Streszczenie w języku angielskim

As part of this doctoral research, highly oriented layers of a naturally derived polymer, namely cellulose nanocrystals (CNCs), were obtained for the first time on non-predefined substrates using the zone solvent evaporation method.

The surface morphology and optical properties of the oriented layers were investigated by means of polarized optical microscopy (POM) and atomic force microscopy (AFM). The results demonstrated a high degree of CNC alignment, which was confirmed, among other observations, by pronounced optical birefringence.

In the subsequent stage of the study, the oriented CNC layers were used as a polymer matrix for the fabrication of fluorescent composites through the incorporation of fluorescein. The effect of cellulose nanocrystal orientation on the fluorescence properties of the resulting layers, including emission intensity, was examined. A clear correlation was observed between the structural ordering of CNCs and the anisotropy of the fluorescence signal, highlighting the potential of such layers for applications in optoelectronic systems and directional optical sensors. These findings are of particular importance for the development of organic biosensors and security materials, such as anti-counterfeiting systems, in which the material responds to UV light in a specific and ordered manner.

Based on a highly oriented CNC layer containing fluorescein, the first naturally derived solid-state pH indicator with a broad sensitivity range (pH 3-12) was developed. The presented research not only expands current knowledge of CNC orientation achieved by the zone solvent evaporation technique, but also points to new directions in the development of biodegradable and functional optical materials.

Another line of research involved the preparation of thin, highly oriented layers of small-molecule compounds, namely non-commercial dithiophene derivatives: 2,7-diC6benzothieno[3,2-b]benzothiophene 5,5,10,10-tetraoxide (diC6-BTBTTO), 2,7-diC12benzothieno[3,2-b]benzothiophene 5,5,10,10-tetraoxide (diC12-BTBTTO), 2,7-diC6benzothieno[3,2-b]benzothiophene 5,5-dioxide (diC6-BTBTDO), and 2,7-diC12benzothieno[3,2-b]benzothiophene 5,5-dioxide (diC12-BTBTDO), provided through collaboration with the research group of Dr. Hab. Remigiusz Żurawiński. Their physicochemical properties and morphology were investigated. The molecular arrangement within the layers was analyzed, and the optical properties of the resulting highly oriented films were characterized.

Organic field-effect transistors (OFETs) were fabricated using highly oriented layers of diC6-BTBTTO, diC12-BTBTTO, and diC6-BTBTDO. All device characterization and measurements were performed at room temperature under ambient conditions. A central challenge in organic electronics is optimizing semiconductor performance, as this directly dictates the efficiency of charge transport. Consequently, achieving a morphologically homogeneous active layer, devoid of structural defects, is essential for enhancing critical transistor parameters, including charge carrier mobility and the I_{on}/I_{off} ratio. Minimizing energy traps at grain boundaries and reducing layer discontinuities are vital for lowering the threshold voltage and improving long-term operational stability.