

Área: FIS

Development and Characterization of Hybrid Nanomaterials Based on ZnO@SiO₂ and Lignin for Broad-Spectrum Photoprotection

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Highlights

- Skin aging is strongly linked to chronic UV radiation exposure;
- Hybrid nanomaterials based on ZnO@SiO₂ were developed and functionalized with lignin;
- UV-vis analysis confirmed the spectral profile of ZnO@SiO₂ and the lignin-functionalized systems and negative zeta potential values confirmed the colloidal stability of the nanomaterials;
- Nanostructured hybrids represent an innovative strategy for safer and more effective sunscreens.

Abstract

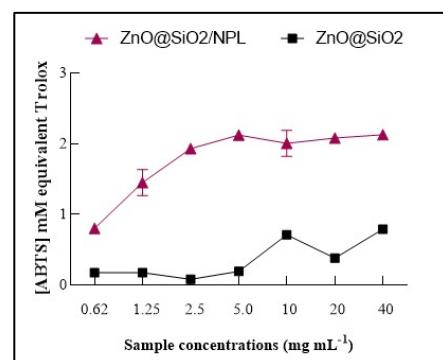
Skin aging, accelerated by ultraviolet (UV) radiation, is closely associated with oxidative stress, inflammation, and collagen degradation. In this context, core-shell ZnO@SiO₂ nanoparticles (NPs) functionalized with lignin represent a promising alternative to conventional UV-blockers, offering enhanced photocatalytic stability, improved cosmetic compatibility, and reduced opacity. This study aimed to synthesize and characterize these hybrid NPs, varying both the synthesis methods and the commercial lignin sources, and to evaluate their colloidal stability, optical properties, and antioxidant capacity for potential application in broad-spectrum photoprotection systems. The NPs were characterized using FTIR spectroscopy, UV-Vis analysis, particle size distribution, and Zeta potential (ZP) measurements. ZP values ranging from -32.5 to -50.4 mV confirmed good colloidal stability (Table 1). FTIR spectra confirmed successful surface functionalization, while UV-Vis analysis showed that lignin extended the UV absorption. Antioxidant assays demonstrated an enhanced ability to neutralize free radicals in the functionalized NPs, reinforcing their safety and highlighting their potential as active ingredients in safe and effective photoprotective formulations (Fig. 1).

Table 1: Average diameter (Z-Average), polydispersity index (Pdl), and Zeta potential of ZnO@SiO₂ and ZnO@SiO₂/Lignin dispersions

	Z-Average (d.nm)	PdI	Zeta Potencial (mV)
ZnO@SiO ₂	-	-	-32.5
ZnO@SiO ₂ /NPL ^a	554.8	0.540	-50.94
ZnO@SiO ₂ /NPL ^b	362.5	0.592	-48.91
ZnO@SiO ₂ /Lig ^{1b}	255.7	0.185	-43.02
ZnO@SiO ₂ /Lig ^{1a}	313.7	0.157	-44.86
ZnO@SiO ₂ /Lig ^{2b}	395.9	0.196	-43.05
ZnO@SiO ₂ /Lig ^{2a}	388.4	0.242	-42.82
ZnO@SiO ₂ /Lig ^{3b}	598.3	0.768	-42.39
ZnO@SiO ₂ /Lig ^{3a}	639.6	0.841	-44.27

¹ synthesis method 1, ² synthesis method 2, ³ synthesis method 3, ^a Sigma-Aldrich Lignin, ^b Suzano Lignin

Figure 1: Antioxidant activity of ZnO@SiO₂ and ZnO@SiO₂/Lignin samples determined by the ABTS method



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