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SMART TEXTILE FABRICATION WITH PHOTOCONTROLABLE, REVERSIBLY PHOTOSWITCHABLE AND ECO-SUSTAINABLE FLUORESCENT BIO-INKS

Verónica Bouça[1], Juliana Oliveira[1(*)], Ana Barros[1], David Ramada[1], Lorena Coelho[1], Ana I. Freitas[2], João Romão[1,2], Lucília Domingues[2], Tatiana Q. Aguiar[2]

[1] CeNTI - Centre of Nanotechnology and Smart Materials, Rua Fernando Mesquita, 2785, 4760-034 Vila Nova de Famalicão, Portugal

[2] CEB - Centre of Biological Engineering, University of Minho, 4710-057 Braga, Portugal

(*) Email: jaoliveira@centi.pt

ABSTRACT

Color-changing materials with controllable photoswitching properties are highly desirable for technical and smart textile products. In the quest for innovative light-responsive textiles, many efforts have been made to develop materials that can be easily incorporated into fibers and/or fabrics by conventional dyeing, printing or coating processes. Current developments commonly incorporate photochromic inks that undergo a color change upon irradiation with light of a specific wavelength and revert to the original color when the light source is removed. However, these inks are based on substances obtained by non-sustainable petroleum-based organic synthesis and do not allow controlled light-driven switching between colors.

In this context, biomolecules which can be easily obtained by biotechnological means and that combine fast and easily tunable fluorescent properties, appear as a more eco-sustainable and highly appealing alternative with a wide range of promising applications.

Therefore, this work explores the development of a new generation of eco-sustainable inks that take advantage of the unique optical properties of selected reversibly switchable fluorescent molecules (RSFMs) for the fabrication of innovative textiles with photocontrolable photoswitching fluorescent properties (Figure 1).

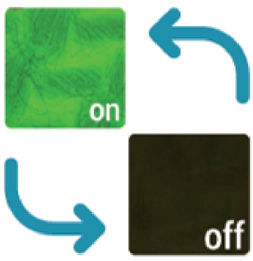

Figure 1. Operating principle of textiles with photoswitching fluorescent properties.

MATERIALS AND METHODS

The eco-sustainable inks were produced by nanoencapsulation of RSFMs obtained by biotechnological means in biocompatible matrices, such as silica, which has the double advantage of improving their thermal and photo stability and of facilitating their incorporation in textiles. RSFMs biologically fused to tags that improve their binding to silica or cotton fibers were also used.

In the scope of this work, non-covalent and covalent entrapment strategies [1,2] were optimized and

their corresponding yields were compared. The fluorescent characteristics of the produced inks were evaluated by spectrofluorimetry and their photoswitching performance was determined with a special equipment developed in-house for such purpose.
The functionalization of cotton-based textiles with the produced inks was achieved via wet chemical methodologies conventionally used in textile fabrication, such as padding, in which the ink-saturated textile is squeezed through pad rollers at controlled pressure and rotation speed to potentiate impregnation. The textiles' fluorescence was checked by optical fluorescence microscopy (OM) and the functionalization efficiency is tested by fastness to washing.

RESULTS AND DISCUSSION

This work is still under development, but the following developments were already achieved:
• RSFMs were successfully entrapped into silica matrices, using either non-covalent or covalent nanoencapsulation strategies. Covalent entrapment led, in general, to better yields than non-covalent approaches. Also, RSFMs biologically fused to silica tags led to the best entrapment yields. The encapsulated RSFMs maintained the original fluorescence and photoswitching properties (e. g. Figures 2.a and 2.b).
• Preliminary textile functionalization tests performed with non-entrapped RSFMs and RSFMs biologically fused to cotton-binding tags revealed that good fluorescence (e. g. Figure 2.c) and photo stability can be obtained with tagged RSFMs. Nevertheless, these inks displayed poor fastness to washing, likely due to their limited thermal stability.
• Textile functionalization tests with encapsulated RSFMs inks are currently ongoing and preliminary results indicate that further optimization is required, namely regarding the RSFMs concentration in the bio-inks.

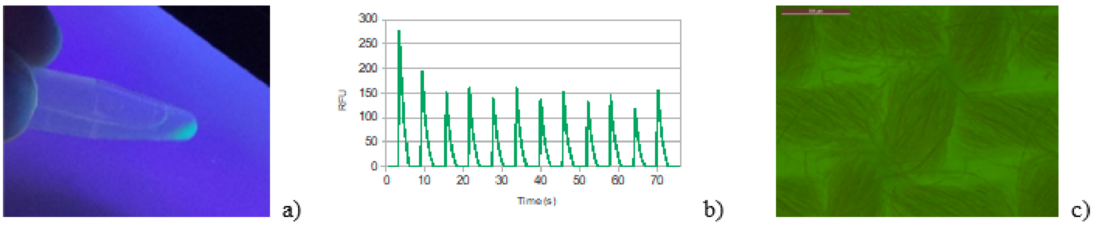

Figure 2. Fluorescence (a) and photoswitching performance (cycles of 3 s exposure to UV light followed by 3 s excitation with blue light) (b) of encapsulated RSFMs, and fluorescence of textile functionalized with non-entrapped RSFMs fused to cotton-binding tags (OM, 50x) (c).

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REFERENCES

[1] a) Cai, Z. et al. (2011). Encapsulated enhanced green fluorescence protein in silica nanoparticle for cellular imaging. Nanoscale, 3, 1974-1976; Cai Z. et al. (2010). A facile method to encapsulate proteins in silica nanoparticles: Encapsulated green fluorescent protein as a robust fluorescence probe. Angewandte Chemie International Edition, 49, 3022-3025.
[2] Kobler, J., Möller, K. & Bein, T. (2008). Colloidal suspensions of functionalized mesoporous silica nanoparticles, ACS Nano, 2(4), 791-799; Tu, J. et al. (2016). Mesoporous silica nanoparticles with large pores for the encapsulation and release of proteins. ACS Applied Materials & Interfaces, 8(47), 32211-32219.