Development of a simple system for on-site detection of hydrogen peroxide.

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Background / Objectives

Background

- Hydrogen peroxide (H_2O_2) is mainly used in industrial processes like pulp and textiles bleaching as well as for disinfection.
- Peak exposures are characteristic in such workplaces and are difficult to evaluate with the existing methods.
- Concentrated H_2O_2 is also used as precursor in manufacturing improvised explosive (IE) by criminals.
- In that case, security agencies need miniaturized systems allowing low detection limit for H_2O_2 in order to locate the IE manufacturing sites.

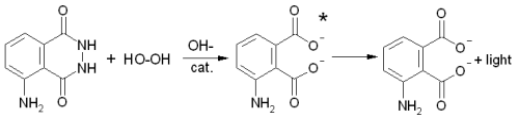
Objectives

- To develop an analytical method based on a portable luminometer allowing to measure H_2O_2 peak exposure (15 minute sampling) with low detection limits;
- To apply it on-site for evaluating occupational exposure and ability to locate IE manufacturing sites.

Methods

Method development

- Off-line procedure based on sampling gaseous H_2O_2 with an impinger filled with water;
- Measurement of the dissolved H_2O_2 with a luminescence-based method using a mixture of horse radish peroxidase (HRP) and luminol, following the reaction scheme:



Luminol reacts with H_2O_2 to produce an electronically excited 3-aminophthalate, which emits in the blue (450 nm).

- Use of a commercially available portable luminometer (Hygienia EnSure, Camarillo, CA, USA).

- Preliminary tests were done in order to optimize the HRP type, ratio HRP/luminol, pH and duration of the recording signal. A bench luminometer (Multiplate reader Infinite M200, Tecan, Männedorf, Switzerland) was used for comparison purpose and considered as reference.

Method validation for the measurement of H_2O_2 in air

- Tests in a cabin (10 m^3) were done in order to evaluate the H_2O_2 levels emitted during:
  - colour preparation and application on paper sheets (modelisation of the coloring activities in an hairdresser salon)
  - concentrating a diluted H_2O_2 solution on an heating plate (modelisation of the first step necessary to prepare improvised explosives).
- Field measurements : a) in an hairdresser salon
  b) in the field (ArmaSuisse - Thun)

Results / Discussion

Method validation

- Figure of merit of the luminescence method for H_2O_2 in air.

Reactive mix	HRP type X 0.8 U/ml – Luminol 8.3 mM in 0.1M Tris pH 8.4
Calibration	Polynomial fit (second order)
Limit of detection	0.25 µM impinger 15 ml H_2O ⟹ 7 µg H_2O_2/m^3
Repetability	< 10%
Reading duration	6 minutes

Coloring activities at an hairdresser salon

- Modelisation in a cabin:

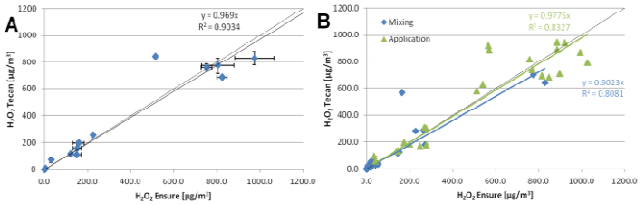


Fig. 1: Comparison of H_2O_2 results determined with the reference luminometer (Tecan) and the portable one (Ensure).
A. Cumulative H_2O_2 levels (mixing+application, 15 min duration);
B. Contribution of the mixing and the application activities.

- The measured levels of H_2O_2 in the cabin could be very high (above the OEL of 710 mg/m^3; Fig. 1).

- Field measurement

Sampling N°	Sampling place	H_2O_2 [µg/m^3]	Activity
1	Fix, next to the client	5 ± 1	Preparation and color application (hairs root). Duration : 37 minutes.
2	Fix, next to the hairdresser	24 ± 1	
3	Personnal (hairdresser)	38 ± 3	
4	Fix, next to the client	11 ± 1	Preparation and color application (locks of hairs). Duration : 15 minutes.
5	Fix, next to the hairdresser	42 ± 3	
6	Personnal (hairdresser)	106 ± 6	
7	Fix, next to the client	6 ± 1	After the colloration Background. Duration: 15 minutes.
8	Fix, next to the hairdresser	6 ± 1	

- The H_2O_2 levels were low; the activity of color application on the locks is the most of concern (use of color with higher H_2O_2 content).

IE preparation (concentrating a diluted H_2O_2 solution on an heating plate)

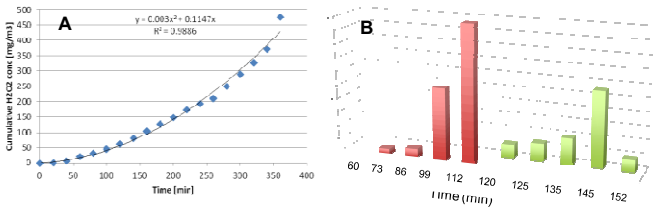


Fig 2: **A**. Evolution of the concentration of H_2O_2 over time in the closed cabin. **B.** Evolution of the concentration of H_2O_2 over time in two impingers, positionned at distance <5m (in red) and between 5-20 m (in green) in the field (ArmaSuisse) determined with the portable luminometer.

- H_2O_2 is volatile (Fig. 2 A.) and the developed method is sensible enough to detect emissions from heated solutions at distances of some meters in real situations (Fig. 2 B.).

Conclusion / Perspectives

- Preliminary testing in an occupational simulation has been successfully completed. Successful low-level environmental sampling/detection indicates a feasible method applicable for short term exposure level for H_2O_2 in occupational setting.
- Detection of H_2O_2 from bomb factories producing IE is possible with the developed method and opportunities exist for continuous on-site monitoring via portable set-up systems.

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