Fluorescent sensor materials with coumarin dyes and semiconductor colloidal CdTe nanoparticles with sensitivity to microconcentrations of ammonia and acetone in exhaled air

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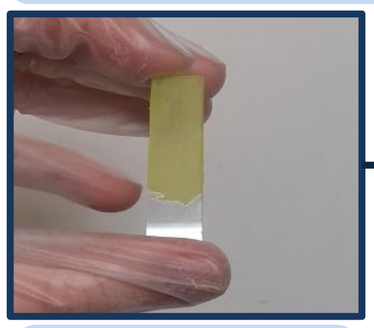
I. Introduction

▪Today, there are many studies on fluorescent sensors sensitive to ammonia and acetone in the air, including those using nanoparticles and nanostructured materials. It is important to create and research such sensors, which could sense analytes in the region of very low concentrations. This is topical for non-invasive diagnosis of diseases based on the analysis of exhaled air. Our recent study showed the possibility of detecting acetone and ammonia molecules in the air with fluorescent sensors based on silicate matrices, coumarin fluorescent dyes, and CdTe nanocrystals.

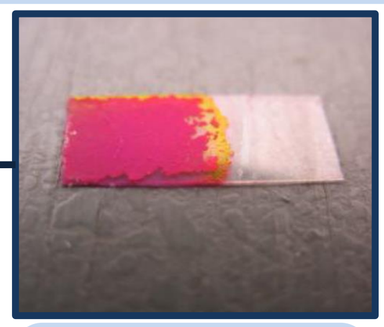
▪**THE AIM** of our study was to investigate the sensory properties of such materials to samples of model mixtures of human exhaled air, where such molecules are present in trace amounts.

II. Methods

Immobilization of dyes from their ethanol solutions was carried out on the sorbent layer attached to the substrate



Sensor material with sensitivity to ammonia in air



Sensor material with sensitivity to acetone in air

Flx-800T fluorometer

The sensitivity of the sensor material was measured by determining its fluorescent response to analyte molecules in the air

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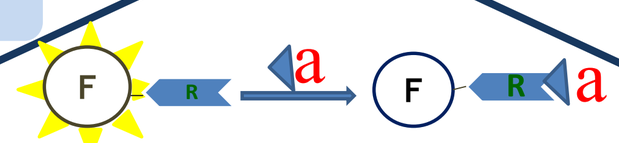
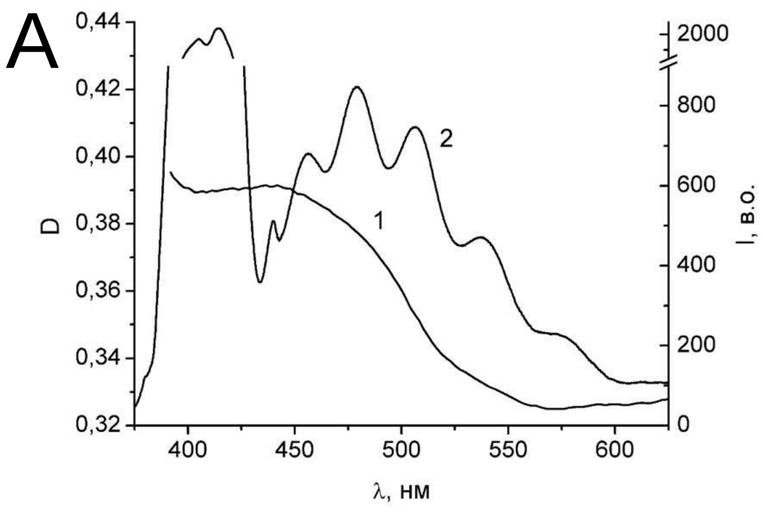


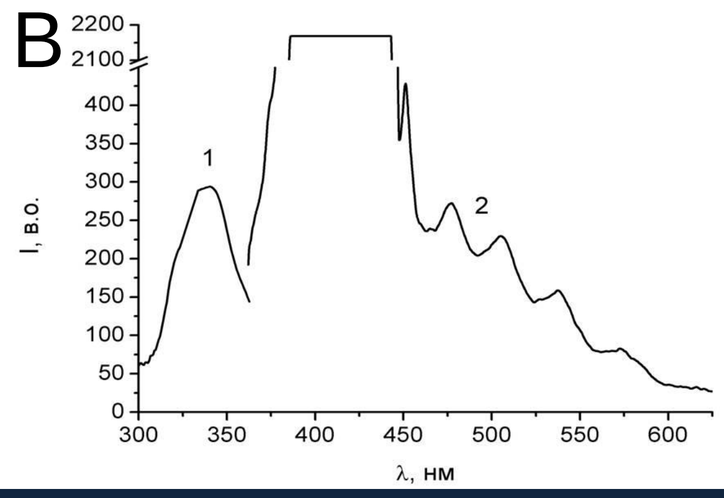
F - fluorophore, R - receptor group, a - analyte molecule (ammonia or acetone).

The gas-sensing material's mechanism of action consists of a decrease in the fluorescence intensity of the gas-sensitive complex Coumarin 7 - QD (CdTe) upon interaction with the ammonia (static quenching), and of the Coumarin 4 dye upon interaction with acetone (dynamic quenching).

III. Photophysical properties



A – sensor material for ammonia with Coumarin 7 and CdTe QDs (1 – absorption spectra, 2 – fluorescence spectra)

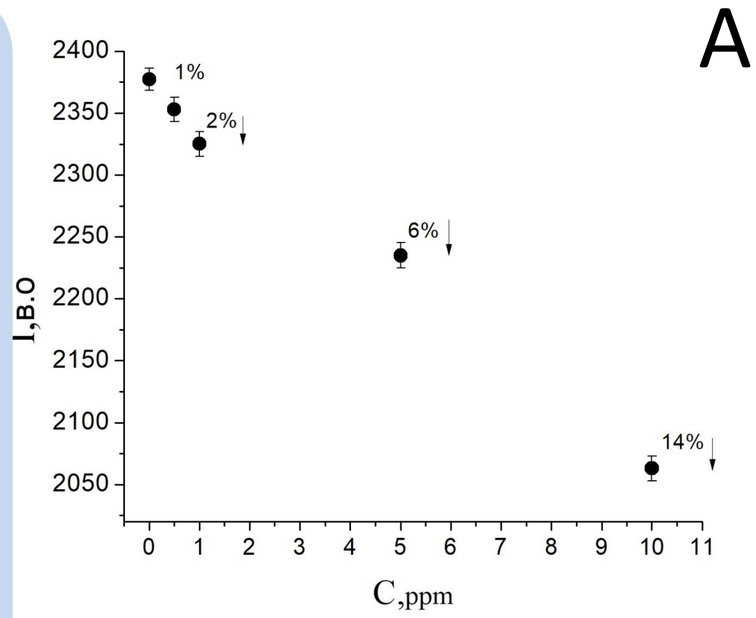


B - sensor material for acetone with Coumarin 4 (1 – fluorescence excitation spectra, 2 – fluorescence spectra)

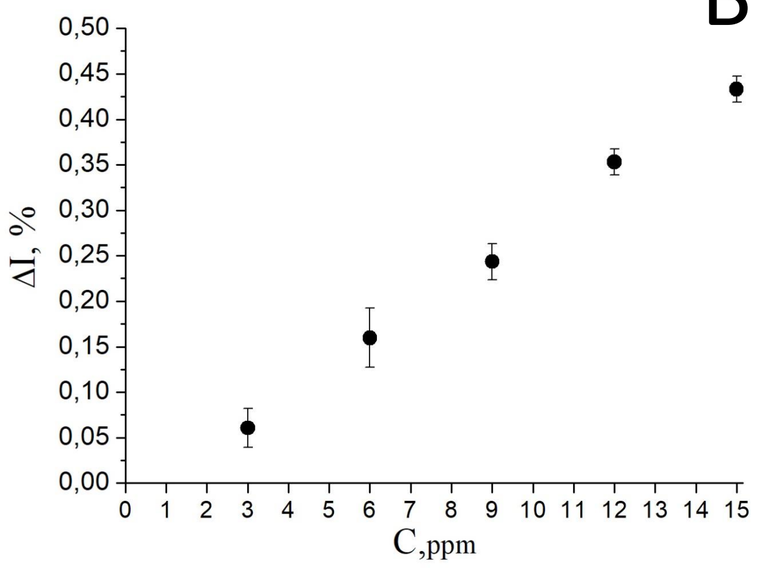
IV. Sensor properties

Fluorescent sensor response of material with Coumarin 7 and CdTe QDs to ammonia (A), sensor material with Coumarin 4 to acetone (B). Results was obtained for model mixtures of exhaled air with acetone or ammonia molecules in microconcentration range (0-15 ppm).

A



B



The obtained results show that when an analyte (ammonia or acetone) is injection into a cuvette with a sample of sensor material, a response is observed, which consists in a drop in the fluorescence intensity of the sample.

V. Conclusions

▪Sensor materials with coumarin 4 and also coumarin 7 and CdTe quantum dots which are sensitive to acetone and ammonia molecules (respectively) in the air were synthesized.

▪Fluorescent sensitivity of such materials to acetone and ammonia molecules in model mixtures of human exhaled air in the range of 0-15 ppm (molecules per million) was revealed.

▪Such materials are promising as sensitive elements of exhaled ammonia and acetone sensors for non-invasive diagnostics of certain diseases.

VI. References

1. Wei Jiang, Jiaqi Yi, Xiaoshuang Li, Fei He, Na Niu, and Ligang Chen. A Comprehensive Review on Upconversion Nanomaterials-Based Fluorescent Sensor for Environment, Biology, Food and Medicine Applications. *Biosensors* 2022, 12(11), 1036.

2. Das S., Pal M. Review—Non-Invasive Monitoring of Human Health by Exhaled Breath Analysis: A Comprehensive Review // J. Electrochem. Soc.-2020.-**167.**-P. 037562.

3. V. P. Mitsai, Ya. P. Lazorenko, A. G. Misyura, and S. O. Mamilov. Gas-Sensing Fluorescent Nanostructured Composites with Coumarin Dyes and CdTe Semiconductor Nanoparticles for Non-Invasive Medical Diagnostics // Nanosistemi, Nanomateriali, Nanotehnologii — 2021 - V. 19, No 4. - P. 941–952.

More information about this work:

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