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VOC detection: hope or hype?
A preliminary study to unlock many challenges

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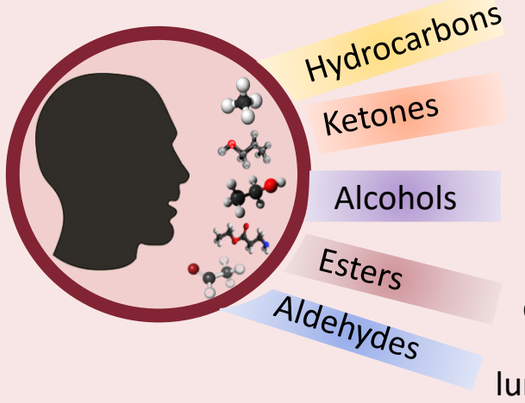
Challenges

- developing a **chemiresistive sensor** for **disease detection**
- exploiting **breath volatile compounds**
- utilizing a **green method** for synthesis and deposition of **nanoparticles** as VOC detectors

VOC

Volatile Organic Compounds (VOCs): chemicals born form **cellular metabolic activity** and present in various **bodily fluids**, most of all in **breath**. Since its origin, the VOC pattern can be considered as a **un/healthy signature**.

Exhaled VOC – disease correlation



multiple sclerosis, Crohn's disease

diabetic ketosis, monitoring fat loss, heart failure

nonalcoholic steatohepatitis, celiac disease

chronic kidney disease, Alzheimer/Parkinson's disease

lung cancer, chronic obstructive pulmonary disease

STANDARD vs NEW technologies for breath analysis

STANDARD TECHNOLOGIES:
Gas Chromatography (GC)
Mass Spectrometry (MS)
GC-MS
Proton Transfer Reaction (PTR) – MS
Ion Mobility Spectrometry
Selected Ion Flow Tube – MS
Spectrometry
Optical Absorption

PRO
- Sensitivity
- Specificity
- Precision

CONS
- Cost effective
- Time consuming
- Need of skilled technicians
- Low portability

NEW TECHNOLOGIES:
Electronic nose
Sensor arrays
Various types of gaseous sensors (piezolelectric, optical, colorimetric, chemiresistive)
Nanomaterial based sensors

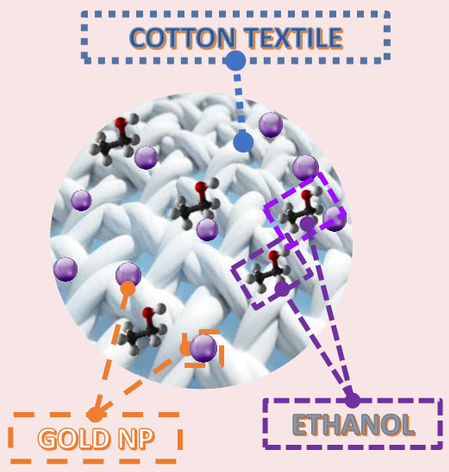
PRO
- Low cost
- Low weight and size
- Real-time monitoring
- Quick method

CONS
- Few studies, especially on a clinical cohort

VOC selection

Selected VOC: **ethanol**.

As this compound originates from **microbial fermentation of the carbohydrates in the gastrointestinal tract**, many studies highlight it as probe for **diabetes mellitus, cystic fibrosis, heart failure, lung cancer, colorectal cancer.**



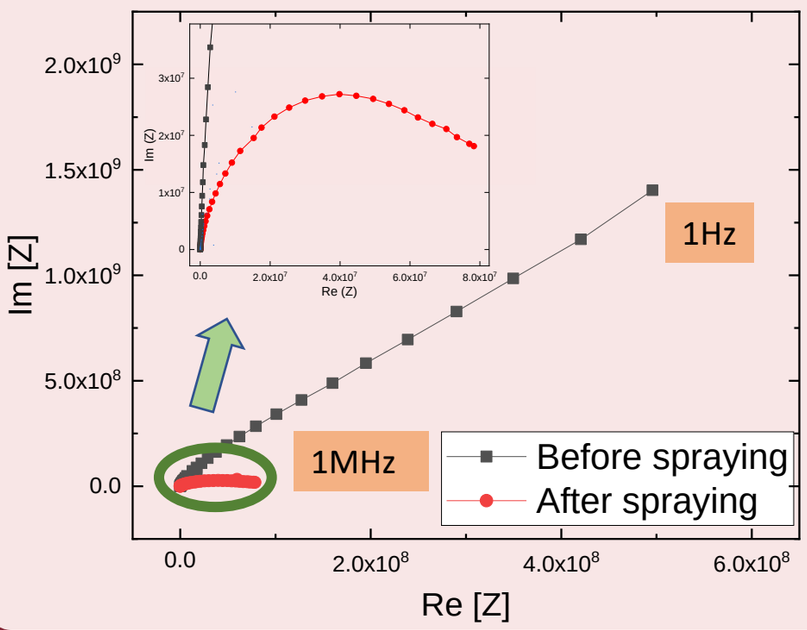
Nanomaterial selection

A plethora of studies underlined the potential of gold nanoparticles (AuNPs) for developing a **lock-and-key system** with a VOC detection purpose.
We developed a chemiresistive device whose output (electrical impedance) is proportional to its input (probe concentration).

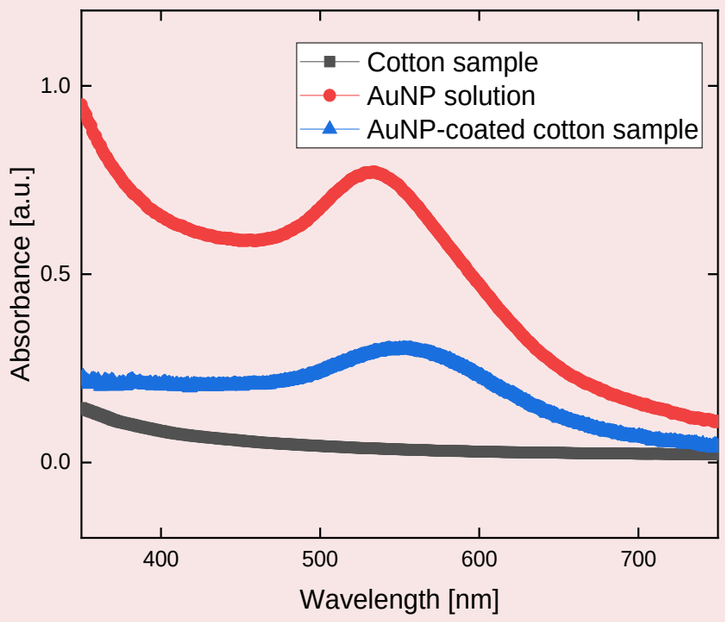
Synthesis step
GOLD PRECURSOR:
Chloroauric acid ($HAuCl_4$)
REDUCING/SURFACTANT AGENT:
Polyvynilpirrolidone (PVP)

Deposition step
DIP COATING of the aqueous solution containing gold nanoparticles on a cotton substrate

Preliminary results



The **Nyquist plot** on the left side, shows a different behaviour by comparing AuNP coated cotton sample before and after spraying a 40% ethanol solution. Ethanol induces an average **change of resistance of:**
- **89% at 1Hz**
- **56% at 1kHz**
- **32% at 1MHz**.



The **optical characterization** in the UV-vis range of both solution and coated cotton reveals the presence of around **20 nm diameter Au NP** associated to a **peak at 550 nm.**

Conclusions

The obtained results encourage to continue in the investigation of new scenarios opened by VOC detection and nanomaterial usage.
Future steps for developing smart devices with a clinical focus include checks with **other probes as biomarkers for various diseases** and with the **addition of capping ligands for enhancing the sensitive response**.

Acknowledgments

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