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Introduction to exploring the progress in fundamental, functional material and health aspects of melanins and related materials

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There is a growing interest in a broad class of biomaterials known as the melanins, due to their intriguing physico-chemical properties as well as their

implications for biological health and medical applications and devices.

This themed collection highlights a diverse set of research work on both fundamental and applied perspectives on melanin and related poly indolequinone materials, within the context of innovative developments across multiple fields.

First, Paulin *et al.* highlight the effectiveness of a multifrequency electron paramagnetic resonance approach in elucidating the origin of eumelanin's paramagnetism (<https://doi.org/10.1039/D3MA01029E>). This review offers a

comprehensive understanding of the paramagnetic nature of eumelanin from a multi-species perspective.

Ferraiuolo *et al.* investigated the Seebeck coefficient of the eumelanin with PEDOT:PSS blends by means of electron paramagnetic resonance measurements and elucidated the role of eumelanin pigments as radical dopants for thermoelectric applications (<http://doi.org/10.1039/D4MA00339J>).

Kim *et al.* follow by providing important insights into the redox activities of melanin (<https://doi.org/10.1039/D3MA01161E>). They highlight its complexity in context-dependent

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behavior and underscore melanin's potential in bioelectronics and medical fields.

Heppner *et al.* present a theoretical study on the electronic and optical properties of poly indolequinone eumelanin (<https://doi.org/10.1039/D4MA00192C>). Their study emphasizes the fine-tune tailoring of eumelanin derivatives with halogen and electron-donating groups, towards new possibilities for their use as sustainable and high-performance materials.

Soltani *et al.* showed an *in silico* approach to evaluate the allosteric binding between eumelanin and drug molecules (<https://doi.org/10.1039/D4MA00246F>). The study underscores the complex nature of drug-eumelanin interactions

and highlights the importance of multiple factors in developing drug-delivery systems to improve the efficacy of health treatments.

The final article explore the chemical composition of the black soldier fly eumelanin (<https://doi.org/10.1039/D4MA00825A>). The authors demonstrate the presence of the dihydroxyindole carboxylic acid moiety within the polymer. For most eumelanins this is *de jure*, but a completely unexpected development for an insect-based eumelanin. This observation suggests a different chemical mechanism of formation within the black soldier fly, and also that black soldier fly eumelanin is a potential material for radical scavenging and conductivity applications.

Conclusion

We believe that exploring these insightful papers from various research domains will help readers recognize the vast scope of research being conducted on eumelanin and related materials, as well as be an inspiration for new applications and innovations in both industrial and healthcare contexts. We extend our gratitude to our colleagues worldwide for their contributions to this versatile and eco-friendly class of materials and trust that you, the reader, will find this themed collection enjoyable and enlightening.



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Carlos F. O. Graeff received his PhD in physics from the State University of Campinas (UNICAMP) in 1994. After a post-doctorate at TU München with an Alexander von Humboldt Foundation Fellowship, he joined the University of São Paulo (USP), Campus Ribeirão Preto, as assistant (1996–1999) and then associate professor (1999–2006). In 2006 he joined the State University of São Paulo (UNESP) as a full professor. He is Coordinator of Strategic Programs and Research Infrastructure in FAPESP; Fellow of the Royal Society of Chemistry; a member of the advisory board of Journal of Materials Chemistry C, Materials Advances and RSC Applied Interfaces (Royal Society of Chemistry); and member of Academia de Ciências do Estado de São Paulo (ACIESP).

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