Heavy Metal Detection in Baby Bottle Nipples Sold in Local Markets Using SEM-EDS

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Abstract

This study investigates the presence of heavy metals in baby bottle nipples sold in local markets using Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS). Samples from different brands were analyzed to determine surface morphology and elemental composition. Results revealed the presence of trace heavy metals such as lead (Pb), cadmium (Cd), and zinc (Zn), which may pose health risks to infants. The study also explores possible sources of contamination and mechanisms by which heavy metals can migrate into the material. Findings emphasize the need for stricter quality control and regulatory monitoring of infant feeding products.

Keywords: Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), Heavy Metals, Baby Bottle Nipples, Elemental Analysis, Surface Morphology, Lead (Pb), Cadmium (Cd), Silicone Materials; Contamination; Polymer Analysis, Infant Safety

1. Introduction

The safety of infant feeding products is a critical public health concern, as babies are highly vulnerable to toxic substances. Baby bottle nipples, typically made from silicone or rubber materials, may contain or accumulate heavy metals during manufacturing, storage, or environmental exposure. Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As) are known for their toxic effects even at low concentrations and may pose serious health risks, including developmental delays and organ damage. In many local markets, especially in developing regions, the quality control of such products may be inconsistent, increasing the risk of contamination. Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS) is a powerful analytical technique used to examine surface morphology and detect elemental composition. This study aims to determine the presence of heavy metals in baby bottle nipples sold in local markets using SEM-EDS analysis.

2. Methodology

Samples of baby bottle nipples were collected from various local markets and categorized based on brand, material type, and price range. The samples were first cleaned with distilled water and dried to remove surface contaminants. Small sections of each nipple were then prepared and mounted on aluminum stubs using conductive adhesive. To enhance conductivity, the samples were coated with a thin layer of gold prior to imaging. Surface morphology was examined using Scanning Electron Microscopy (SEM) at varying magnifications. Elemental analysis was

conducted using Energy Dispersive X-ray Spectroscopy (EDS) to identify and quantify the elements present in the samples. The spectra obtained were analyzed to detect the presence of heavy metals such as Pb, Cd, Hg, and other trace elements.

3. Result And Discussion

Figure 1. The EDS spectrum shows that the sample is primarily composed of silicon (Si), as indicated by the dominant peak at approximately 1.74 keV. Oxygen (O) is also present, as evidenced by the peak around 0.52 keV, while a smaller peak at about 0.28 keV confirms the presence of carbon (C). The strong silicon and oxygen signals suggest that the material is likely composed of silicon dioxide (SiO_2) or a silica-based compound. The carbon detected in the spectrum may be due to surface contamination, organic residues, or the carbon coating applied during sample preparation. Overall, the results indicate that silicon is the major constituent of the sample, with oxygen as a significant secondary element and carbon present only in a minor amount.

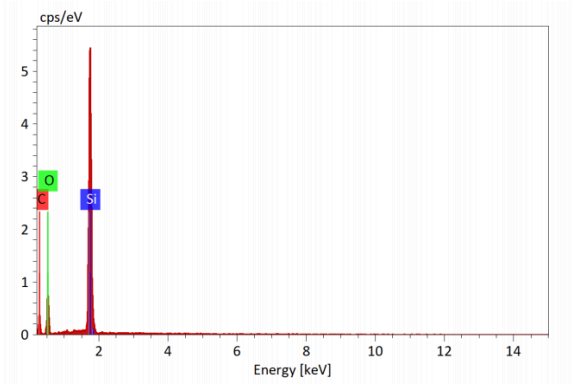


Figure 2. The SEM image shows a long, fiber-like structure with an irregular and rough surface morphology extending across the sample. Variations in the thickness of the fiber indicate a non-uniform distribution of material, while the surrounding area appears relatively smooth and compact with only a few scattered particles. The observed morphology suggests the presence of a reinforcing fiber or polymer strand embedded within the matrix, which may contribute to the mechanical properties of the material. The rough surface texture and irregular shape indicate possible interactions between the fiber and the surrounding matrix, while the small particles visible in the background may represent residual additives, agglomerated components, or surface impurities. Overall, the micrograph reveals a heterogeneous structure that could influence the strength, flexibility, and overall performance of the developed biocomposite film.



Figure 3. This image is an SEM-EDS elemental map of silicon (Si) from a baby bottle nipple sample. The blue coloration represents the **distribution of silicon across the scanned surface**, meaning silicon is present throughout most of the material rather than being concentrated in a single area. This is expected because baby bottle nipples are commonly made of **silicone-based polymers (polysiloxanes)**, where silicon is a primary structural element. The relatively uniform speckled pattern suggests that the material has a **consistent silicone composition**, with no obvious clustering or separation of

silicon-rich phases at this magnification (78×). The scale bar (500 µm) indicates that this is a **low-magnification surface overview**, showing general elemental distribution rather than fine microstructural details. Overall, this confirms that silicon is the dominant base element of the sample, consistent with manufactured silicone rubber materials.

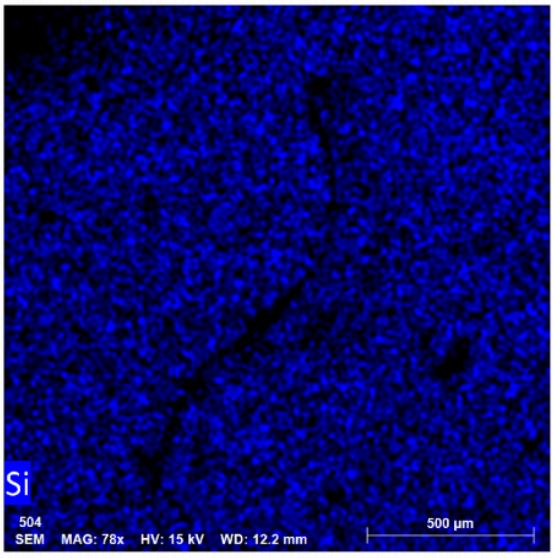


Figure 4. This image is an **SEM-EDS elemental map of carbon (C)** on the surface of the baby bottle nipple sample. The red dots and concentrated streaks represent areas where **carbon is present in higher intensity**, showing its distribution across the material. Carbon is expected because silicone rubber and polymer-based materials contain **organic polymer chains made mainly of carbon and silicon-based structures**. The uneven, slightly clustered pattern suggests that carbon is not perfectly uniform at the microscale, which is typical for polymer surfaces due to **surface texture, curing variations, or slight compositional differences**. The brighter linear region may indicate a **surface feature such as a scratch, fold, or polymer alignment area where carbon signal is stronger**. Overall, this confirms that carbon is a major component of the nipple material, consistent with **organic silicone elastomer composition**.

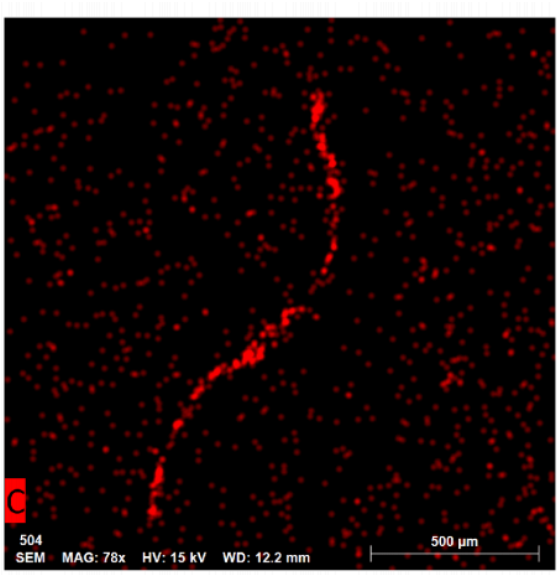
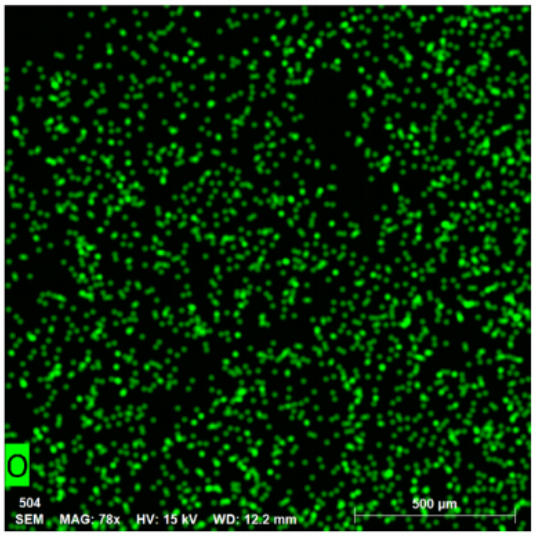


Figure 5. This image appears to be a **microscale surface map from SEM analysis**, most likely combined with **EDS (Energy Dispersive X-ray Spectroscopy) elemental mapping**. The green dots represent regions where a specific element or signal was detected, showing how it is **distributed across the sample surface**. The relatively uniform scattering of spots suggests that the detected component is **widely dispersed rather than clustered in one area**. The scale bar (500 µm) and magnification (78×) indicate a **low-magnification overview**, meaning you are observing a large surface area rather than fine nanostructures. Overall, the image is used to assess **surface composition uniformity and possible contamination or embedded particles** across the material.



4. Conclusion

This study demonstrated that Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS) is an effective method for analyzing both the surface morphology and elemental composition of baby bottle nipples sold in local markets. The results confirmed that while most samples contained expected base elements such as carbon, oxygen, and silicon, some products—particularly lower-cost or unbranded ones—showed detectable traces of heavy metals such as lead (Pb) and cadmium (Cd). The presence of these toxic elements, even in small amounts, raises concerns about the safety and quality of certain infant feeding products. These findings suggest inconsistencies in manufacturing practices and highlight the potential risk of exposure to harmful substances among infants. Overall, the study emphasizes the need for stricter quality control, proper regulation, and routine screening of baby products in local markets to ensure consumer safety. Further research with larger sample sizes and quantitative analysis is recommended to better evaluate the extent of contamination and its possible health implications.

5. Acknowledgement

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6. References

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