Application of nanostructured sensors for Cultural Heritage monitoring and protection

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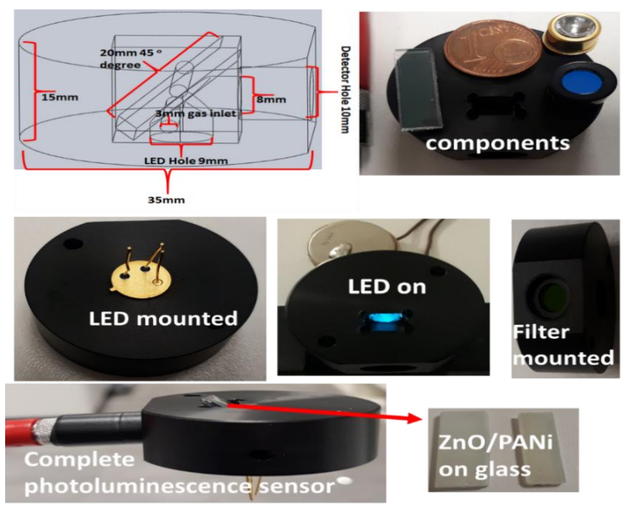
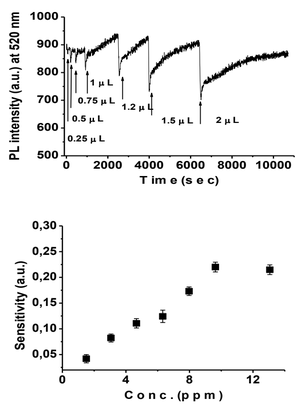
THE PROBLEM

Cultural Heritage films preservation is nowadays understood as a two-phase action: on one side, it consists of restoring and recovering damaged film elements. On the other hand, an increasing attention is directed to monitoring the parameters responsible for the old films degradation.
A new emerging problem in old film preservation regards phenomena of degradation caused by compounds produced by the films themselves, with type of gas produced and effect on the item depending on the composition of the artifacts themselves. Typically, nitrocellulose films will produce nitrogen oxides compounds (particularly NO_2), while cellulose acetate films will produce acetic acid. Both these class of compounds can catalyze further degradation in the film and, in case of spill-over, promote degradation in near, non-degraded films.

OUR SOLUTION



We developed a sensor based on photoluminescence transduction. A thin layer of ZnO/PANI composite deposited on a glass substrate showed remarkable sensitivity to acetic acid.



The photoluminescence of the composite when exposed to green light (520 nm) decreased proportionally to the concentration of acetic acid to which it was exposed.

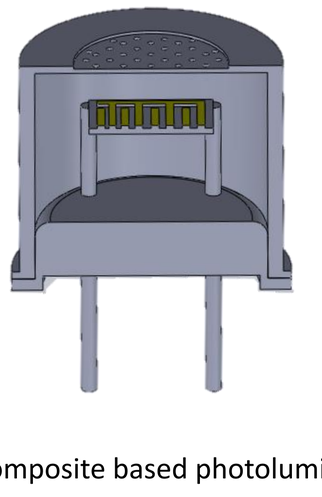
Sample	Visual analysis	Value found with A-D strips	Value found with photoluminescent sensor system
Film 1 (photo of offices)	No deterioration	0 (< 0.75 ppm)	Nd
Film 2 (photo of Italian street)	Deterioration started	1 (1 – 2 ppm)	1,5 ppm
Film 3 (phot of construction site)	Actively degrading	2 (6 – 8 ppm)	7,6 ppm

The sensor was used to determine the acetic acid produced by some photographic films. The results obtained show a good correlation with the values found using the official methodology (AD-strips).

CONCLUSIONS

The results presented in this work show that ZnO/PANI-based nanocomposites are good candidates for the determination of acetic acid at room temperature based on photoluminescence measurements.
The results of the photoluminescence and measurements of these composites exposed to the acetic acid vapors show that photoluminescence decrease with increasing the samples concentration.
Here developed ZnO/PANI-based sensor showed good sensitivity to acetic acid in the range of 1–13 ppm, with acceptable response and recovery times suitable for the monitoring of acetic acid. A new miniaturized sensing system based on ZnO/PANI sensing layer prototype was developed. The prototype combines LED (UV) and a fiber optic measurements system with photoluminescence ZnO/PANI sensing element. The sensor prototype collected the photoluminescence signal via optical fiber with high yield.

We are now applying these developed sensible nanomaterial to integrate them in MOS technology.
The first results obtained makes us hopefull that this integration is possible and it will leed to a new generation of miniaturazied acetic acid sensors for Cultural Heritage protection and preservation.



M. Turemis, D. Zappi, M.T. Giardi, G. Basile, A. Ramanaviciene, A. Kapralovs, A. Ramanavicius, R. Viter, ZnO/polyaniline composite based photoluminescence sensor for the determination of acetic acid vapor, Talanta. 211 (2020) 120658. https://doi.org/10.1016/j.talanta.2019.120658.
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