

# Chemical Composition of British coins investigated by X-Ray Fluorescence

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## ABSTRACT

Qualitative analysis of chemical compositions of four English coins have been performed by X-ray fluorescence (XRF) in order to find the changes according to the year of manufacture or the value of coin. Copper and iron have been found in all coins while nickel is in all except 2 pence (1998). 20 pence coins contain additionally manganese. There are no significant changes in chemical composition of 20 pence coins manufactured in 1983 and 2004. The measurements were performed with the use of MiniPal4 spectrometer by PANalytical.

## X-RAY FLUORESCENCE

X-rays are part of the electromagnetic spectrum and are expressed in terms of their energy (keV) or wavelength (nm).

In XRF, X-rays are applied to a sample material. A stable atom comprises a nucleus and the electrons orbiting it. Orbiting electrons are organized into shells: each shell is made up of electrons with the same energy. Interaction with X-ray photon can lead to photoelectric effect, in which one of the inner electrons is being removed from atom leaving unoccupied electron energy level. As a result an electron from a higher energy level falls into this space, and an X-ray photon is emitted. This X-ray photons are the source of the fluorescence.

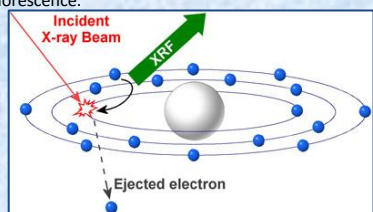


Fig.5 Scheme of X-ray fluorescence process

The energy level of atoms are very specific to each element. So the energies of the X-Rays produced in the fluorescence precisely describe which elements are present (as we can see in Fig.3).

Modern XRF instruments are capable of analyzing solid, liquid, and thin-film samples for both major and trace components. As this is not a diffraction technique, the sample materials do not need to be crystalline or ordered, but the sample must be completely homogeneous. The analysis is rapid and usually sample preparation is minimal or not required at all.

XRF analyzers are made by several components that affect their performance and capabilities. An X-ray source, known as an X-ray tube emits an X-ray beam into the sample. The resulting energy that is characteristic to the element, is emitted and collected by the detector. The type of detection system varies in each model, providing different benefits that suite a particular testing need. A last component is the software package; which is based on algorithms developed for specific applications and processes the information collected by the detection system. The resulting XRF spectrum shows intensity of X-Rays (usually in counts per second) as a function of energy (usually in eV).

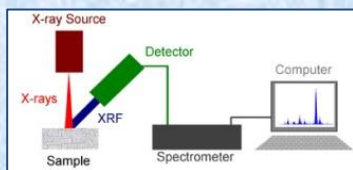


Fig.7 XRF Spectroscopy

There are two main types of XRF spectroscopy. Energy Dispersive XRF (EDXRF) and Wavelength Dispersive XRF (WDXRF), which differ primarily in the way the fluorescent X-rays are detected and analyzed.

## CONCLUSION

With the use of X-ray fluorescence, qualitative analysis of chemical composition of four British coins was performed by comparison of the XRF spectra of selected coins.

In conclusion, copper and iron have been found in all four British coins, with copper being the main component in all cases. Except in 2 pence (1998), remaining coins contain also nickel. There are some traces of manganese in both 20 pence coins; and there are no significant changes in chemical composition of 20 pence coins manufactured in 1983 and 2004.

## LITERATURE

- [1] Manual of the exercise Z22, II Pracownia Fizyczna, Uniwersytet Jagielloński
- [2] <http://xdb.lbl.gov/>

## APPARATUS

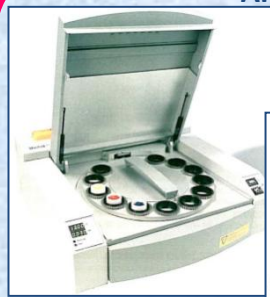
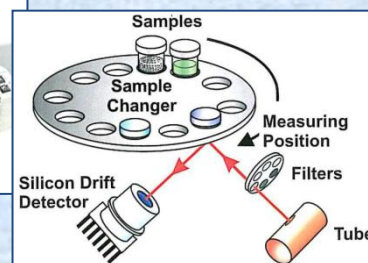


Fig.1 XRF Spectrometer used (PANalytical MiniPal4)

Fig.2 Scheme of the measuring system



## INVESTIGATED COINS



## RESULTS

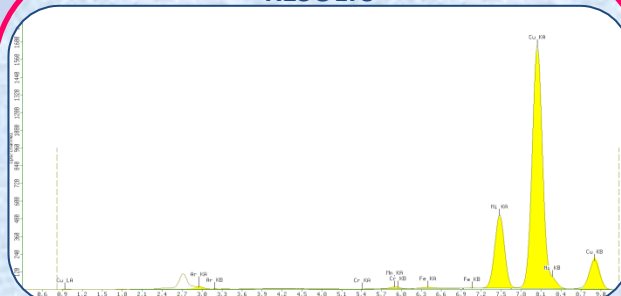


Fig.3 Final fluorescence spectrum for the 20 pence coin from 2004

Fig.4 Table with qualitative analysis of chemical composition of each coin (Intensity normalized with respect to the Cu $\alpha$  peak)

|               | Cu  | Fe   | Ni    | Mn   |
|---------------|-----|------|-------|------|
| 2 pence 1998  | 100 | 1.04 |       |      |
| 10 pence 2000 | 100 | 0.78 | 53.5  |      |
| 20 pence 1983 | 100 | 0.96 | 33.52 | 0.34 |
| 20 pence 2004 | 100 | 1.11 | 29.7  | 0.62 |