

# Investigations into the Contribution of Lactic Acid to Acetaldehyde Formation during E-Vapor Aerosol Generation Using a Model Reaction System

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## Abstract

Electronic cigarette aerosols may contain carbonyl compounds formed via thermal degradation of e-liquid components. While acetaldehyde formation is typically attributed to propylene glycol and glycerin degradation, recent studies suggest organic acids such as lactic acid may also contribute.<sup>1</sup> This study evaluated the potential of lactic acid to form acetaldehyde using a microwave-based model reaction system designed to simulate aerosol generation conditions.<sup>2</sup> E-liquids containing lactic acid and <sup>13</sup>C<sub>3</sub>-labeled lactic acid were thermally treated and analyzed for acetaldehyde and isotopically labeled products. Detection of <sup>13</sup>C<sub>3</sub>-acetaldehyde in labeled samples demonstrates that lactic acid does act as a direct precursor to acetaldehyde under microwave reaction conditions. While lactic acid was confirmed as a precursor to acetaldehyde formation using this model system, resulting acetaldehyde levels remained approximately 99% lower per puff than those observed in cigarette smoke.

## Introduction

- Carbonyl formation in e-vapor aerosols is well established, with acetaldehyde commonly attributed to PG/GLY degradation<sup>3</sup>
- Emerging literature suggests the organic acid, lactic acid, may contribute to acetaldehyde formation, yet direct experimental confirmation of this mechanism remains limited<sup>1</sup>

**Objective:**  
Evaluate whether lactic acid directly contributes to acetaldehyde formation using a microwave-based model reaction system and stable isotope-labeled lactic acid to trace the source of the reaction products

## Methods

- Model e-liquid formulations:
  - 45% PG, 45% VG, 4% Nicotine, 2.5% Water, 3% Lactic Acid
  - Equivalent formulation with <sup>13</sup>C<sub>3</sub>-labeled lactic acid (isotopic tracer)
- Model Reaction System:
  - Microwave-based, model reaction system, optimized (125 °C, 1 min hold) to simulate aerosol thermal reaction conditions<sup>2</sup>
  - Microwave reaction conditions were selected to produce acetaldehyde yields comparable, on an aerosol mass basis, to those generated by a pod-based prototype research device delivering approximately 8 mg aerosol mass per puff under CORESTA CRM 81 (50-puff) conditions
- LC-MS/MS Analysis
  - Quantification of acetaldehyde
  - Detection of <sup>13</sup>C<sub>3</sub>-acetaldehyde for source tracking

## Results

- Key finding:**
- Under the conditions of this study, approximately 76% of acetaldehyde formed was derived from lactic acid, based on isotopic labeling
  - Detection of <sup>13</sup>C<sub>3</sub>-acetaldehyde confirms carbon transfer from lactic acid
  - Results demonstrate that lactic acid can contribute meaningfully to acetaldehyde formation pathways in a microwave model system

## Conclusion

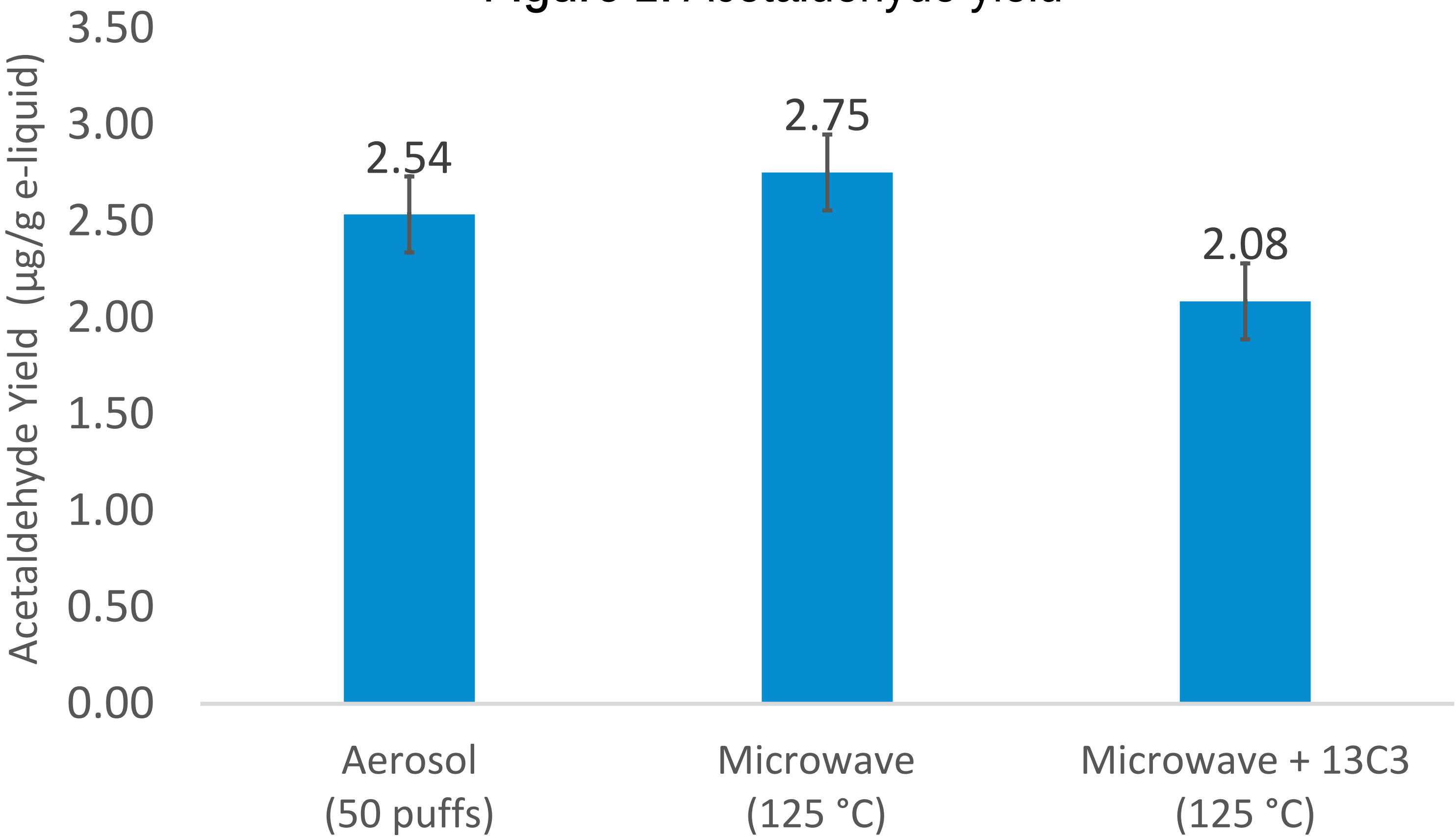
- Lactic acid contributes directly to acetaldehyde formation when model e-liquid is heated under microwave reaction conditions chosen to replicate typical acetaldehyde levels in e-vapor aerosols
- <sup>13</sup>C-labelling confirms direct carbon incorporation from lactic acid carbons into acetaldehyde
- Despite this contribution, overall acetaldehyde levels in the conditions tested here remain substantially lower-often ~99% lower per puff than in cigarette smoke, e.g., 0.022 µg/puff for the aerosol here (2.54 µg/g X 8.615 mg AM/puff \*1/1000) versus 48.7 µg/puff for a 1R6F reference cigarette
- This precursor study (and prior) serves as a model approach to studying e-vapor aerosol constituent formation

## References

1. Harris, T. Physical and Chemical Characterization of Aerosols Produced from Experimentally Designed Nicotine Salt-Based ELiquids. *Chem. Res. Toxicol.* 2024, 37 (8), 1315-1328.
2. Melvin, M.S. et al. Formation of Diacetyl and Other α-Dicarbonyl Compounds during the Generation of E-Vapor Product Aerosols. *ACS Omega* 2020, 5 (28), 17565-17575
3. Bekki, K., Uchiyama, S.; Ohta, K.; Inaba, Y.; Nakagome, H.; Kunugita, N. Carbonyl Compounds Generated from Electronic Cigarettes. *International Journal of Environmental Research and Public Health* 2014, 11 (11), 11192-11200

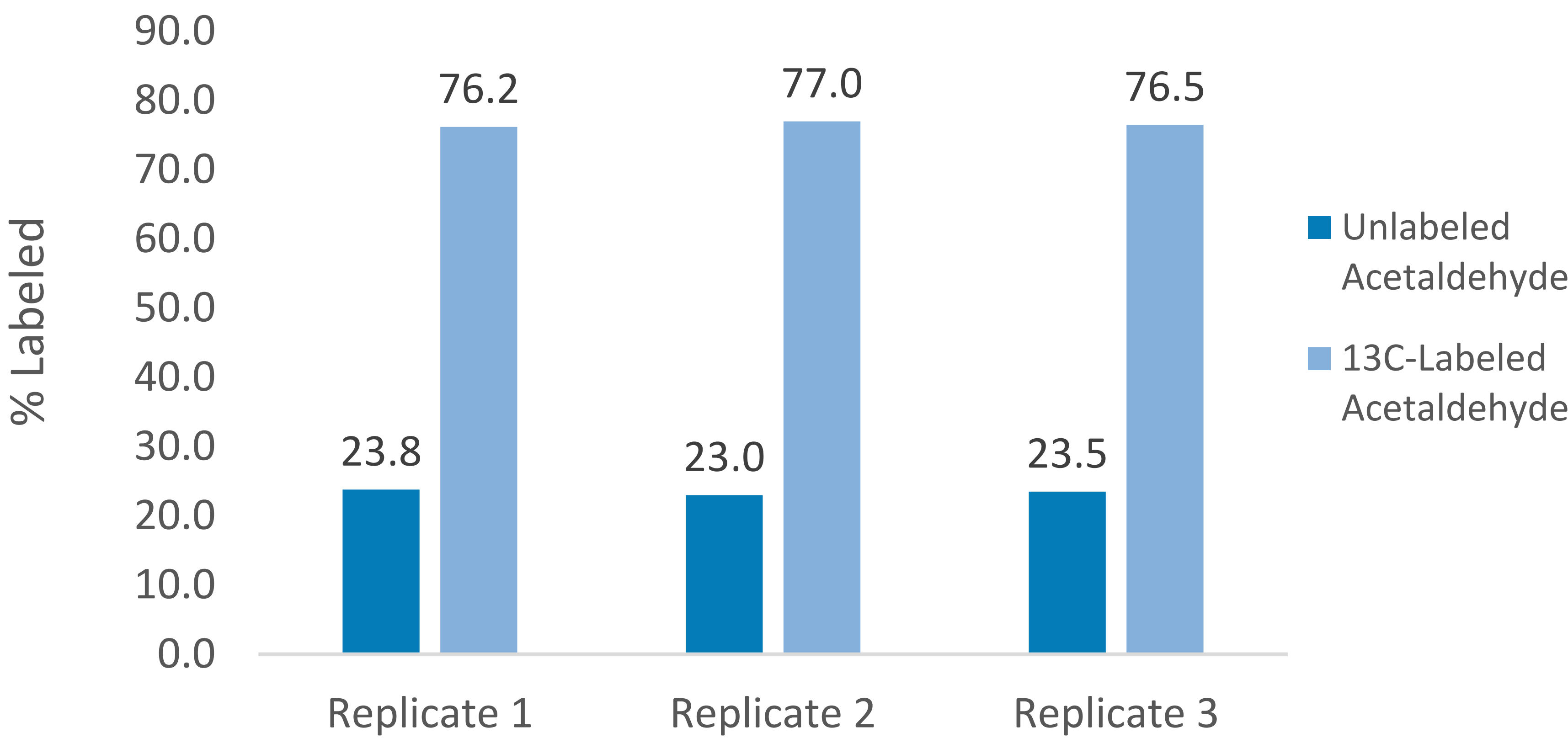
Isotopic labeling demonstrates that lactic acid is a direct precursor to acetaldehyde formation under microwave reaction conditions representative of e-vapor aerosol formation.

Figure 1: Acetaldehyde yield



Acetaldehyde yields from aerosol generation and microwave model reaction system under comparable conditions.

Figure 2: Relative isotopic composition of acetaldehyde



Relative isotopic composition of acetaldehyde formed from <sup>13</sup>C<sub>3</sub>-lactic acid, confirming incorporation of labeled carbon into acetaldehyde.

