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# ABSTRACT:

## Advanced Multifunctional Hybrid Nanostructured Materials: Key Drivers of Innovation and Sustainable Development

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Sustainability in modern industry is essential for conserving primary resources, ensuring long-term viability and recycling/recovering secondary raw materials. Businesses that adopt eco-friendly practices can minimize environmental impact while still fostering innovation and resilience. In this regard, hybrid organic-inorganic materials (HOIM) play a crucial role in advancing multiple sectors by offering unique combinations of functional properties, such as enhanced strength, conductivity, and flexibility, that traditional materials cannot achieve. These functional materials actually may drive innovation in industries like electronics, automotive, healthcare, textiles, and renewable energy, contributing to more efficient and sustainable technologies. Additionally, nanostructured HOIM shows promise in solving challenges like environmental remediation and enhanced surface performance, making them critical to the future of sustainable materials research and engineering [1]. The sol-gel method has emerged as an eco-friendly and versatile synthetic approach for developing smart multifunctional nanohybrid materials and coatings. With advantages such as low processing temperatures, high homogeneity, and non-toxic solvents, this method enables the creation of sustainable materials beneficial to both human health and the environment. Future advancements in HOIM focus on bio-based and secondary raw materials, recyclability, and adherence to circular economy principles [2]. Furthermore, a rational safe-by-design approach is therefore crucial in balancing performance, sustainability, and environmental responsibility in material sciences.

[1] Plutino, M.R. et al Gels 2024, 10, 498. Plutino, M.R. et al. Inorganics 2023, 11, 306.

[2] Plutino, M.R. et al. Patent Number WO 2021/124103 A1 and WO 2021/124097 A1.
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