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# Ammonia Resistive Sensor

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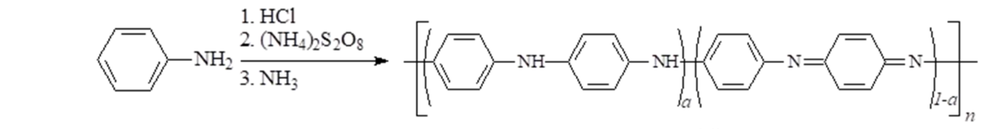
## Field of invention:

Ammonia concentration monitoring is important in the agri-food industry, in particular for the premises where fresh fruits and vegetables are stored for long time-frame, or for those where composting processes of food waste occur. The information on the ammonia concentration in the atmosphere of respective facilities is important both to secure the human health ($NH_3$ is a harmful gas even at low concentrations, *i.e.* 35 ppm), and to ensure the market value while protecting the environment. Significant benefits in food waste reduction may be achieved by considering a multidisciplinary approach Internet of Things – Phytochemistry.

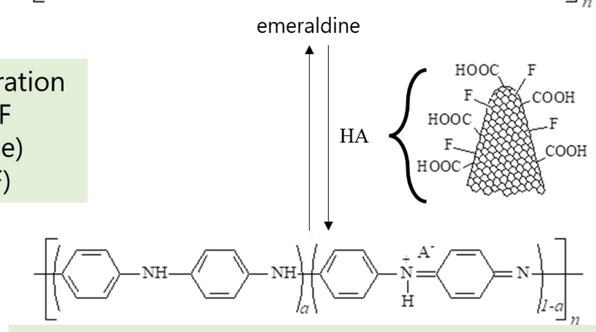
## Original approach:

This invention refers to new resistive sensors for monitoring ammonia concentration, with the sensitive layers consisting of binary nanocomposites containing oxyfluorinated carbon nanohorns (ox-CNH-F) and doped polyaniline. Both components are p-type semiconductors, and thus the detection principle resides in variation of the layers resistance when in contact with environments with different ammonia concentration values.

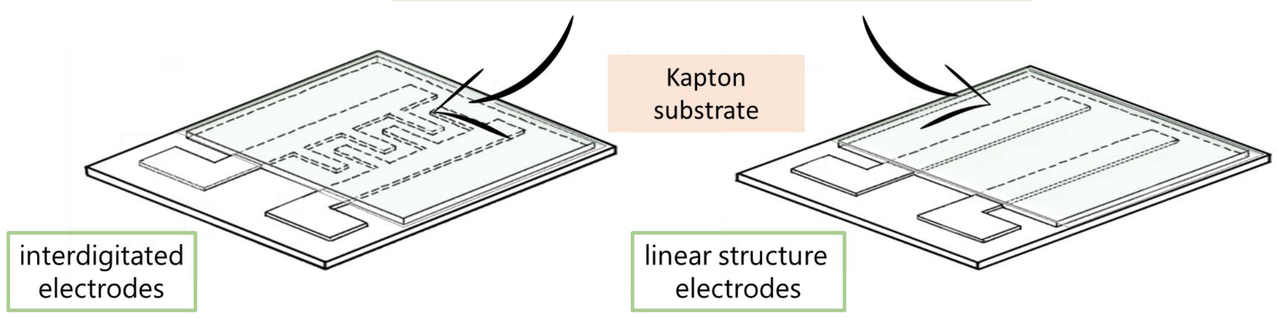
## Ammonia sensor manufacturing




conductive polyaniline preparation by doping with ox-CNH-F (protonation of emeraldine) (HA stands for ox-CNH-F)




doped polyaniline with oxidized carbon nanohorns




interdigitated electrodes

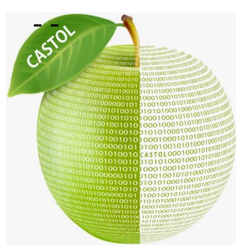
linear structure electrodes

## Sensor Design:

- the sensing device consists of a dielectric substrate (*i.e.* Kapton), linear / interdigitated metal electrodes (*i.e.* Al, Cr, Au, Pt) and a sensitive layer made of a thin film made of a binary nanocomposite ox-CNH-F / doped polyaniline;
- two-steps preparation process of a new p-type conductive polyaniline;
- presence of carboxyl-type oxygenated functions on the nanocarbon material is essential in the emeraldine doping process; this is achieved by treatment of nanocarbonic materials in argon-oxygen plasma;
- deposition method of the electrodes on the dielectric substrate may be direct printing, sputtering or evaporation
- investigations of $NH_3$ sensing characteristics of the ox-CNHs-F/polyaniline sensing layer was performed by applying a constant current between the two electrodes of the sensor, and measuring the voltage while exposing it to environments with different values of ammonia levels.

## Advantages:

- the use of binary nanocomposites of ox-CNHs-F/ polyaniline has significant advantages in the resistive detection of $NH_3$
- functionalization of nanocarbon nanohorns in $F_2$-$N_2$ and Ar-$O_2$ plasma in the conditions of this invention, ensure an optimal C:F:O atomic ratio;
- fluorine atoms increase the number of carriers in the carbon nanohorns due to inductive electron-attracting effect; as the conduction is achieved through holes (p-type carriers), the device's sensitivity to ammonia molecules increases; also, presence of fluorine atoms reduces the hysteresis through their hydrophobic effect;
- chemical and thermal stability and superior mechanical properties;
- due to the π-π interactions between polyaniline and the nanohorn material, the de-doping process is less likely;

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