Sustainable photoluminescent braided fabric structure for automotive-interior application and a novel characterization method of thereof

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Abstract

As the automotive industry expands its sustainability strategy beyond vehicle electrification, manufacturers are increasingly adopting sustainable interior materials while maintaining stringent requirements for design and aesthetics. Currently, illumination-related design elements rely almost exclusively on electrically powered solutions (LED or OLED systems), leaving a clear gap for energy-free textile lighting technologies with smart functional behavior. Within this context, bicomponent sheath–core photoluminescent fibres were developed through a melt-spinning process, combining smart functionality, sustainability and high-value design features. Additionally, a novel method for their photoluminescent characterization was developed.
The fibres were produced with several sheath–core ratios: the core composed of 100% recycled material, and the sheath successfully incorporating up to 40 wt% of a long-afterglow photoluminescent pigment (strontium aluminate phosphor), integrated in a UV-resistant polymeric compound via twin-extrusion compounding. Subsequently, photoluminescent braided structures of varying diameters were manufactured. To optimize durability, foulard impregnation finishing with anti-pilling agents was applied, successfully enhancing its abrasion resistance, exceeding 35,000 Martindale cycles without rupturing. Additionally, UV ageing tests (ISO 105-B06) scored 4–5, meeting automotive standards.

To evaluate the long-afterglow performance, a novel image-photometry characterization method was developed to overcome the sensitivity limitations of standard luminance meters (0,01 cd/m2). Optimized in compliance with reference standards such as DIN 67510-1 and CIE 191, by calibrating 16-bit linear RAW images captured by a DSLR camera with experimental luminance data of the developed photoluminescent braided structures, a robust calibration equation was established. This approach allowed the accurate determination of

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the fibers' luminance values at the lower limit of the mesopic vision regime (0,001 cd/m2), proving their extended visibility over several hours. The developed method offers a low-cost, scientifically rigorous solution for the optical characterization of photoluminescent solutions.
This work was developed within the scope of the project "Be.Neutral – Agenda de Mobilidade para a Neutralidade Carbónica nas Cidades" (C644874240-00000016), financed by PRR – Plano de Recuperação e Resiliência under the Next Generation EU from the European Union.

Keywords: Photoluminescent braided structures, Bicomponent sheath core fibres, Sustainable, Melt spinning