Kinetics of Optical Absorption Changes in Polymer Gas-Sensitive Nanostructures

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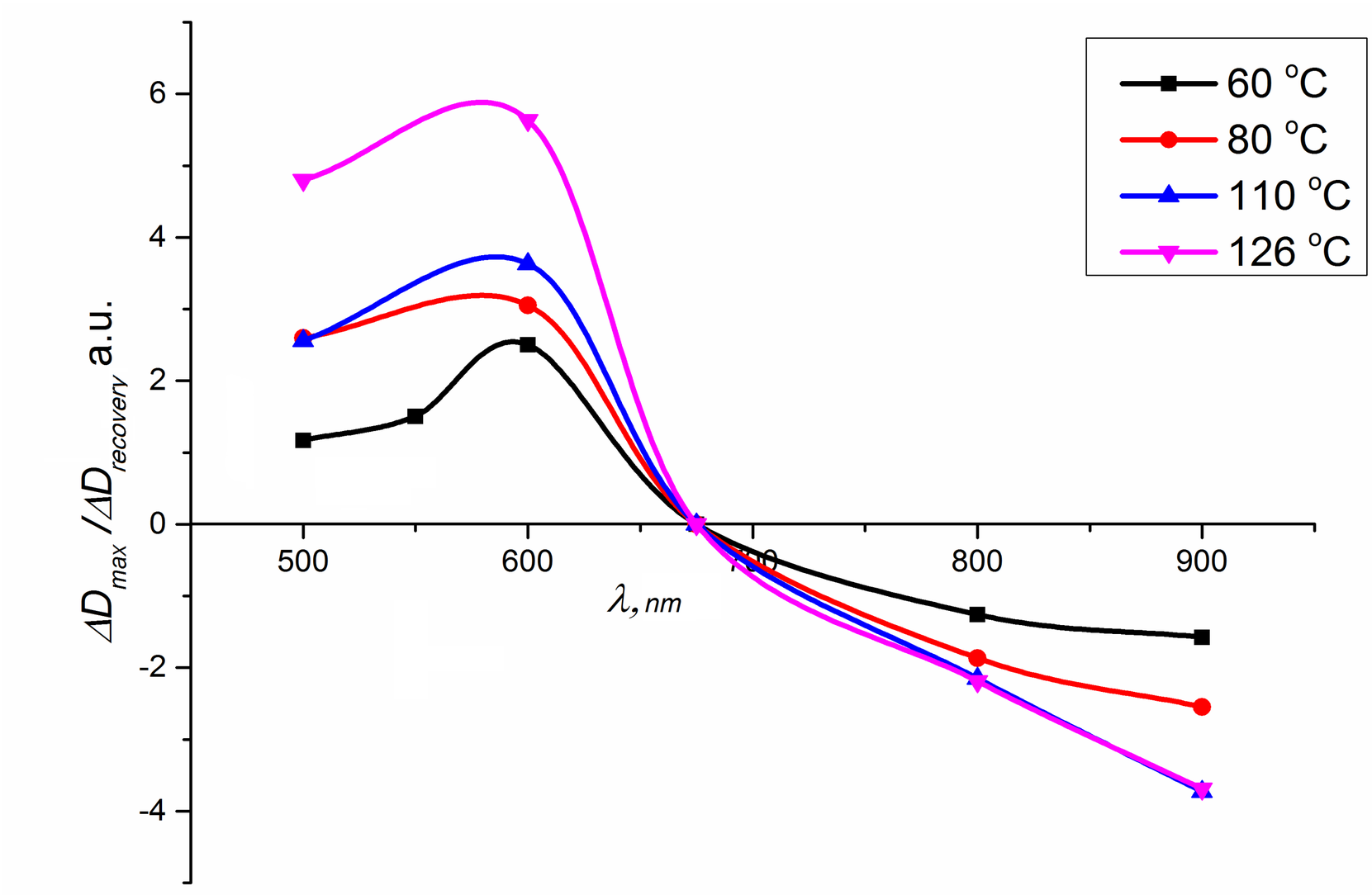
In recent years, there has been increased interest in the use of polymer films sensitive to various gases in optical gas sensors, in particular, electrically conductive polyarenes, due to their high manufacturability, ease of synthesis and use, and low cost [1,2]. At the same time, the peculiarities of changes in the optical properties of sensor elements under the action of gases, in particular, the kinetics of these changes and their recovery significantly affect the operational parameters of sensors based on them.

Gas-sensitive nanostructured polymer structures were obtained by the electrochemical deposition method, as it allows to vary the composition, topology, thickness, and properties of the synthesized layers within wide limits and to optimize them effectively.

The kinetics of changes and recovery processes of optical absorption of nanostructured films of polyaniline and binary nanostructures based on a mixture of polyorthoanisidine and polyorthotoluidine under the action of ammonia, carbon dioxide, and sodium sulfide vapors in the wide spectral range λ = 350–900 nm were studied.



Spectral dependence of the degree of recovery at different air blowing temperatures of the optical absorption of polyaniline films with a thickness of 350 nm after gas-stimulated changes under the action of NH3 gas at a pressure of 6 Pa (*ΔDmax* – maximum changes in optical absorption under the influence of gas, *ΔDrecovery* – residual changes in optical absorption after recovery)

Spectral and temporal ranges of sensitivity, speed and recovery parameters of active 2D nanoelements for smart optical gas sensors are established.

The absolute values of the degree of relative recovery increase with distance from the isobestic point of 675 nm and reach maximum values in the visible region of the spectrum at wavelengths of 550–600 nm, and in the infrared region of the spectrum at a wavelength of 900 nm. This means that when using these films as active elements of optical gas sensors, maximum sensitivity can be achieved using light sources in the specified spectral regions. When using polymer films of a different composition in reversible optical gas sensors, as well as when identifying other gases, identical calibration and testing studies should be carried out in order to optimize the wavelengths of light sources and photodetectors, as well as temperatures and recovery times.

An important parameter is the degree of recovery of the original characteristics of the sensor elements after the analyte has ended. It was established that the optimal temperature value for restoring the optical absorption at a wavelength of 600 nm of PANI thin films after exposure to ammonia is 80 oC. At the same time, in the conditions of calibration and synchronization processes of gas sensors, not only the absolute recovery of the properties of active elements, but also the relative degree of recovery of their properties at different wavelengths is important. We constructed the curves of the spectral dependence of the relative degree of recovery at different air blowing temperatures of the optical absorption of polyaniline films after gas-stimulated changes under the action of ammonia.

The spectral and temporal regions of maximum changes in the optical absorption of the studied polyaminoarene films and the optimal conditions for their maximum recovery have been established. Proposed recommendations for the use of synthesized nanostructures as active 2D nanoelements for smart optical gas sensors with improved values of sensitivity, speed, and recovery parameters.

1. *Wong Y.C., et al.* Conducting Polymers as Chemiresistive Gas Sensing Materials: A Review // J. Electrochem. Soc.-2020-**167** -037503.
2. *Chen Z., et al.* Smart gas sensor arrays powered by artificial intelligence // J. of Semiconductors-2019-**40**-111601.