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K-Alpha: XPS Investigation of Printed Paper

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Key Words

- K-Alpha
- Auto-analysis
- Paper
- Point Analysis
- Printing
- Surface Analysis
- XPS

The award-winning Thermo Scientific K-Alpha X-ray photoelectron spectrometer (XPS) features superior performance, fast analysis and outstanding chemical detectability. The enhanced system was used to investigate two samples of printed paper. One sample was printed using a laser printer, and one sample 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 the ink (via a nozzle or other dosing mechanism), its application via a 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, then smearing of the print, or even clogging of the print head can occur. If the surface of the substrate is not uniform, then the print may appear mottled, patchy, or flake away.

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.

XPS offers a simple way of characterizing these kinds of samples. It can be used to analyse both conducting and insulating samples with no special sample preparation steps. The only requirement is that the sample is vacuum compatible.

Experimental

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. The increase in sensitivity offered by the new K-Alpha 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.

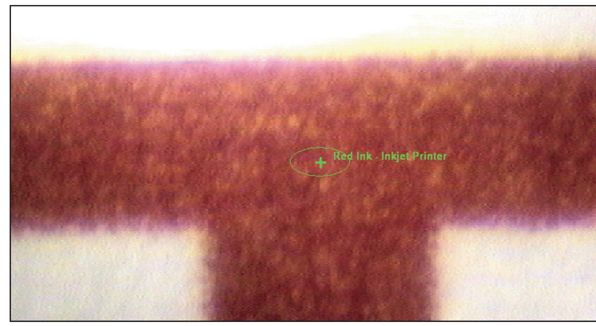
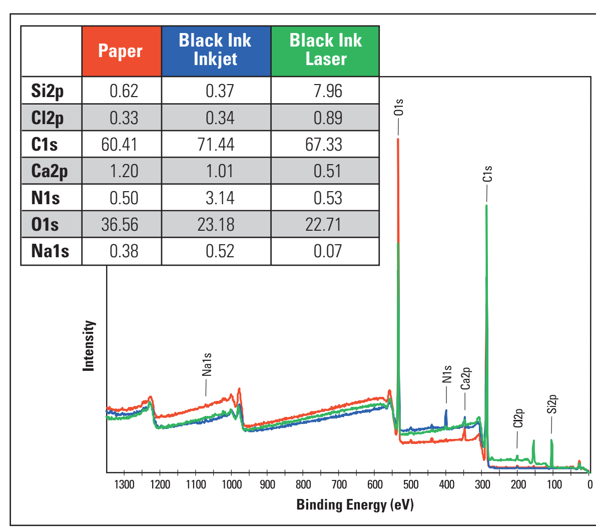


Figure 1: Optical image of one of the samples in the K-Alpha system. The analysis area is defined by the size of the X-ray spot, shown as an ellipse on the image

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.



	Paper	Black Ink Inkjet	Black Ink Laser
Si2p	0.62	0.37	7.96
Cl2p	0.33	0.34	0.89
C1s	60.41	71.44	67.33
Ca2p	1.20	1.01	0.51
N1s	0.50	3.14	0.53
O1s	36.56	23.18	22.71
Na1s	0.38	0.52	0.07

Figure 2: Survey spectra from printed and unprinted areas

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 the bleaching process.

After collecting 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.

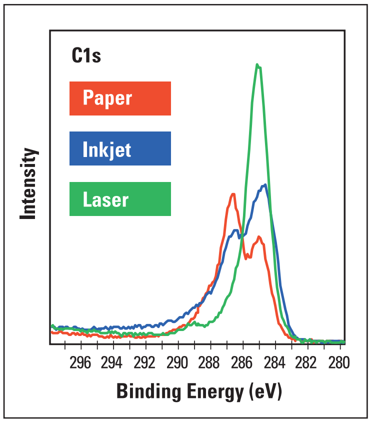


Figure 3: High resolution C1s spectra from areas printed in black ink by the inkjet and laser printers

It is possible to use the Avantage software 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 Figure 4 and Figure 5.

Figure 4 highlights the difference between the inkjet and laser inks, which is 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.

Summary

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.

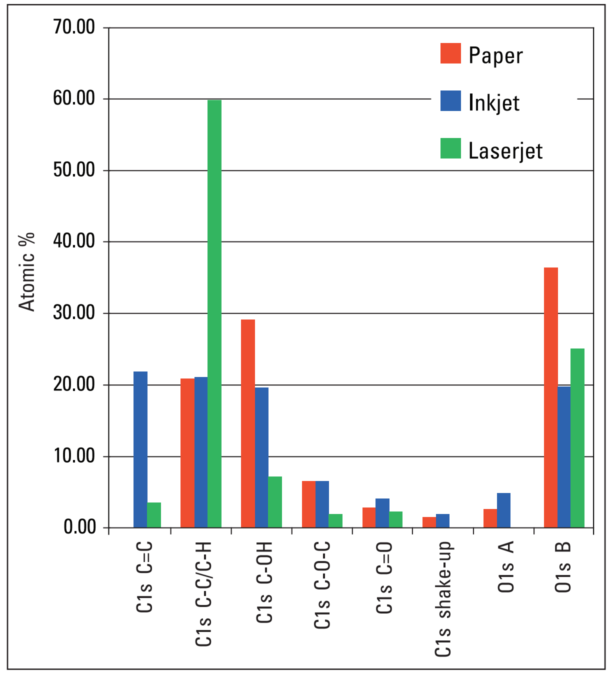


Figure 4: Quantification results for areas printed in black ink based on the C1s & O1s high resolution spectra only

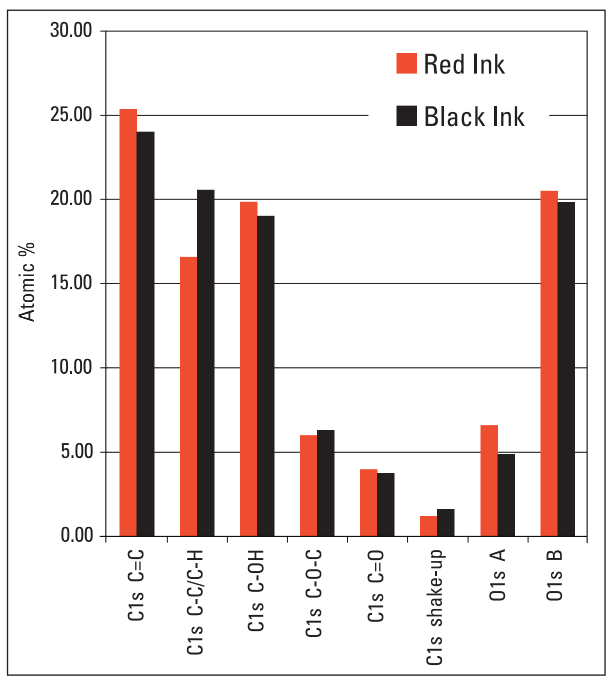


Figure 5: Quantification results for the C1s & O1s high resolution spectra for the red and black inkjet ink

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