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OPTICAL ACTIVE 3D INKS FOR COUNTERFEIT PREVENTION BASED ON CARBON DOTS AND CELLULOSE NANOCRYSTAL

E.O. Ryabchenko (ITMO University, Saint Petersburg, Russia)
Scientific advisor – Dr. E.F. Krivoshapkina
(ITMO University, Saint Petersburg, Russia)

Abstract. This paper describes novel inks for fraud and counterfeit prevention for 3D gel printing method. Cellulose nanocrystals (CNC) gelated with photoluminescent carbon dots seems as a perspective printable composition for manufacturing of 3D structures due to commercial availability of materials, printing with high performance and non-toxicity. In this work, two combined optical effects are used: fluorescence from CDots, and polarization from CNC. Polarization patterns could define the origin of pattern: printed or hand-frauded. Described inks also has shear-thinning properties which provides the possibility to be imprinted on surfaces with complicated geometries or topologies. Such novel opportunities could increase degree of goods protection in comparison with current methods.

Introduction. Materials for counterfeit and fraud prevention seems as an important direction in science. Manufacturers around the world had losses in 10-15% of their annual year income due to counterfeit of goods.

At this moment we have a wide range of methods, but most of them has issues in their implementation. One of such methods – is a usage of optical active structures and elements: quantum dots, holographic images, watermarks, etc. Most of them has the same issue based on impossibility of implementation on geometrically and topologically complicated surfaces, and also a weak protection from imitation. We suggest 3D Gel extrusion printing as a solution: shear-thinning inks shall cover complicated surfaces, and also may provide high degree of protection through usage of nanocolloidal inks with specific optical activity. In this work, we use gelated inks based on cellulose nanocrystals (CNC) and carbon dots (CDots). Described materials were chosen due to their commercial availability and properties, compatible for ink creation. Optical active CDots in mixture decreases Debayue radii of CNC, and gel appear. CDots, as optical active element, emits light under monochromatic irradiation (e.g. UV).

In our work, two types of CDots were synthesized: blue and red. Inks, based on mixtures of CNC and CDots show their emission in independent wavelength: when the one of them is exited, another is not, and it lead us to creation of many 3D optical-active structures applicable for counterfeit prevention.

Except the fluorescence, obtained ink composites exhibit the polarization activity under cross-polarizers. Polarization patterns appears in case of inks extrusion, and they copied GCode of models. By programming of GCode and usage of this property we could print triple-image 3D structure in which two images might be patterned with fluorescent inks, and the last one by polarization pattern.

Materials and Methods. As the printing composition, mixture of CNC and CDots were chosen due to their good mutuality with each other, commercial availability and optical features. CNC were used as stock 5 % w. solution, and CDots were synthesized via solvothermal method from citric acid and urea. We also studied rheological, optical and mechanical properties of obtained inks

Obtained inks successfully printed via 3D gel printer Cellink Bio X. For 3D printing it is decided to print models which already used in prevention of counterfeit: barcodes, numbers, grids, text, coded squares. Inks shall be noticed as high performance and precision printed and optimization of printing parameters were resulted in avoiding of issues such overextrusion, holes, relaxation and others.

Conclusion. In this study, the concept of security printing was developed through usage of inks based on CDots nanoparticles and CNC. This research demonstrated usage of combination protective methods for manufactured goods through extrusion printing. Obtained gelated inks also showed their

perspectivity for security printing. Our further plans in this work is the development of printing methods on the complex surfaces from geometrical and topological points of view and usage of novel optical effects for anticounterfeit prevention

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E.O. Ryabchenko

E.F. Krivoshapkina