Identifying Elements in Products using X-Ray Fluorescence Spectrometry

Consumer products are increasingly made of a complex array of materials using processes that can use many different chemicals. The product may also have been treated with chemicals, for example, to make it fire retardant or stain resistant. X-ray fluorescence spectrometry (XRF) can be used to accurately measure the atomic composition of a material.

Of the atoms that make up the periodic chart of the elements some are known by themselves to be detrimental to human health. For example, lead and mercury are atomic elements that are known neurotoxins that cause brain damage and retard brain development. Chlorine is an atomic element that can be used as an indicator that a component is made of Polyvinyl Chloride (PVC) plastics. Bromine is an atomic element that can indicate the use of brominated flame retardants.

Some atomic physics:

Atoms are composed of a nucleus and electrons orbiting around the nucleus. The electrons orbit around the nucleus of each type of atom in characteristic patterns referred to as “shells.” X-rays have enough energy to knock electrons out of a shell. If an electron is extracted from an inner shell, an electron from an outer shell will move to replace it. When the electron moves from the outer shell to the inner shell, it releases energy in the form of a photon (light). The energy of the “fluorescent” photon released is distinct for each atomic element creating a measurable “fingerprint” for that element (See *Figure 1* below). The shorter their wavelength, the more energy photons have. (See electromagnetic spectrum below.)

X-Ray Fluorescence Spectrometry (XRF):

XRF technology uses an electrical x-ray tube similar to what is used in a dentist’s office, however, the x-ray tube in a handheld XRF analyzer is about 100 times less powerful. The material to be tested is placed under the handheld XRF analyzer and exposed to x-rays. The x-rays knock inner shell electrons out of the atoms causing the atoms to release their characteristic fluorescent photons. The XRF analyzer collects the fluorescent photons and creates a spectrum showing the number of fluorescent photons per second for each of the characteristic energies (see *Figure 2*, right). The spectrum is then matched to the experimentally known fingerprint for each atomic element to identify.

Figure 1: X-ray fluorescence of an atom. Incident X-rays extract a K level electron. Either K_α or K_β radiation is emitted, depending on whether the vacancy in the K shell is filled by an L or M electron.

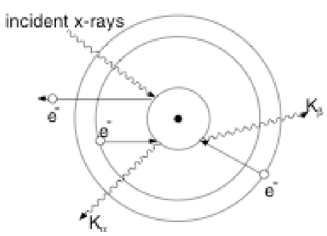
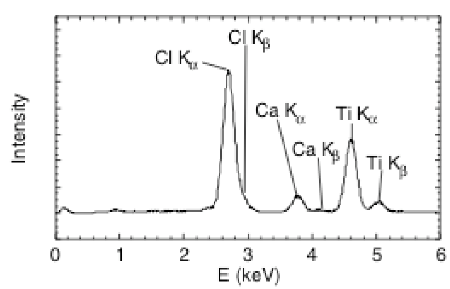
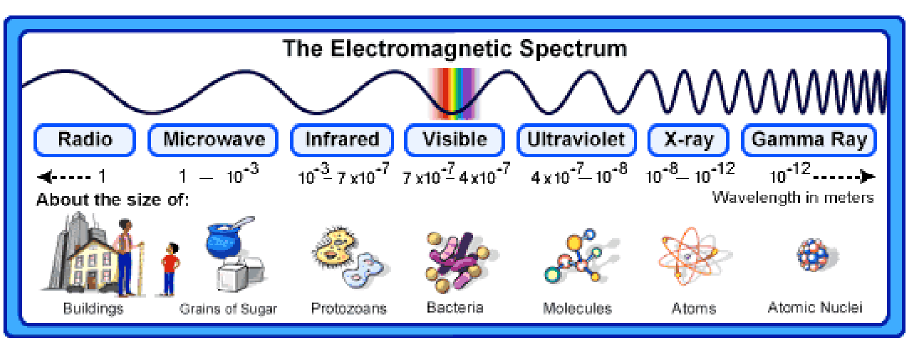


Figure 2: XRF spectrum of a plastic sample. Peaks at 2.6, 3.7 and 4.5 keV are K_α peaks for Cl, Ca and Ti, respectively.



Above Figures from: *X-Ray Fluorescence Spectroscopy in Plastics Recycling* by Riise, Biddle, and Fischer, accessed 8-06-07, www.plasticsresource.com.



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