Optical Labeling with Artificial Intelligence Using Infrared-Responsive Functional Textiles

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In this study, we address the above-said challenges by utilizing a straightforward sol-gel technique for synthesizing a SiO_2/Al_2O_3 monolith (SAM) binary coating using a singular di-sec-butoxyaluminoxytriethoxysilane (DBATES) precursor.[1] The compact structure of the binary coating protects Ag_2S quantum dots (QDs) from external factors such as moisture and oxygen, thereby enhancing their stability. Furthermore, we successfully modified the initial long-chain dodecanethiol ligand to create a hydrophilic SAM surface (Ag_2S@SAM), which improves adhesion to PALF-lyocell yarn. To achieve uniform particle size, the Ag_2S@SAM composite was subjected to a ball-milling process (defined as Ag_2S@SAM-B). Unlike traditional physical printing methods, we integrated fluorescent materials into textiles using a chemical cross-linking technique.[2] This procedure involves using carboxymethyl cellulose sodium salt (CMC) as a dispersant and citric acid (CA) as a cross-linking agent, significantly improving compatibility between Ag_2S QDs and the PALF. After the cross-linking process, the fibers were blended and transformed into fluorescent yarns via conventional industrial yarn production line which involves several processes such as carding, roving drawing, and spinning, resulting in enhancing stability and distribution of the fluorescent PALF into the yarns. Additionally, we explore the potential for SWIR markers to be detected using an infrared camera employing hyperspectral imaging for image recognition and artificial intelligence (AI)-based automatic classification. We developed a two-dimensional convolutional neural network (2D-CNN) to analyze the SWIR images, resulting in an enhancement of AI recognition accuracy to 87% through our algorithms. Finally, we present a comprehensive manufacturing process for integrating fluorescent materials into textiles and demonstrate SWIR image recognition capabilities.

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