

# Investigation of printed paper

The award-winning Thermo Scientific K-Alpha X-ray Photoelectron Spectrometer (XPS) System was used to investigate two samples of printed paper.

One sample was printed using a laser printer; the other was prepared using an inkjet printer. XPS was used to identify chemical differences between the two surfaces and differences between the shades of ink from the same printer.

## Introduction

Printing applications involve several surface processes: the distribution of ink (via nozzle or other dosing mechanism), its application via plate or cylinder, and finally the interaction between the ink and the surface of the media. If the surface interaction between the ink and the printing head is not ideal, smearing of the print or even clogging of the print head can occur. If the surface of the substrate is not uniform, the print may appear mottled, patchy, or it may flake.

Generally, these failures will be caused by a deviation of the surface chemistry away from that which is expected. This can be quite subtle, involving a small change in the composition at the surface compared with the bulk, or it can be a large change; for example the introduction of a contaminant during the manufacturing process. In both cases, there is a need to characterize the surface for both chemical and elemental information.

The Thermo Scientific™ K-Alpha™ X-ray Photoelectron Spectrometer (XPS) System offers a simple way of characterizing these kinds of samples. It can be used to analyze both conducting and insulating samples with no special sample preparation steps. The only requirement is that the sample is vacuum-compatible.

## Experiment

Samples of standard copier paper were printed with identical graphics using inkjet and laser printers. Spectra were collected from the unprinted paper and from areas printed red or black.



Figure 1: Optical image of one of the samples in the K-Alpha XPS System. The analysis area is defined by the size of the X-ray spot, shown as an ellipse on the image.

The increase in sensitivity offered by the K-Alpha XPS System allows for the data to be collected in a substantially reduced timeframe compared to the original instrument, without compromising spectral quality.

As the samples were insulating, the K-Alpha turnkey charge compensation system was used. This system is simple to use and requires no user intervention while maintaining consistent analysis conditions across the sample set.

Figure 1 shows an optical image of one of the samples in the analysis position of the spectrometer. Superimposed on this is an elliptical marker showing the size and position of the analysis area.

## Results

The results of the analysis are shown in Figures 2–5. Figure 2 features survey spectra from the paper and areas printed in black by both printers. Survey spectra are typically used to provide elemental information from the surface, and so can be useful in identifying contaminants.

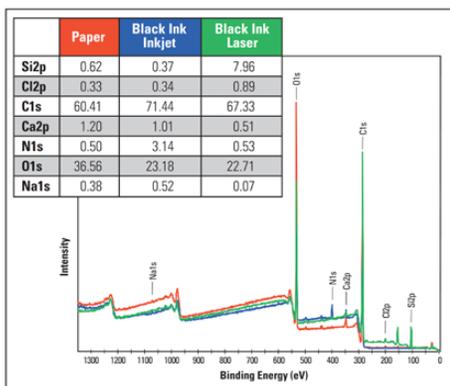


Figure 2: Survey spectra from printed and unprinted area.

In this case, clear differences can be seen in the minor components of the inks, with the laser print being relatively rich in silicon, compared with increased nitrogen in the inkjet ink. Minor components associated with the paper substrate can also be identified; for example chlorine used in bleaching.

After collection of a survey spectrum, an automated routine can be used to identify the elements present. High-resolution spectra can then be acquired for those elements. Examples for the C1s high-resolution scans are shown in Figure 3. The spectra show that there is a clear difference in the chemistry of the inkjet and laser inks, with the inkjet ink appearing to have a more complex chemistry.

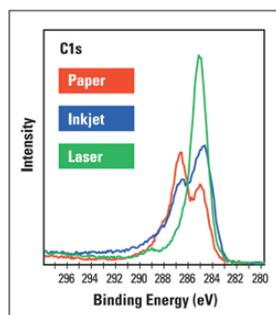


Figure 3: High-resolution C1s spectra from areas printed in black ink by the inkjet and laser printers.

It is possible to use the Thermo Scientific Avantage Data System supplied with all Thermo Scientific surface analysis instruments to peak fit the high-resolution spectra and quantify the individual chemical states. The output for such an analysis of the spectra in Figure 3 and of a comparison of the red and black inkjet inks are shown in Figures 4 and 5.

Figure 4 highlights the difference between the inkjet and laser inks, predominantly due to the variation in the saturated hydrocarbon bonding in the molecule. In Figure 5, it can be seen that XPS can differentiate the two ink colors investigated. The chemical changes are quite subtle but again principally involve variation in the (C-C/C-H) functionality and a small change in the amount of oxygen in the ink molecule.

## Results

XPS can be used to investigate surface effects involved in printing. The chemical signature of different printing methods can be detected, and the chemical functionalization of the ink can be quantified.

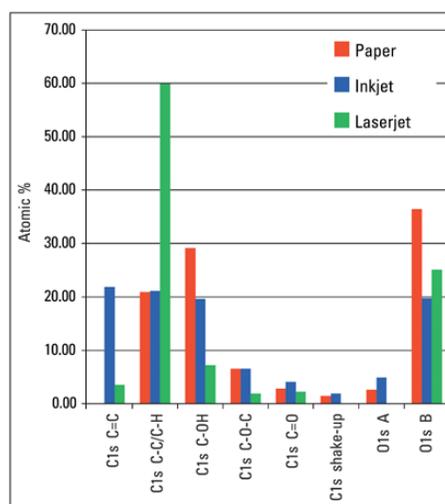


Figure 4: Quantification results for areas printed in black ink based on the C1s and O1s high-resolution spectra only.

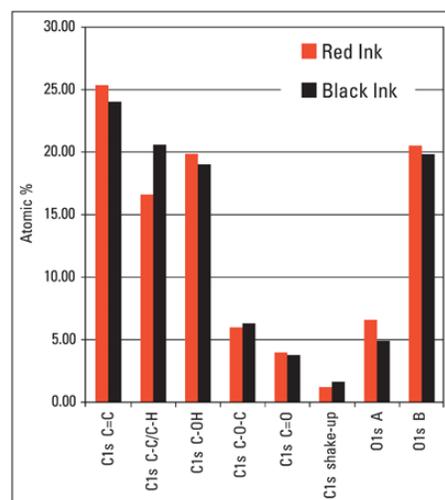


Figure 5: Quantification results for the C1s and O1s high-resolution spectra for the red and black inkjet ink.

Find out more at [thermofisher.com/xps](https://thermofisher.com/xps)