

X-Ray Fluorescence (XRF) Spectroscopy Unit

Introduction

The X-Ray Fluorescence (XRF) Spectroscopy Unit, located in the Nuclear Physics Laboratory, is a member of Laboratory Network for Research Support in the University of Ioannina. X-Ray Fluorescence Spectroscopy has long been recognized as a powerful technique for the qualitative and quantitative elemental analysis of a wide range of solid and liquid samples. Compared to other competitive techniques, such as Atomic Absorption Spectroscopy (AAS) or Inductively Coupled Plasma Spectroscopy (ICPS), XRF has the advantage of being non-destructive, multi-elemental, fast and cost-effective. Furthermore, it offers a fairly uniform detection limit across a large portion of the Periodic Table and is applicable to a wide range of concentrations from 100% to a few ppm.

As illustrated in Fig. 1, the method involves atom excitation by primary X-rays – originating either from a radioisotopic source or an X-ray tube – and subsequent detection of the X-rays emitted by the sample during the de-excitation process (fluorescence photons). The X-ray fluorescence spectrum of a sample reveals a number of characteristic peaks. The energy position of the peaks identifies the atoms present in the sample (qualitative analysis), whereas the peak intensity leads to the relative or absolute elemental composition of the sample (semi-quantitative or quantitative analysis).

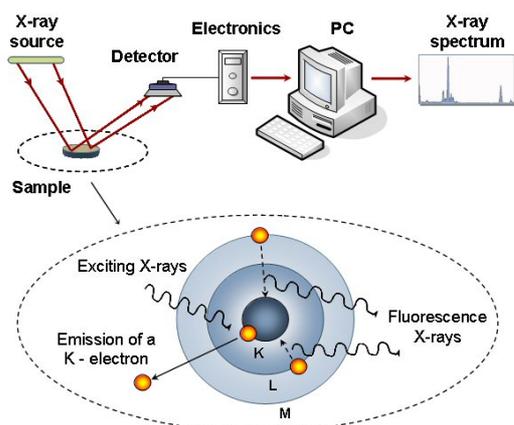


Figure 1: A schematic view of the XRF principle.

Facilities & Infrastructure

A typical XRF arrangement consists of a primary irradiation source and a detection system for moni-

toring the secondary irradiation emitted by the sample. The XRF Spectroscopy Unit (Fig. 2) includes:

- Two radioisotopic sources: Cd-109 ($T_{1/2}=1.3$ y, emitting 22.2 keV X-rays) and Am-241 ($T_{1/2}=470$ y, emitting 59.6 keV X-rays). Combined measurements with the two sources allow the detection of elements from potassium (K) to uranium (U).
- A Si(Li) detector (CANBERRA, SL80175): 5-mm-thick crystal, 80 mm² active surface area, 25- μ m-thick Be window, 171 eV resolution at 5.9 keV, liquid nitrogen cooling.
- A Si-PIN diode detector (Amptek X-123 complete X-ray spectrometer): 300- μ m-thick, 6 mm² active surface area, 12.5- μ m-thick Be window, 145 eV resolution at 5.9 keV, thermoelectrical cooling.
- A PC-based arrangement and software for data collection and analysis.
- A variety of Standard Reference Materials for calibrating the measuring setup.
- Standard laboratory equipment (grinders, mortars, sieves, furnace, balance, pellet press, freeze drier) for sample preparation.



Figure 2: A general view of the XRF Spectroscopy Unit.

Services

The XRF Spectroscopy Unit provides a range of analytical services, which typically involve major and trace elements determination in a variety of samples. Most commonly analyzed samples include:

- ❑ soils and sediments
- ❑ archaeological ceramics and glass artifacts
- ❑ synthetic organometallic compounds
- ❑ synthetic aluminosilicates, metal oxides etc
- ❑ natural water and industrial wastewater
- ❑ metals and alloys
- ❑ plant and animal tissues

Given the diversity of applications covered by the XRF technique, analyses are being requested by staff from various Departments of the University of Ioannina, while users from other Academic and Research Institutes, as well as local productive units are also interested in our services (Fig. 3).

The Unit further supports academic activities by contributing to students' education and practice, both at the undergraduate and post-graduate level.

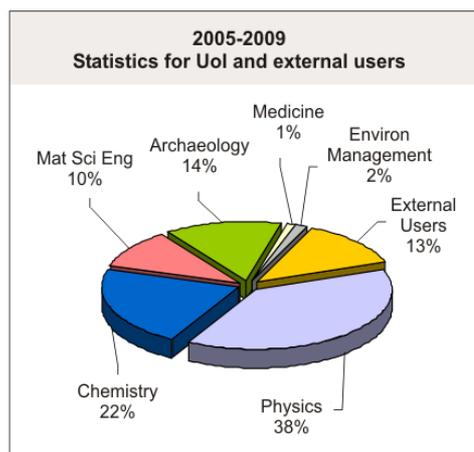


Figure 3: Statistics for University of Ioannina and external users during the period 2005-2009.

Staff & Contact Information

The XRF Spectroscopy Unit is supervised by a Scientific Committee composed of academic staff members from the University of Ioannina.

Information can be obtained by contacting:

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Representative Publications

1. C. Papachristodoulou, A. Oikonomou, K. Ioannides, K. Gravani: *A study of ancient pottery by means of X-ray fluorescence, multivariate statistics and mineralogical analysis*. *Analytica Chimica Acta* 573-574 (2006) 347-353.
2. D. Karamanis, P.A. Assimakopoulos: *Efficiency of an Al-pillared montmorillonite on the removal of cesium and copper from aqueous solutions*. *Water Research* 41 (2007) 1897-1906.
3. D. Karamanis, K.G. Ioannides, K.C. Stamoulis: *Natural radionuclides and heavy metals in bottled water in Greece*. *Desalination* 213 (2007) 90-97.
4. C. Papachristodoulou, D. Patiris, K. Ioannides: *An X-ray fluorescence method for measuring the bulk etch rate of solid state nuclear track detectors*. *Nuclear Instruments and Methods B* 264 (2007) 177-182.
5. D. Karamanis, K. Stamoulis, K. Ioannides, D. Patiris: *Spatial and seasonal trends of natural radioactivity and heavy metals in river waters of Epirus, Macedonia and Thessalia*. *Desalination* 224 (2008) 250-260.
6. D. Karamanis, K.G. Ioannides, K.C. Stamoulis: *Environmental assessment of natural radionuclides and heavy metals in waters discharged from a lignite-fired power plant*. *Fuel* 88 (2009) 2046-2052.
7. C. Papachristodoulou, K. Gravani, A. Oikonomou, K. Ioannides: *On the provenance and manufacture of late Hellenistic red-slipped fine ware from ancient Cassope (NW Greece): evidence by X-ray analytical methods*. *Journal of Archaeological Science* (2010) in press.
8. D. Gournis, C. Papachristodoulou, E. Maccallini, P. Rudolf, M.A. Karakassides, D.T. Karamanis, M.-H. Sage, T.T.M. Palstra, J.-F. Colomer, K.D. Papavasileiou, V.S. Melissas, N.-H. Gangas: *A two-dimensional magnetic hybrid material based on intercalation of a cationic PB analogue in montmorillonite nanoclay*. *Journal of Colloid and Interface Science* (2010) in press.