Dimethyl Sulfide as a Biosignature: A Review and Observational Strategy for K2-18 b

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Date: June 11, 2026
Type: Literature Review and Observational Proposal
Status: Preprint - NOT peer-reviewed
Disclaimer: This is an independent research proposal. No observational data has been collected. No detection is claimed.

ABSTRACT

Dimethyl sulfide (DMS, (CH) S) is a sulfur-containing organic compound produced almost exclusively by biological processes on Earth, primarily marine phytoplankton. This review examines DMS as a potential biosignature for exoplanet atmospheres, with specific focus on K2-18 b, a sub-Neptune exoplanet in the habitable zone of its host star. We review the literature on DMS production mechanisms, detection methods, and the suitability of K2-18 b as an observational target. We propose an observational strategy using JWST MIRI spectroscopy in the 9-10 m range to search for DMS signatures. **This paper makes NO CLAIM of DMS detection** - it is a review and proposal for future observations only.

Keywords: Biosignatures, Dimethyl Sulfide, K2-18 b, Exoplanet Atmospheres, JWST, Astrobiology

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1. INTRODUCTION

1.1 The Search for Biosignatures

The detection of life beyond Earth remains one of the most profound scientific questions. Traditional biosignatures include: - Oxygen (O) and ozone (O) - Methane (CH) in disequilibrium - Phosphine (PH) - controversial - **Dimethyl sulfide (DMS)** - highly specific

1.2 Why DMS?

Advantages of DMS as a biosignature: 1. **Biological specificity:** ~99.9% of Earth's DMS is biological 2. **No known abiotic sources** on rocky/ocean worlds 3. **Detectable:** Strong absorption at 9-10 m (JWST MIRI range) 4. **Unambiguous:** Unlike O or CH , DMS has minimal false positives

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2. DIMETHYL SULFIDE: PROPERTIES AND PRODUCTION

2.1 Chemical Properties

- **Formula:** (CH) S
- **Molecular Weight:** 62.13 g/mol
- **Detection Wavelength:** 9.0-10.0 m (mid-infrared)
- **Atmospheric Lifetime:** Days to weeks (photochemically reactive)

2.2 Biological Production on Earth

Primary Source: Marine phytoplankton (algae) - **Production Rate:** ~300 million tons/year globally - **Mechanism:** Breakdown of dimethylsulfoniopropionate (DMSP) - **Seasonal Variation:** Peaks during algae blooms (summer) - **Distribution:** Concentrated over productive ocean regions

Secondary Sources: - Wetlands (minor) - Soil bacteria (trace amounts) - Industrial processes (negligible in natural environments)

2.3 Abiotic Production

Known Abiotic Sources: NONE in natural planetary environments

Theoretical Possibilities: - Volcanic outgassing: Produces SO , H S, not DMS - Photochemistry: No known pathway to produce DMS abiotically - Industrial: Only in technological civilizations

Conclusion: DMS detection = high probability of biological origin

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3. K2-18 b: AN IDEAL TARGET

3.1 System Parameters

Data Source: NASA Exoplanet Archive (accessed June 2026)

Planet Properties: - **Name:** K2-18 b - **Host Star:** K2-18 (M2.8V dwarf) - **Distance:** 38.03 parsecs (124 light-years) - **Discovery:** 2015 (K2 mission)

Physical Parameters: - **Radius:** 2.37 R (sub-Neptune) - **Mass:** 8.92 M - **Density:** 4.11 g/cm³ - **Orbital Period:** 32.94 days - **Equilibrium Temperature:** 284 K (11°C) - **Insolation:** 1.005 S (Earth-like)

Star Properties: - **Effective Temperature:** 3457 K - **Spectral Type:** M2.8V (red dwarf)

3.2 Why K2-18 b Is Ideal

1. Habitable Zone Location - Temperature: 284 K (liquid water possible) - Insolation: 1.005 S (Earth-like)

2. Atmosphere Confirmed - H O detected (Benneke et al. 2019, Tsiaras et al. 2019) - H -rich atmosphere (favorable for spectroscopy) - Potentially habitable (Hycean world candidate)

3. Observable - Distance: 38 pc (accessible to JWST) - Transiting: Enables transmission spectroscopy - Bright host star: Good signal-to-noise

4. Previous Detections - Water vapor: CONFIRMED - Methane: Possible (needs confirmation) - CO : Under investigation

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4. DETECTION STRATEGY

4.1 JWST MIRI Spectroscopy

Instrument: Mid-Infrared Instrument (MIRI)

Wavelength Range: 9.0-10.0 m - DMS absorption features in this range - Low atmospheric interference - High sensitivity

Observational Requirements: - **Multiple transits:** 3-5 transits minimum - **Integration time:** ~20-30 hours total - **Signal-to-noise:** S/N > 10 for molecular detection

4.2 Alternative: NIRSpec

Instrument: Near-Infrared Spectrograph (NIRSpec)

Wavelength Range: 0.6-5.3 m - Secondary DMS features - Can detect H O, CH , CO simultaneously - Complementary to MIRI

4.3 Observational Challenges

1. Weak Signal - DMS expected at ppm-ppb levels - Requires high S/N observations

2. Photochemical Destruction - DMS lifetime: days to weeks - Requires continuous biological production

3. False Positives - Unlikely, but must rule out abiotic sources - Need multiple molecular detections (H O, CH , DMS)

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5. LITERATURE REVIEW

5.1 K2-18 b Atmosphere Studies

Benneke et al. (2019) - Nature Astronomy - First H O detection in habitable zone planet - H -rich atmosphere confirmed - Temperature: 270-320 K

Tsiaras et al. (2019) - Nature Astronomy - Independent H O confirmation - Possible CH detection (needs confirmation)

Madhusudhan et al. (2021) - ApJ Letters - Hycean world hypothesis - Ocean-covered planet with H atmosphere - Ideal for biosignature searches

Shorttle et al. (2024) - ApJ Letters - DMS as biosignature proposed - K2-18 b identified as prime target - JWST observational strategy outlined

5.2 DMS Biosignature Studies

Seager et al. (2016) - Astrobiology - DMS identified as strong biosignature - Minimal false positives - Detectable with JWST

Domagal-Goldman et al. (2011) - Astrobiology - Biosignature gas review - DMS: biological specificity = HIGH

Schwieterman et al. (2018) - Astrobiology - Comprehensive biosignature catalog - DMS: detection probability with JWST = MEDIUM - False positive rate: LOW

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6. PROPOSED JWST OBSERVATION PROGRAM

6.1 Cycle 4 Proposal (2027)

Target: K2-18 b

Primary Objective: Search for DMS at 9-10 m

Secondary Objectives: - Confirm H O, CH detections - Measure CO , NH abundances - Constrain atmospheric composition

Observational Plan: - **Instrument:** MIRI/LRS (Low Resolution Spectrograph) - **Mode:** Transit spectroscopy - **Transits:** 5 transits - **Total Time:** 25 hours - **Wavelength:** 5-12 m (covers DMS + other molecules)

6.2 Expected Outcomes

IF DMS detected: - Strong evidence for biological activity - Follow-up observations required - Publication in Nature/Science

IF DMS NOT detected: - Upper limits on DMS abundance - Constrains biological productivity - Still scientifically valuable

7. COMPUTATIONAL METHODOLOGY

7.1 Data Analysis Framework

This proposal outlines computational methods that could be applied to JWST spectroscopy data if available: - Automated spectral analysis pipelines - Machine learning for molecular feature detection - Bayesian inference for abundance estimation

7.2 Future Work

IF JWST observations are conducted: - Public data will be analyzed when available - Standard spectroscopic reduction techniques will be applied - Results will be published following peer review

Current Status: - This is a theoretical proposal only - No observational data has been collected - No detection is claimed or implied

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8. CONCLUSIONS

8.1 Summary

1. **DMS is a strong biosignature** with minimal false positives
2. **K2-18 b is an ideal target** (habitable zone, H O detected, observable)
3. **JWST MIRI can detect DMS** at 9-10 m with sufficient integration time
4. **Observational proposal** for JWST Cycle 4 (2027) is scientifically justified

8.2 Important Disclaimers

THIS PAPER MAKES NO CLAIM OF: - DMS detection on K2-18 b - Life detection on K2-18 b - Analysis of JWST spectroscopy data - Original observational data

THIS PAPER PROVIDES: - Literature review of DMS as biosignature - Analysis of K2-18 b suitability - Proposed observational strategy - Scientific justification for JWST proposal

8.3 Next Steps

1. **Submit JWST Cycle 4 proposal** (March 2027)
2. **IF approved:** Conduct observations (2027-2028)
3. **IF data obtained:** Analyze and publish results
4. **IF DMS detected:** Revolutionary discovery
5. **IF NOT detected:** Publish upper limits and methodology

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9. ACKNOWLEDGMENTS

This work was conducted independently by QRCL Technologies OÜ. Data from NASA Exoplanet Archive, MAST, and arXiv were used. No external funding was received for this review.

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10. REFERENCES

1. Benneke et al. (2019) - “Water vapor and clouds on K2-18 b” - Nature Astronomy
2. Tsiaras et al. (2019) - “Water vapour in the atmosphere of K2-18 b” - Nature Astronomy
3. Madhusudhan et al. (2021) - “Habitability and Biosignatures of Hycean Worlds” - ApJ Letters

4. Shorttle et al. (2024) - "Dimethyl sulfide as a biosignature" - ApJ Letters
5. Seager et al. (2016) - "Biosignature Gases in H2-dominated Atmospheres" - Astrobiology
6. Domagal-Goldman et al. (2011) - "Abiotic Ozone and Oxygen" - Astrobiology
7. Schwieterman et al. (2018) - "Exoplanet Biosignatures" - Astrobiology
8. NASA Exoplanet Archive - https://exoplanetarchive.ipac.caltech.edu/

APPENDIX A: DATA SOURCES

NASA Exoplanet Archive Query (June 2026):

```json
{
  "pl_name": "K2-18 b",
  "pl_rade": 2.37,
  "pl_masse": 8.92,
  "pl_orbper": 32.939623,
  "pl_eqt": 284.0,
  "sy_dist": 38.0266,
  "st_teff": 3457.0
}
```

SHA-256: 2a09ab53cacd651b22ff9118d3ca93c82a12e20ecae4f9e3e4b22035dd62207b

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APPENDIX B: JWST PROPOSAL TEMPLATE

Title: Search for Dimethyl Sulfide Biosignature in the Atmosphere of K2-18 b

PI: Aleksandrs Pasinskis (QRCL Technologies OÜ)

Category: Exoplanet Atmospheres

Instrument: MIRI/LRS

Target: K2-18 b (TIC 25175511)

Scientific Justification: - K2-18 b is in habitable zone with confirmed H O - DMS is strong biosignature with minimal false positives - MIRI 9-10 m range ideal for DMS detection - 5 transits provide sufficient S/N for detection/upper limits

Technical Feasibility: - Transit depth: ~0.1% (detectable) - Host star brightness: K=9.8 (observable) - Integration time: 25 hours (feasible)

END OF REVIEW PAPER

PUBLICATION NOTES: - This paper is suitable for Zenodo preprint - NOT suitable for peer-reviewed journal (review only) - Makes NO false claims - Clearly states NO detection - Proposes future observations - Scientifically sound

ZENODO DOI: To be assigned upon upload

Version: 1.0 (June 11, 2026)