Nanooptics and nanophotonics

Nanophotonic elements for smart packaging and printing techniques of their application

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The use of nanophotonic elements in systems of advanced packaging is promising because these items can register changes in the state of the packaged product by changing their luminescent properties. The functionality of such systems is based on the reaction of the fluorescent component with functional groups of certain substances that are formed as a result of deterioration of food. The luminescence intensity may be recorded visually under UV radiation or using instrumental methods, enabling creation of electronic devices such as sensors (as a part of a smart packaging) for the observation and control of the state of packaged foods during storage and, therefore, their suitability for consumption.

Nanoscale zinc oxide (ZnO) was chosen as a safe fluorescent component of the composition. ZnO has intense luminescence in a wide range of the visible spectrum and changes its intensity in contact with the target substances. The possibility of incorporating ZnO nanocrystals as acolloidal solution into polymer matrixes was investigated. By analyzing the luminescence spectra, the optimum compositions were created, suitable for forming films (layers) on polypropylene surfaces in which nano-ZnO does not lose its luminescent properties.

The compositions were applied by screen and pad printing techniques onto polypropylene film, which is widely used as packaging material. There was studied the influence of technological factors – layer thickness (i.e. the use of different depths of cells in pad and screen printing plates and the number of layers), screen mesh frequency, resolution, molecular weight of the polymer, concentration of nano-ZnO on luminescent properties and optical density of the coatings. There were established the effects of the studied factors on the height and proportions of the luminescence peaks of printed nanophotonic elements, and there was found that the ratio of luminescence peaks can be varied by varying the parameters of application of the compositions onto the surfaces, therefore varying luminescence color. It allowed to develop a mathematical model for obtaining printed nanophotonic elements with specified initial luminescent properties and their subsequent change for smart packaging systems. The investigation was supported by the State Fund for Fundamental Researches of Ukraine (grant F54.2/005)