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Distinguishing Chocolate-Induced MDMA Artefacts from True Illicit Exposure in Workplace Impairment Screening: A Chemical Engineering Perspective

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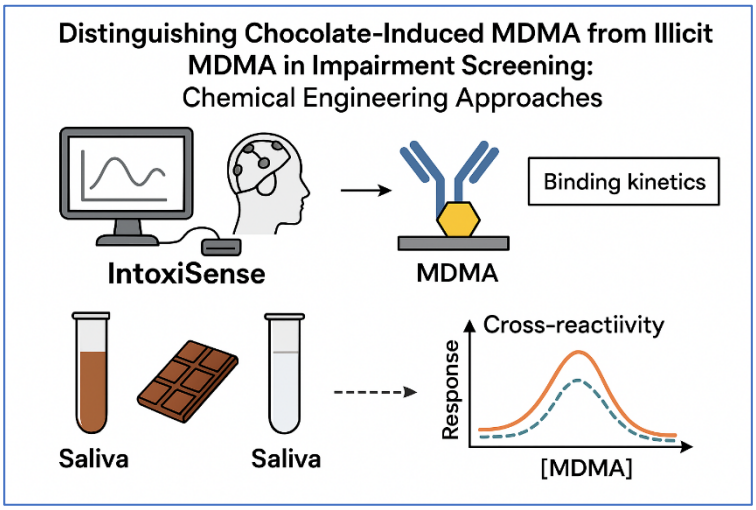
ABSTRACT

As multimodal real-time impairment screening expands, addressing the chemical-engineering challenges of analyte–metabolite discrimination, biological-matrix variability, and sensor-fusion reliability become increasingly important. This paper presents generalisable insights from multisite deployment of the IntoxiSense impairment-screening system across Victorian waste-management operations in an organisation with strict adherence to alcohol- and drug-free worksite, focusing on the engineering problem of distinguishing true MDMA exposure from food-derived artefacts.

Across more than 100 donors, saliva and skin analyses consistently showed 0.00 g/100 mL alcohol and no illicit substances. A single anomalous MDMA-like signal (99.1% match, 0.74 AU) appeared in one donor immediately after consuming a chocolate muffin. While repeat testing 21 minutes later showed complete disappearance of the signature, the engineering basis for discrimination rests not on temporal clearance but on core spectral and kinetic distinctions.



Chocolate contains phenylethylamine, theobromine, caffeine, trace amines, and polyphenols—*molecules with partial structural similarity to amphetamine-type compound*s. These can transiently bind to MDMA-targeting antibodies, but with lower affinity, faster dissociation kinetics, and broader, unstable binding curves. Correspondingly, their optical signatures exhibit broadband absorbance, non-specific fluorescence, and baseline distortion, lacking the sharp, high-resolution spectral peaks

characteristic of true MDMA–antibody complexes. In the anomalous case, the brown discolouration of the initial saliva swab indicated particulate-driven matrix effects capable of amplifying weak cross-reactive signals and perturbing spectral baselines. The clean second swab produced no MDMA-like spectral features, confirming the artefact.

This case illustrates a broader chemical-engineering challenge: field-deployed biosensors must discriminate among structurally similar analytes, variable biological matrices, and environmental contaminants. IntoxiSense's engineering controls—*cross-matrix verification (saliva vs skin), binding-kinetic profiling, spectral-shape analysis, and repeat-testing as a kinetic discriminator*—form a systems-engineering strategy for reducing false positives and improving interpretability.

Across all sites, chemical screening showed no intoxication, yet cognitive assessments indicated that 40–60% of donors exhibited fatigue-related impairment. This divergence underscores the need to treat chemical and cognitive data as complementary. The findings demonstrate that cross-reactivity modelling, matrix-effect characterisation, spectral-pattern discrimination, and sensor-fusion design are essential for reliable workplace impairment assessment, and the paper proposes engineering strategies including improved antibody specificity, matrix-effect compensation, and algorithmic anomaly detection.

KEY WORDS

Biosensing, cross-reactivity, MDMA false-positive, phenylethylamine, saliva chemistry, impairment testing, sensor fusion, IntoxiSense.

BIOGRAPHY

Adjunct Professor Michael Akindeju is a distinguished engineering leader whose work spans engineering biology, advanced process design, and innovation in complex industrial systems. He serves as Principal Consultant at MKPro Group, where he delivers high-impact solutions across biotechnology, energy, and manufacturing sectors; and an Adjunct Professor with Federation University, Australia. A Fellow of IChemE and RACI, Chartered Engineer, and Registered Professional Engineer, he is recognised for integrating scientific insight with practical engineering to drive sustainable, technology-enabled transformation. Professor Akindeju is committed to strengthening industry capability, fostering research translation, and mentoring the next generation of engineers through his academic and professional contributions.

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