Innovative detector to identify and sort lead-containing post-consumer PVC cables

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Abstract. A feasibility study was conducted to assess the viability of using X-ray Fluorescence (XRF) technology for the detection of lead on Polyvinyl Chloride (PVC) products. PVC is a widely used material in various industries, and concerns about lead contamination have prompted the exploration of efficient and reliable detection methods.

1. Introduction

X-ray Fluorescence (XRF) has emerged as a powerful analytical technique with wide-ranging applications, including elemental analysis in the field of plastic sorting. This paper aims to provide an overview of the fundamental principles of XRF and explore its applications in the identification and sorting of plastics based on elemental composition. The ability of XRF to rapidly and non-destructively analyse a diverse range of materials makes it an invaluable tool in the recycling industry, contributing to the efficient separation and recycling of plastic waste.

Plastic waste has become a global environmental concern, necessitating effective recycling strategies. The identification and sorting of plastics are crucial steps in the recycling process. XRF, a non-destructive analytical technique, plays a pivotal role in achieving accurate and rapid elemental analysis, contributing to the efficient sorting of plastic materials.

2. XFR basis

XRF relies on the principle of measuring the characteristic X-rays emitted when a material is exposed to high-energy X-rays. The incident X-rays displace inner-shell electrons, leading to the emission of fluorescent X-rays as electrons transition to lower energy levels. By detecting and analysing these emitted X-rays, the elemental composition of the material can be determined.

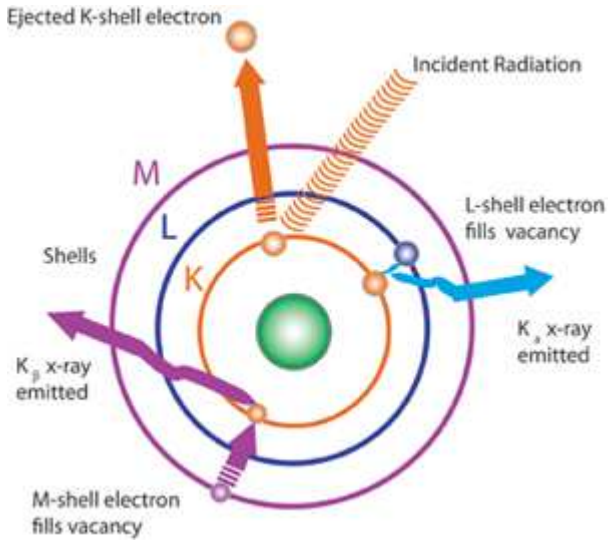

Figure 1. XRF basis

3. Instrumentation

XRF instruments for plastic sorting typically consist of an X-ray source, sample chamber, and detector. The X-ray source generates high-energy X-rays, which interact with the plastic sample. The detector

then measures the energy and intensity of the emitted fluorescent X-rays, allowing for the identification and quantification of elements present in the sample.

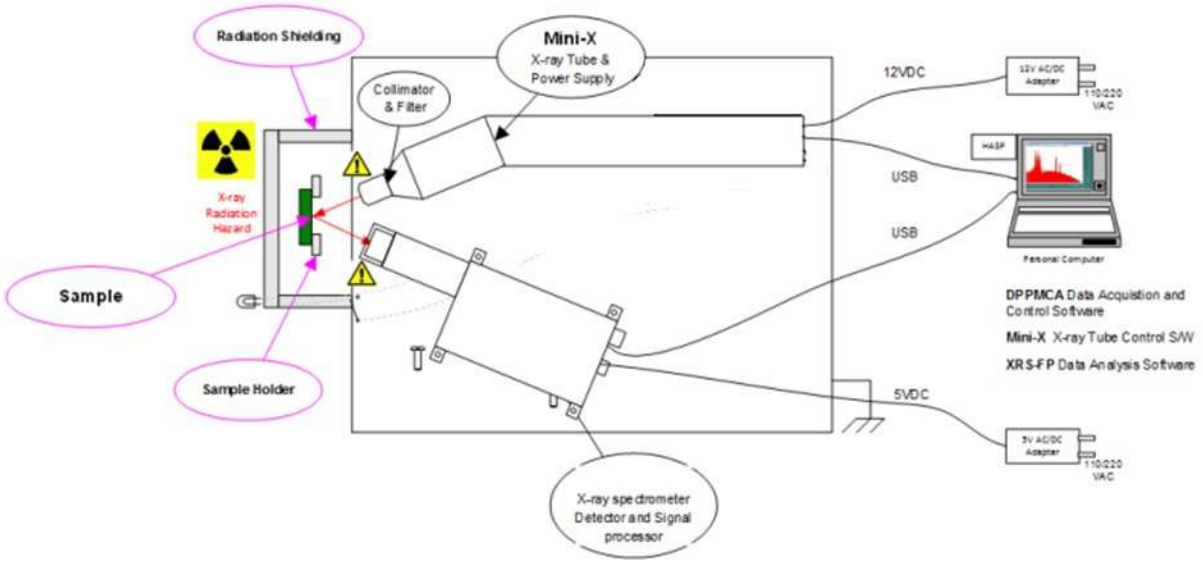

Figure 2. Typical setup instrumentation

4. Applications in Plastic Sorting

a) Polymer Identification: XRF can distinguish different polymers based on their elemental composition. This is particularly useful in sorting mixed plastic waste, where various types of polymers may be present.

b) Contaminant Detection: XRF enables the detection of trace elements or contaminants in plastics, ensuring the quality of recycled materials. Common contaminants such as heavy metals can be identified and sorted for proper disposal.

c) Quality Control: XRF facilitates quality control in the plastic recycling process by ensuring that sorted materials meet desired specifications for recycled products.

5. Objective of feasibility study

A feasibility study was conducted to assess the viability of using X-ray Fluorescence (XRF) technology for the detection of lead on Polyvinyl Chloride (PVC) products. PVC is a widely used material in various industries, and concerns about lead contamination have prompted the exploration of efficient and reliable detection methods.

During the study, we performed tests to verify the feasibility of the use of XRF technology in industrial production to detect the presence of lead (Pb) in PVC samples

The Project links partners ranging from producers, large-scale European consortiums and Industry to explore technologies for the future, taking an ambitious step beyond the current state-of-the-art.

The Project combines cutting-edge technologies for a wide range of industrial applications.

From this study, a series of information has been obtained that indicates the feasibility for the future development of an online machine that includes the following characteristics:

- detection of Pb traces in PVC products as granulates (size <10mm)
- reliability and industrial production capacity
- ease of use by moderately trained operators
- compliant with current regulations for operators' safety

The primary objective of this study was to evaluate the effectiveness of XRF in accurately detecting lead presence on PVC surfaces.
Laboratory experiments were carried out using a modified laboratory XRF facility to analyse moving PVC samples with known lead concentrations. The samples were prepared to simulate real-world scenarios. The X-Ray source emitted X-rays onto the PVC surface, and the resulting fluorescence spectra were analysed to determine the presence of lead.

6. Results

The feasibility study demonstrated that XRF is capable of detecting lead on PVC surfaces with good sensitivity and accuracy. The method provided quick and non-destructive measurements, making it suitable for production applications. The results showed the capability to distinguish sample with and without lead presence.

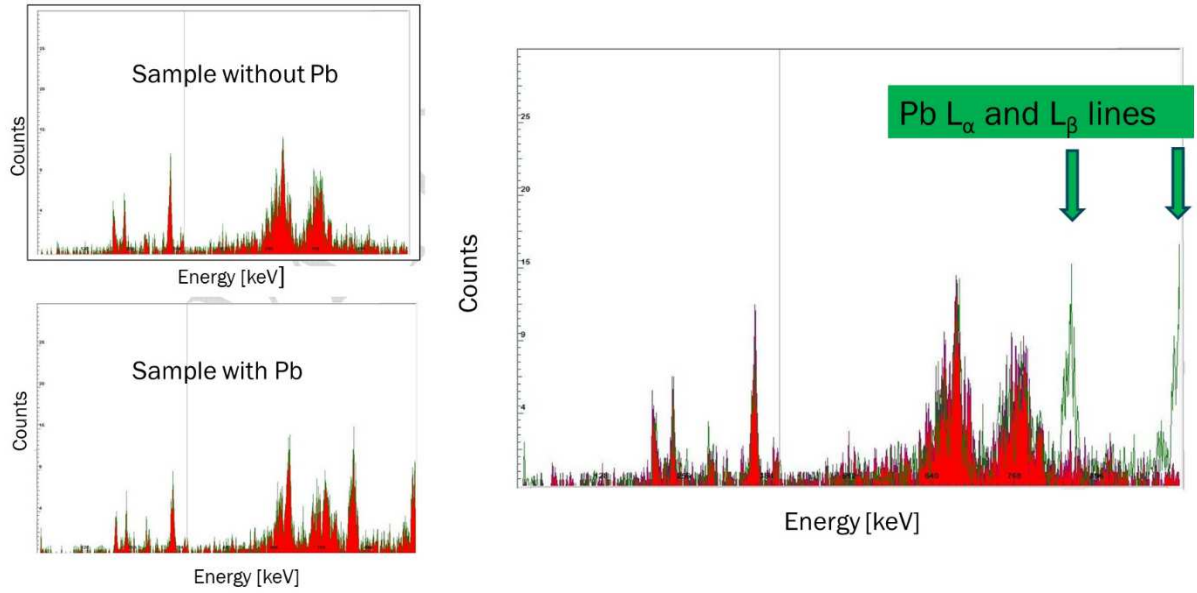

Figure 3. Comparison of the X-fluorescence spectra of PVC samples with and without lead

The advantages of using XRF for lead detection on PVC include its non-destructive nature, rapid analysis, and suitability for on-line testing. However, it is essential to consider potential limitations such as sensitivity to sample geometry, interference from other elements, and the need for proper calibration.

7. Challenges and Future Prospects

As an outcome of this study, we started a project that aims to develop and test on real production conditions a pilot plant that will be installed on an Italian recycling company.

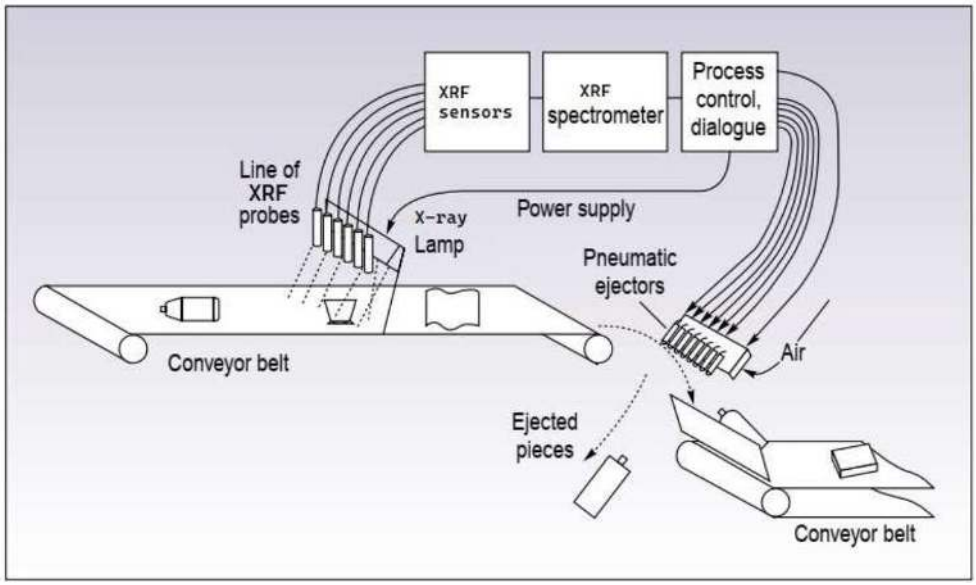

Figure 4. Schematic diagram of pilot plant