III CONVEGNO PLASTAMINATION
ISTITUTO EURO-MEDITERRANEO DI SCIENZA E TECNOLOGIA (IEMEST)
VIA MICHELE MIRAGLIA N.20, PALERMO
13 FEBBRAIO 2026

ENGINEERED PARTICLES IN DRUG DELIVERY AND TISSUE ENGINEERING: IMPLICATIONS FOR PUBLIC HEALTH

Anna Barbara Di Stefano[1], Simona Di Leo[1], Mara Franza[2|3], Francesca Toia[1|2|3]

[1]BIOPLAST-Laboratory of BIOlogy and Regenerative Medicine-PLASTic Surgery, Plastic and Reconstructive Surgery Section, Department of Precision Medicine in Medical, Surgical and Critical Care, University of Palermo, Italy; [2]Plastic and Reconstructive Surgery Section, Department of Precision Medicine in Medical, Surgical and Critical Care, University of Palermo, Italy; [3]Section of Plastic and Reconstructive Surgery, Department of DAI chirurgico, Azienda Policlinico Paolo Giaccone, Palermo, Italy

Engineered particles play a central role in contemporary drug delivery and tissue engineering, enabling targeted therapies, controlled release, and advanced regenerative strategies. Micro- and nanoscale particulate systems—often based on synthetic and semi-synthetic materials—have significantly improved therapeutic efficacy and patient outcomes across a wide range of clinical applications. Among these, biocompatible hydrogels have emerged as versatile matrices capable of fostering stem cell viability, guiding differentiation and serving as injectable scaffolds for minimally invasive therapies[1,3]. Despite these advances, current research largely emphasizes material design and therapeutic efficacy, while the implications of long-term systemic exposure, biodistribution, and population-level health effects of engineered particulate systems remain insufficiently integrated. This contribution addresses this gap by adopting a cross-scale perspective that links material design and clinical functionality with emerging public health and risk assessment considerations. As the use of such particles continues to expand, important questions arise that extend beyond individual treatments and into the domain of public health. Once administered, these materials may persist, accumulate or interact with biological systems in ways that are not yet fully understood, particularly with respect to their long-term fate and systemic interactions. Moreover, their intentional design for stability, functionality and bioactivity challenges traditional distinctions between therapeutic agents and environmental or occupational exposures. This contribution provides an overview of the main classes of particles used in drug delivery and tissue engineering, focusing on their design principles, clinical advantages and safety considerations. Special attention is given to emerging evidence on systemic exposure, life-cycle aspects and the need for harmonized risk benefit assessment frameworks.

References

1. Muscolino E, Di Stefano AB, Trapani M, et al. Injectable xyloglucan hydrogels incorporating spheroids of adipose stem cells for bone and cartilage regeneration. Mater Sci Eng C Mater Biol Appl 2021;131:112545.
2. Di Stefano AB, Muscolino E, Trapani M, et al. κ-Carrageenan and PVA blends as bioinks to 3D print scaffolds for cartilage reconstruction. Int J Biol Macromol 2022;222:1861-75.
3. Di Stefano AB, Di Marco C, Toia F, et al. Effect of nanocomposite chitosan/hydroxyapatite pH-induced hydrogels on the osteogenic differentiation of spheroids from adipose stem cells. Int J Biol Macromol 2025;299:140213.