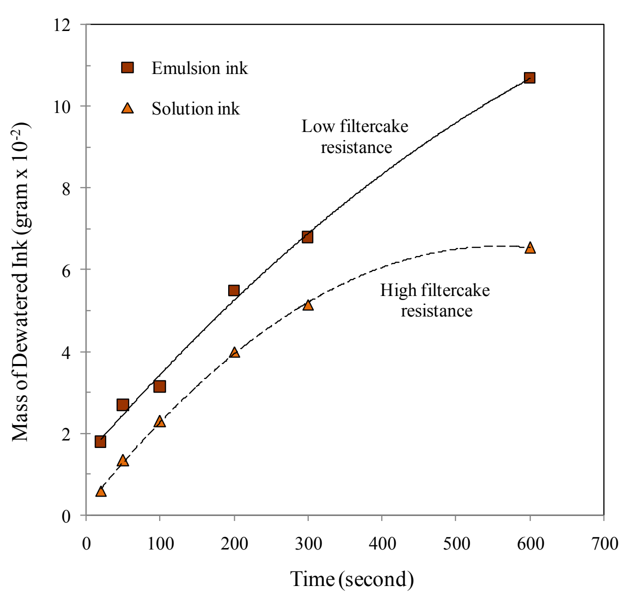


Figure 4. Mass of water through a filter as a function of time for 1 bar pressure and 7.1 $cm^2$ area.

A model is proposed that predicts the correct trends in ink transfer for parameters that match the laboratory conditions. The model of Ninness et al (1998) is modified to account for a known inlet feed flow rate and nip load. Figure 5 is a schematic of the model.

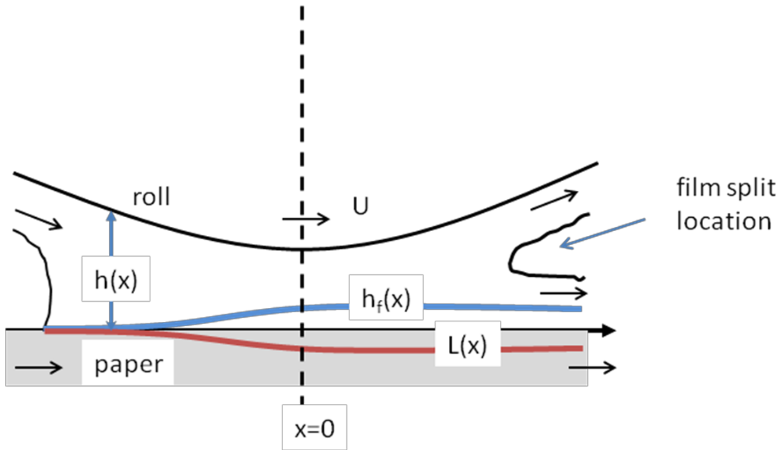


Figure 5. Schematic of model. Flow into the nip dewaters fluid into paper, generates pressure, and the film splits at 50% of the free liquid film.

When the filtercake resistance is high, the model predicts little loss of water into the paper and around a 50/50 film split. When the filtercake resistance of the ink is high, the model predicts some penetration, and more than a 50% transfer. When water does penetrate the sample, the capillary pressure of the paper plays a role in the amount of dewatering. Figure 6 shows the predictions for conditions that are close to the laboratory conditions. The emulsion ink has more penetration and more of a dependence of transfer on the substrate contact angle than the solution polymer ink.

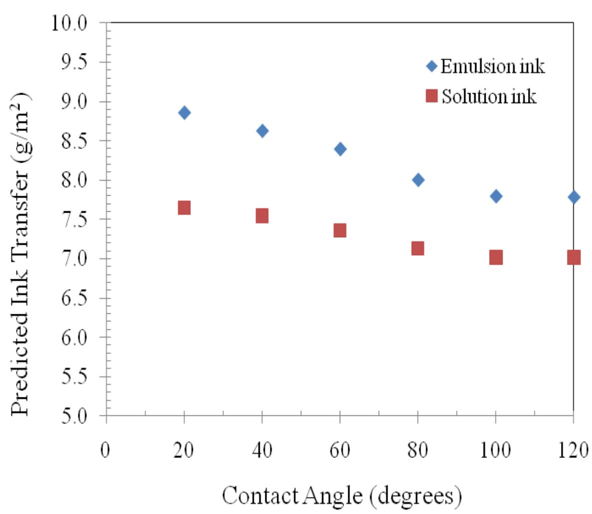


Figure 6. Predicted ink transfer from the model for parameters that are close to the laboratory conditions.

Ninness, B., D.W. Bousfield, and N.G. Triantafillopoulos, "Fluid Dynamics Model of the Film-Fed Nip with a Porous Web", Proceeding of the TAPPI Coating Conf., pp. 515-530, TAPPI Press, Atlanta, GA (1998).

Ninness B., D.W. Bousfield, and N. Triantafillopoulos, "Modeling of Film-Fed Size Press and Comparison with Pilot Scale Data", Proc. 10th Int. Coating Science and Tech. Symposium. pp. 181-185 (2000).