

REVIEWER'S REPORT

Manuscript No.: IJAR- 59479

Title: Influence of Filter Morphology on Pyrolysis Mass Spectral Response,

Recommendation:

Accept after minor revision

Rating	Excel.	Good	Fair	Poor
Originality		✓		
Techn. Quality			✓	
Clarity			✓	
Significance	✓			

Reviewer's ID: Bilqees Hamza

Detailed Reviewer's Report

General Overview

This manuscript presents an empirical investigation into how the physical morphology of sample collection filters influences simulant distribution and subsequent pyrolysis mass spectral response in an infrared (IR) laser-driven military biological detection system. Using sucrose as a nonpathogenic biological simulant, the study compares two original filter variants (Type A with a central ejector hole and an open surface network vs. Type B with no central hole and a denser surface structure) alongside a newly manufactured "Modified" filter designed to replicate Type B morphology.

The primary metric evaluated is the peak-height ratio of m/z 123 to m/z 95, a spectral indicator critical to the automated biological classification algorithm of the detector. The empirical findings show statistically significant and meaningful differences across the three filter groups ($N=10$ per group, Kruskal-Wallis $H(2)=23.907$, $p<0.001$). Type A filters promoted deeper internal penetration of the simulant, resulting in lower median peak-height ratios (2.31%) and repeated classification failures (misidentifications). Conversely, Type B (9.73%) and Modified filters (12.85%) retained the simulant predominantly on the surface, yielding higher peak-height ratios and 100% correct classification.

The paper is well-written, logically organized, and addresses a critical engineering problem in analytical pyrolysis mass spectrometry. The statistical methodology (exact permutation tests, Holm multiple-testing adjustments, and Cliff's delta effect sizes) is rigorous. Minor revisions are required to improve figure

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references, clarify heat transfer mechanisms, and standardize minor textual elements prior to final publication.

Key Strengths

- Practical Engineering Significance:** The manuscript identifies an overlooked physical cause for instrument misclassification—filter morphology and simulant penetration depth—offering actionable insights for troubleshooting thermal desorption and pyrolysis mass spectrometry detection systems.
- Methodological and Statistical Rigor:** The experimental design includes exact non-parametric tests (Kruskal-Wallis and Mann-Whitney U via full permutation enumeration), multiple testing corrections (Holm method), and non-parametric effect sizes (Cliff's delta).
- Validation Through Design Iteration:** The inclusion of a third experimental group ("Modified filters") constructed intentionally to mirror Type B morphology successfully proves causality and demonstrates process reproducibility.
- Clear Visual Evidence:** Optical micrographs and cross-sectional images clearly demonstrate the difference in simulant surface retention versus deep substrate penetration between Type A and Type B filters.

Recommendations for Improvement

While the study is technically sound and well-argued, the authors should make the following minor adjustments before publication:

- Fix In-Text Table Citation in Section 3.2:**

In Section 3.2 (line 156), the text refers to "Table 1" as listing the individual peak heights and peak-height ratios for Type A and Type B filters. However, there is another "Table 1" in Section 2025/Rainbo data if looking across standard layouts, or a numbering overlap. Ensure all table numbers in the main text match their respective captions sequentially throughout the manuscript (e.g., Table 1 for Type A/B, Table 2 for Modified filters, Table 3 for Pairwise stats).

- Elaborate on the Thermal Degradation Mechanism:**

In Section 4 (Discussion), the authors state that deeper penetration alters heat transfer and pyrolysis time-temperature history. Adding a brief sentence explaining *why* deeper penetration reduces the m/z 123 peak relative to m/z 95 (e.g., lower effective surface irradiance from the IR laser leading to incomplete secondary pyrolytic conversion into 2,5-furandicarboxaldehyde) would strengthen the physical chemistry discussion.

- Clarify Sample Size and Generalizability Limitations:**

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While $n=10$ filters per group is sufficient for non-parametric statistical significance given the complete group separation ($\Delta = -1.00$), the authors should explicitly state in the Discussion that testing was limited to a single nonpathogenic simulant (sucrose). Brief mention of how complex biological matrixes (e.g., bacterial endospores or proteinaceous aerosols) might behave on these porous media would add valuable perspective.

4. Minor Editorial Polish:

- Ensure consistency in sub-heading numbering and font sizes across Sections 2, 3, and 4.
- Verify that all software versions and statistical package references (e.g., Python 3.12, SciPy, statsmodels) maintain uniform formatting throughout Section 2.5.

Final Evaluation and Verdict

This manuscript presents an impactful, well-supported investigation into the role of sampling media morphology in pyrolysis mass spectrometry. The scientific reasoning is sound, the experimental data are convincing, and the statistical execution is rigorous.

The manuscript is **accepted with minor revisions**. Addressing the minor editorial cleanup, table citation numbering, and thermal mechanism elaboration requested above will ensure the paper is fully ready for publication.