From Environmental Optical Indicators to Light-Activated Therapy: Investigating Phycocyanin-Based Photopolymer Architectures

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Bio-derived chromophores are attracting increasing interest as sustainable alternatives to conventional functional materials, offering unique opportunities for the development of light-responsive systems. Among them, phycocyanin, the major pigment-protein complex of Spirulina (*Arthrospira platensis*), combines strong optical activity, environmental responsiveness, and emerging biomedical relevance. This contribution presents recent advances in the development of multifunctional photopolymer architectures based on a complex Spirulina-derived pigment extract containing both phycocyanin- and chlorophyll-related species.[1] Rather than isolating individual chromophores, the intrinsic compositional complexity of the extract is deliberately preserved and exploited as a functional feature. Through spectroscopic investigations, photopolymerization studies, and additive manufacturing approaches, the interplay between pigment photophysics, radical-mediated processes, and material processing is examined across both liquid and solid-state environments. The results demonstrate that the optical response of the extract can be modulated by chemical stimuli and by photocuring conditions, while maintaining colorimetric and luminescent functionality after incorporation into photopolymer matrices and digital light processing (DLP)-printed architectures. In addition to their role as environmentally responsive materials, these systems provide a useful platform for investigating how bio-derived chromophores behave under light-driven radical processes and within complex three-dimensional polymeric environments. Importantly, this study represents one of the scientific foundations of LUCENT (Light-triggered Ultra-precise Carbon-enhanced Phycocyanin Engineered Needles for Therapy), the Marie Skłodowska-Curie Postdoctoral Fellowship recently awarded by the European Commission. The understanding gained on phycocyanin stability, optical response, radical-mediated transformations, and integration into photopolymer architectures has directly motivated the development of the project, which aims to combine phycocyanin, carbon nanodots, and advanced additive manufacturing strategies for light-activated therapeutic platforms. More broadly, these findings highlight how investigations of bio-derived light-responsive materials can generate new opportunities at the interface of sensing, additive manufacturing, and light-activated biomedical technologies.

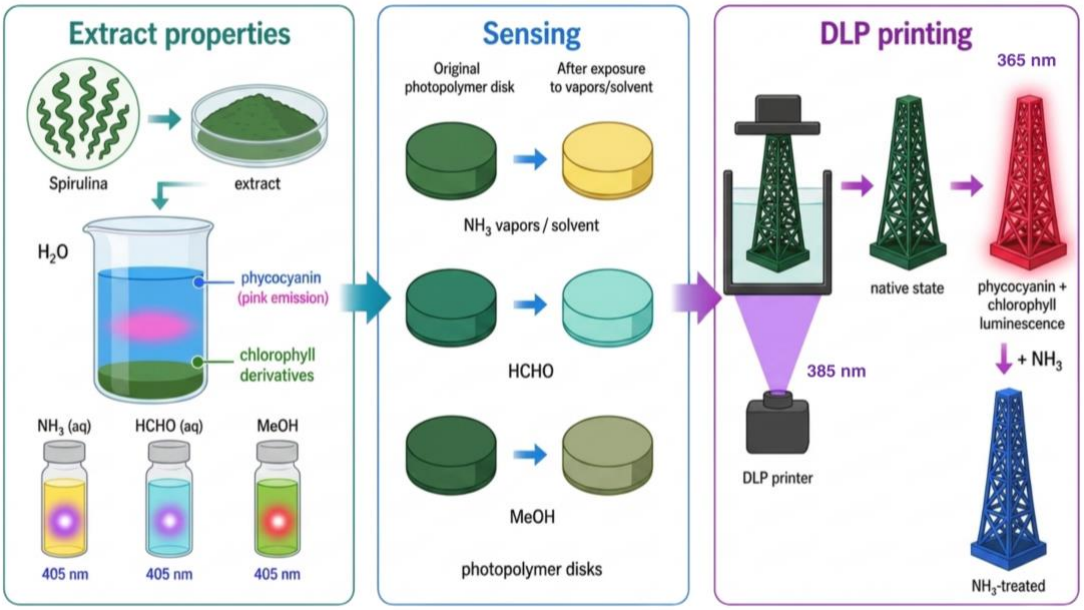

Figure 1 – From Spirulina extract to optically responsive 3D-printed architectures.

REFERENCES

[1] Olla C., Martis A., Barontini C., Carbonaro C.M., Roppolo I., Ricci P.C., Secci F., Chiappone A. (2026) "A Spirulina-Derived Pigment Extract Combining Phycocyanin and Chlorophyll for Optically Responsive Photopolymer Architectures". *Sustainable Materials and Technologies*, in press. https://doi.org/10.1016/j.susmat.2026.e01247.