Ink Drying measured by Surfoptic Imaging Reflectometer Technology Demonstrator

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Introduction

The mechanisms associated with the immobilisation and drying of printing ink are of great interest to printers, papermakers and suppliers of paper coating pigments. The drying properties affect both optical appearance of a finished product, but also mechanical properties such as resistance to scuff. Various workers have investigated the development of gloss during ink setting shedding light on processes like filament formation and relaxation. However, time-resolved reflectometry studies are even more powerful. Besides reflectance measurements, the optical and macroscopic roughness of the surface may be measured together with its composition via the refractive index. The latter may provide insights into the migration of pigment components during the drying process.

This note describes some preliminary experiments conducted with the Imaging Reflectometer Technology Demonstrator. This version of the instrument was the technology test bed and was rather slower than the current prototype. However, the results serve to illustrate the potential of the method.

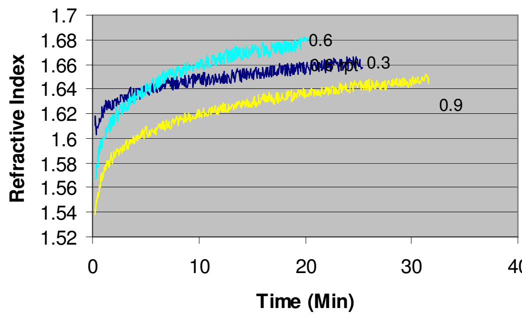
It should be noted in the following that the gloss and microroughness by Total Integrated Scatter (TIS) were not calibrated, so the absolute values may not be right. However, the trends and relative values are comparable within the data set.

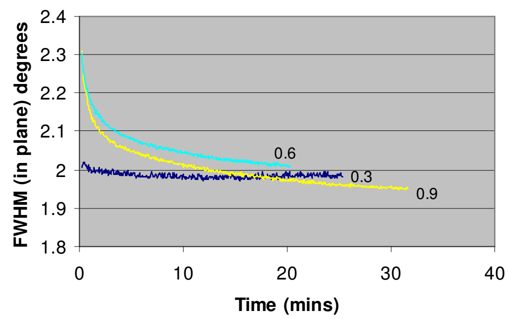
Experiments

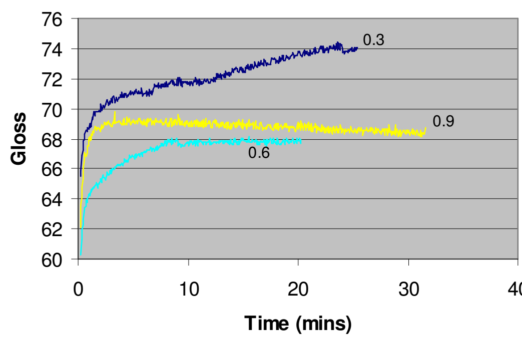
A magenta offset process ink was applied at various loadings to a clay coated basesheet using a laboratory IGT offset printing unit. The ink was quick setting Sun Chemical Swales CR0197. Imerys Minerals Ltd, Paper Group, kindly provided materials and conducted the printing experiments. After printing, samples were transferred as fast as possible to the reflectometer. The transfer typically took 15-20 sec, therefore the data collected do not include changes occurring immediately upon printing. Ink loading is described in terms of the volume of ink applied to the offset rollers (here 0.3, 0.6 and 0.9 ml). This expression of ink loading correlates with mass of ink per unit area transferred to the paper.

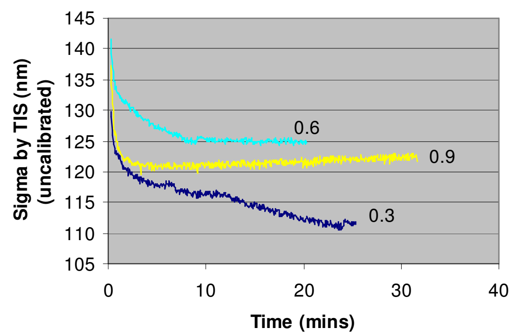
The instrument used in these experiments was the Imaging Reflectometer “Technology Demonstrator”, a preliminary version of the instrumentation which was not capable of measuring all parameters simultaneously. Nor was the instrument fully calibrated. However, the data obtained are illustrative of the possibilities for time resolved measurements.

Results









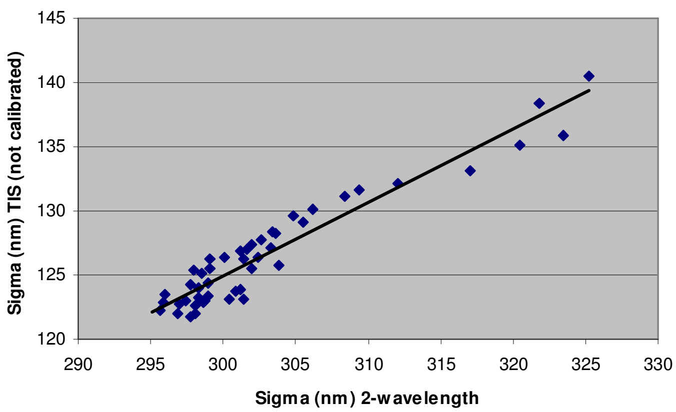
The results are summarised in the above graphs. The coated paper is a porous substrate and capillary imbibition of the ink vehicle contributes to the drying process. After application, the FWHM of the reflectogram decreases rapidly, eventually tending to plateau. The FWHM is a direct measure of the angular distribution of the scattered light. The larger the FWHM, the wider the light is scattered. When the ink is applied, filaments form at the printing nip. The ink is therefore initially rough, but viscoelastic forces within the ink tends to draw the filaments down tending towards a level surface. Thus the FWHM is a direct measure of ink filament relaxation. The final value depends on the waviness of the paper surface itself.

Gloss rises rapidly as the ink consolidates. The definition of gloss depends upon the measurement geometry. Here measurement are made over about ± 10°. It is important to remember that the perceived effect of FHWM on gloss depends on the acceptance angle of the gloss detector. In these measurements, FHWM (i.e ink filamentation) in unlikely to have influence on “gloss”. However, gloss clearly changes. Both refractive index (especially for polarised light) and microroughness affect gloss. In this instance, changes in these parameters likely account for most of the gloss change. The results suggest physical changes at the ink surface (e.g. a depletion of ink vehicle or solvent leading to a rise in concentration of high refractive index pigment). Interestingly in the 0.9 ml loading, the gloss peaks and then begins to decrease over longer times.

This may be attributable to pigment particles protruding from the surface increasing microroughness. It is significant also that physical changes continue to occur some time after the ink has apparently consolidated.

It is clear that there is a great deal of information in the data. The purpose of this note is not to explore the science in detail, but rather to highlight the possibilities of time-resolved reflectometer data for such studies. For further background on ink drying studies, see the references at the end of this note.

At the time of the measurements it was not possible to measure microroughness by two wavelength ($\sigma(2\lambda)$) at the same time as RI and other parameters (all measurements may be made together in the current instrument). However, these measurements were obtained separately. The following plot show the correlation between microroughness by two wavelengths and microroughness by TIS. Although rather noisy, the correlation suggests that the two methods should yield similar trends (as indeed they do). Note the absolute values do not agree owing to lack of calibration for these particular measurements.



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