

Addressing Calibration Transfer in Electronic Noses for Urine Headspace Analysis through Synthetic Reference Samples and Advanced Feature Extraction

Laura Capelli

*Politecnico di Milano, Department of Chemistry, Materials and Chemical Engineering "Giulio Natta"
Piazza Leonardo da Vinci 32, 20133 Milano*

laura.capelli@polimi.it

Abstract:

The widespread adoption of electronic noses (e-Noses) in biomedical applications is hindered by sensor-to-sensor variability, which requires each individual device to be calibrated separately. This limitation severely affects system scalability and becomes particularly critical when dealing with biological samples such as human urine, whose collection, storage, and standardization are inherently challenging.

This work presents a methodological framework to address calibration transfer e-Nose devices based on Metal-Oxide (MOX) sensors for urine headspace analysis. The proposed approach relies on Direct Standardization (DS), a transfer learning technique requiring the measurement of reproducible transfer samples on both "master" and "slave" devices. For this purpose, synthetic urine formulations were specifically developed starting from literature data on urine volatile composition, with the objective of reproducing representative urine headspace characteristics while ensuring high repeatability and availability. These synthetic standards were then used to support the transfer of calibration models across different e-Nose units.

In parallel, advanced feature extraction and engineering strategies were investigated to improve the robustness and discriminative power of the generated models under realistic operating conditions, where both biological and instrumental variability typically affect performance. The combination of calibration transfer and enhanced feature extraction represents a promising step toward scalable and deployable e-Nose systems for biomedical applications.

Keywords:

Electronic nose; training; direct standardization; transfer samples; diagnosis