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# nmRC CASE STUDY

## POLYMER COMPOSITION AND SPATIAL DISTRIBUTION

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# Polymer Composition and Spatial Distribution

## X-ray Photoelectron Spectroscopy (XPS) Case Study

# POLYMER CHARACTERISATION



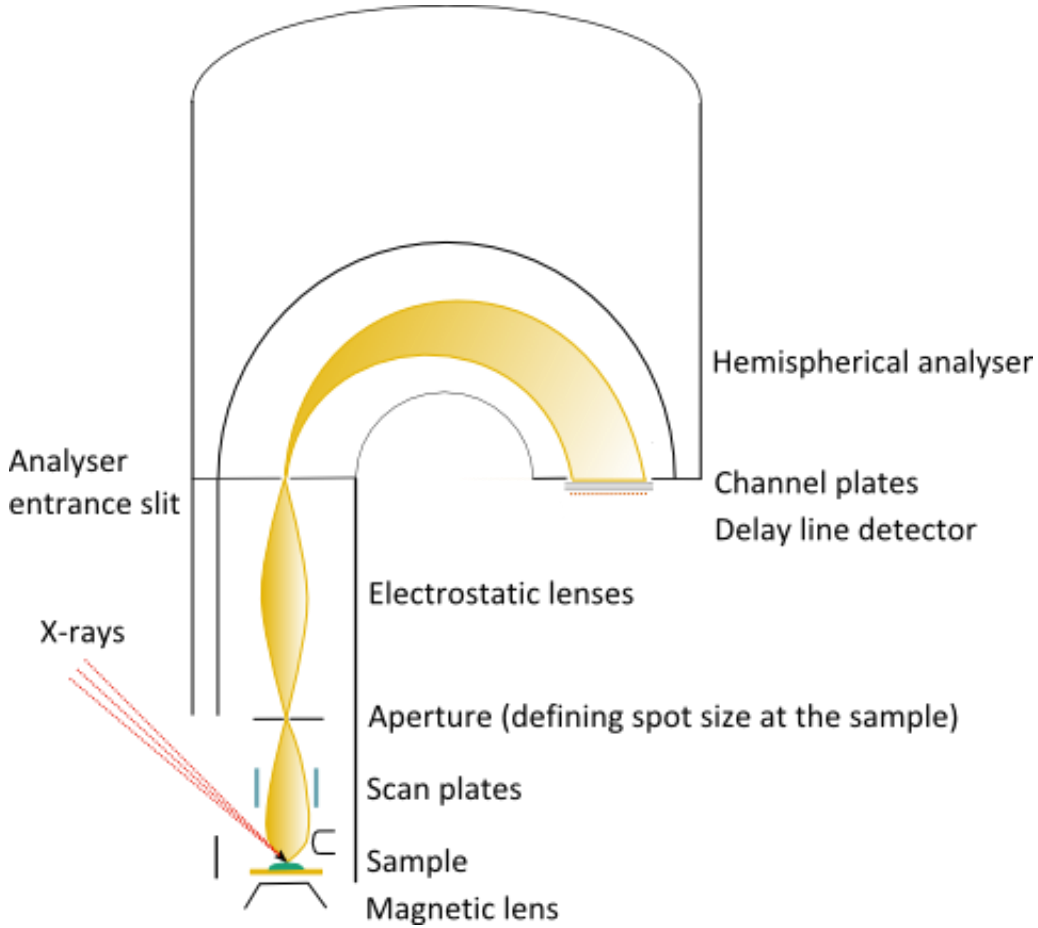
- Polymers are not always directly or easily identifiable at the surfaces of materials.
- Macro distributions and thicknesses may be of interest, but how can they be assessed?
- X-ray photoelectron spectroscopy (XPS) is a means of chemical analysis sensitive to light elements.
- XPS is also a highly surface sensitive technique (~ top 10nm), ideal for studying thin films of polymers or liquids*.

** Analyse ionic liquids with the liquid phase photoelectron spectroscopy instrument (LiPPS) at the NNNC.*

# XPS PRINCIPLES



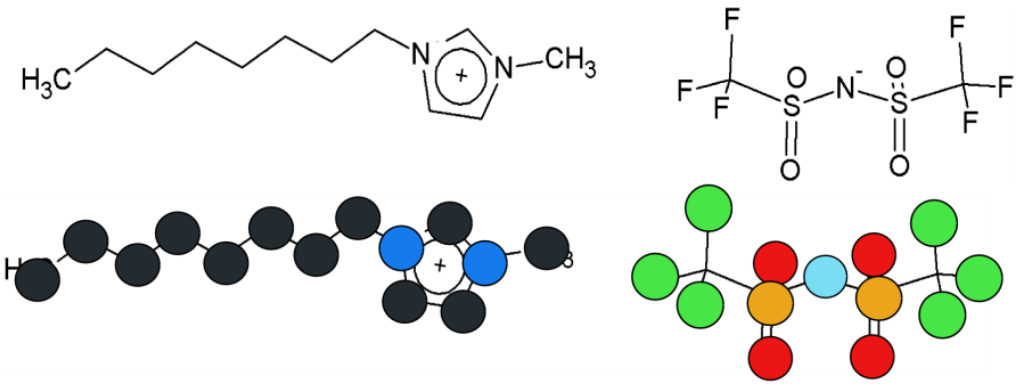
- X-rays excite electrons out of the sample surface.
- These are collected and their energy analysed.
- Electron energies depend on the element they originated from.
- The resulting spectrum is dependent on what elements are in the surface layer and in what abundance.



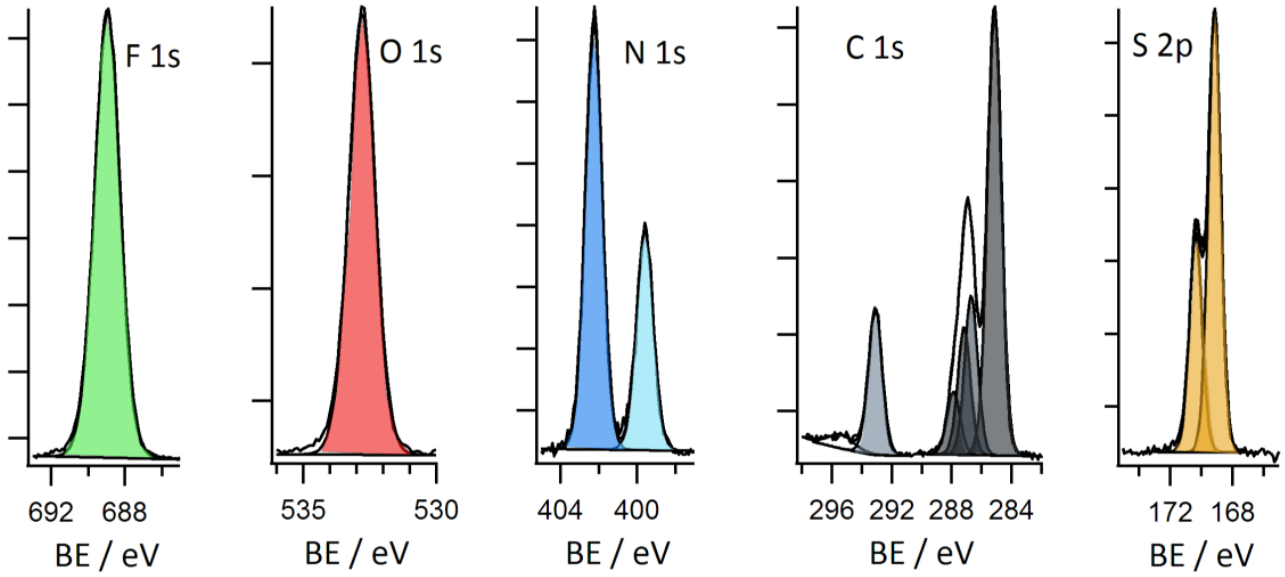
# SPECTRAL IDENTIFICATION



- XPS Identification of polymers possible by elemental spectra.
- Example analysis of an ionic liquid:



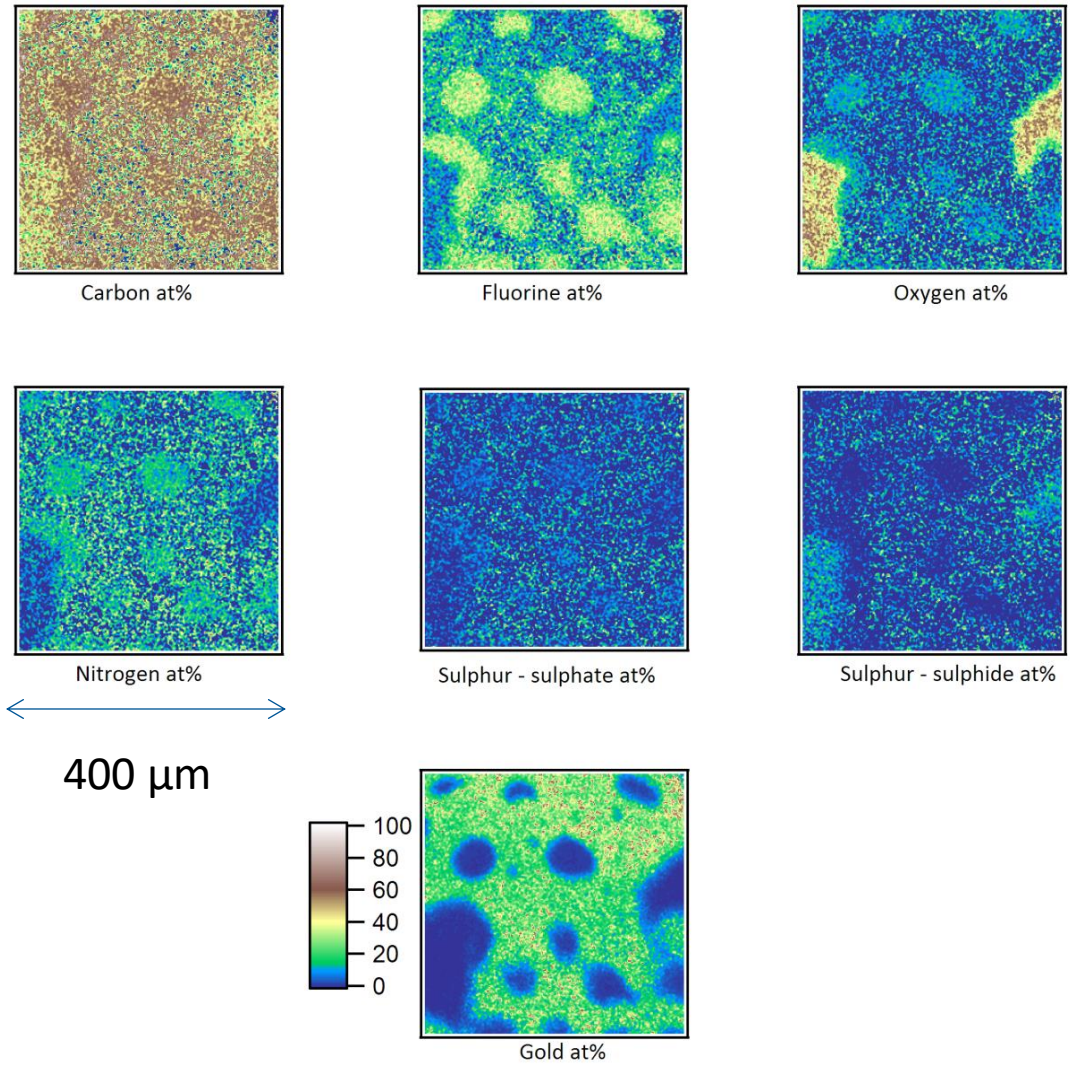

| | Fluorine | Oxygen | Nitrogen | Carbon | Sulphur | Total |
|---|---|---|---|---|---|---|
| No Atoms | 6 | 4 | 3 | 14 | 2 | 29 |
| At% Expected | 20.7 | 13.8 | 10.3 | 48.3 | 6.9 | 100 |



# SPATIAL LOCALISATION



- Parallel imaging of a sample surface can be performed.
- This can provide the spatial distribution of elements, and therefore surface components e.g. polymers
- Example XPS mapping of ionic liquid droplet distribution on a gold surface.



# SUMMARY



- XPS is a highly surface sensitive technique capable of chemical identification localisation, and quantification.
- Sensitive to light elements with ~0.1% atomic sensitivity it can play a key role in thin film polymer and liquid characterisation.
- Potential applications:
  - *Polymer identification.*
  - *Surface enrichments of one polymer constituent.*
  - *Drug entrapment and depth and coverage with protective layers.*
  - *Micron scale polymer spatial segregation or coating distributions.*
  - *Chemical stability of coatings.*
  - *Polymer mixing in cross section.*

# REFERENCES / ACKNOWLEDGEMENTS



**For more details on the work showcased in this case study see the following publications:**

E. F. Smith, D. Briggs, and N. Fairley, "Further developments in quantitative X-ray photoelectron spectromicroscopy: preliminary results from the study of germanium corrosion," Surf. Interface Anal., vol. 38, no. 2, pp. 69–75, 2006.

E. F. Smith, F. J. M. Rutten, I. J. Villar-Garcia, D. Briggs, and P. Licence, "Ionic Liquids in Vacuo: Analysis of Liquid Surfaces Using Ultra-High-Vacuum Techniques," Langmuir, vol. 22, no. 22, pp. 9386–9392, Oct. 2006.

The X-ray photoelectron spectroscopy (XPS) analysis documented here was performed at the Nanoscale and Microscale Research Centre (nmRC) at the University of Nottingham. www.nottingham.ac.uk/nmrc

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# ADDITIONAL INFORMATION



- We hope the information provided in this case study is of interest.
- If you wish to get in touch with us to discuss any of the information provided, raise a query/concern or provide feedback then please use any of the methods listed below:

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