AEROTAPE: A NOVEL TECHNOLOGY FOR REAL TIME QUANTIFICATION AND CHARACTERIZATION OF DUST AND ITS SOURCES

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RESUME

L'instrument **AEROTAPE**, développé par Oberon Sciences, permet de mesurer et d'identifier en temps réel les particules atmosphériques (0,8–10 µm) grâce à des images analysées par une IA. Il offre une meilleure différenciation des sources naturelles et anthropiques que les compteurs optiques classiques. Les tests menés à Nicosie et Limassol montrent une bonne précision et un bon accord avec les instruments de référence. Des campagnes supplémentaires (à Paris et aux Émirats arabes unis) sont prévues pour améliorer la classification des particules et mieux distinguer les poussières locales des poussières transportées.

ABSTRACT

AEROTAPE, developed by Oberon Sciences, is a new instrument that measures and identifies airborne particles (0.8–10 µm) in real time using imaging and AI. It enables better differentiation between natural and human-made particle sources compared to traditional optical counters. Field tests in Nicosia and Limassol show high precision and good agreement with reference instruments. Additional campaigns (in Paris and the UAE) are planned to improve particle classification and to better distinguish local dust from long-range transported dust.

MOTS-CLÉS : poussières, microscopie, Intelligence artificielle, surveillance en temps réel / **KEYWORDS:** Dust, microscopy, artificial intelligence, real-time monitoring

EU Member States are allowed to subtract the contribution of natural sources (such as desert dust or sea salts) from measured PM_{10} concentrations when verifying compliance with air quality standards. However, they must do so with pertinent data, which can be sometimes challenging. The recent EU Air Quality Directive enforces a drastic reduction of PM_{10} annual limit values (from 40 to 20 $\mu g \cdot m^{-3}$) and daily limit values (from 35 times above 50 $\mu g \cdot m^{-3}$ to 18 times above 45 $\mu g \cdot m^{-3}$) by 2030. These stricter limits will increase the need for accurate apportionment of natural and anthropogenic PM sources in the coarse fraction. Particular attention should be given to traffic sites, where high PM levels originate from local (e.g., road traffic resuspension) and regional (long-range transported) dust sources.

We present here a novel instrument developed at Oberon Sciences, France, called AEROTAPE illustrated by Figure 1.

Figure 1. Aerotape instrument with a PM10 head on the roof of the Cyprus Institute in Cyprus

This instrument samples atmospheric particles within the range of 0.8 – 10 µm diameter by impaction. Briefly, the air is sampled over a three-minute period at a flow rate of 15 L/min onto a transparent adhesive tape equipped with an on-board microscope that takes pictures of the sample. The sample is illuminated at different angles and wavelengths to deduce particle size and nature using the onboard camera. The tape is uncoiled at variable velocities to prevent picture saturation, enabling the sampling of extremely concentrated aerosol conditions and preventing over-deposition. All the pictures are sent to a server to be automatically processed by an artificial intelligence (AI) module. This allows real-time differentiation of particle types, as well as the derivation of particle size and shape distribution based on the projected area of individual particles. The principle is reported in Figure 2.

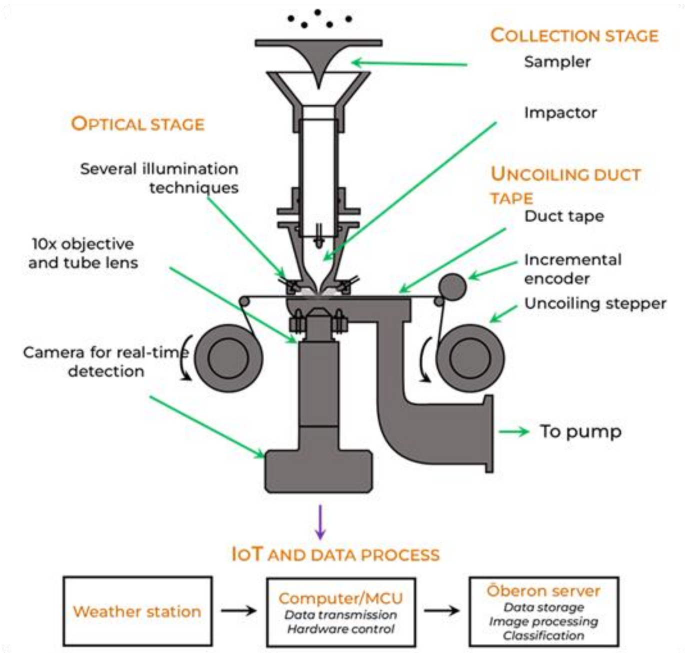

Figure 2. basic operating principle of the AEROTAPE

The added value of this instrument compared to a traditional Optical Particle Counter (OPC), which uses the Mie scattering theory of spherical particles, is (i) the use of a camera in the axis of the impaction for real-time counting, (ii) the acquisition of visual information on the geometric shape of the particles, and (iii) the ability to capture their colour using an RGB array. This will improve the differentiation between particle types such as soluble and insoluble particles, plastics, metals, and combustion ash, thus enabling a more accurate assessment of natural contributions to PM levels.

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The metrological (accuracy and precision) performance of AEROTAPE was assessed at two different urban sites (Nicosia and Limassol), leveraging the unique opportunity to benchmark its performance under the distinct characteristics of a capital city and a commercial port. The precision was evaluated by comparing observations from two co-located AEROTAPEs, while its accuracy was assessed against reference instruments like FIDAS200 and TEOM1405.

In Nicosia, data collected from November 2024 to August 2025 show consistently high precision, with strong agreement between parallel AEROTAPE measurements. Similarly, preliminary results from the ongoing campaign in Limassol, initiated in late July, indicate a statistically significant correlation between AEROTAPE and FIDAS200, confirming the instrument's stable performance across environments. The first results are presented in Figure 3.

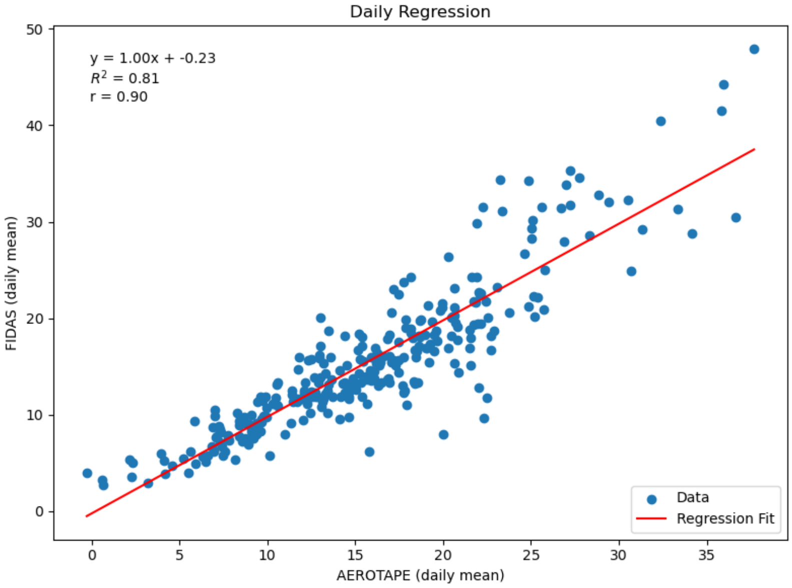

Figure 3. FIDAS200 vs AEROTAPE in the supermicron size (2.5-10 µm) measured in $\mu g.m^{-3}$

To further optimize the AEROTAPE technique, we plan to perform a series of additional field campaigns, allowing us to collect particles from diverse locations influenced by different sources. This will provide a robust dataset for training and refining particle classification methods. One aim is to characterize PM dust from transportation-related emissions in different regions and climates, via intensive field campaigns conducted at a traffic site in Paris (France). Moreover, desert dust will be characterized during intensive field campaigns in the United Arab Emirates (UAE), combined with remote-sensing and in-situ monitoring technologies (drones, balloons, and ground-based). The resulting data will help create a database to improve the characterization of PM dust sources and address the quantification of local vs regional dust contributions.

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