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REVIEW ON INNOVATIONS IN BIOMEDICAL COATINGS: NANOSTRUCTURED AND BIODEGRADABLE SOLUTIONS

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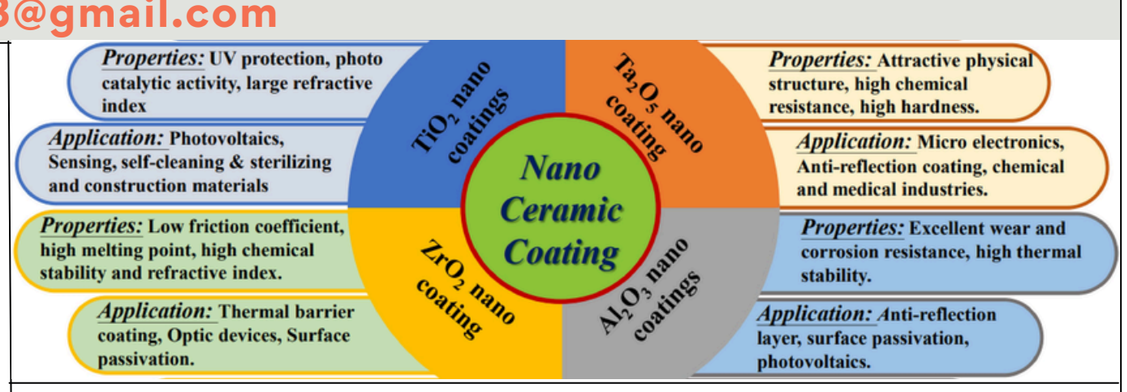
INTRODUCTION & AIM

Nanostructured and biodegradable coatings enhance biomedical applications by improving implant biocompatibility, drug delivery, and antimicrobial properties. While nanostructured coatings boost cell adhesion and controlled release, biodegradable coatings, like PLA and chitosan, ensure safe degradation without surgical removal. Their combination in hybrid coatings offers advanced solutions for implants, stents, and biosensors. This review explores recent innovations and their impact on patient care. This review highlights advancements in nanostructured and biodegradable coatings, focusing on their composition, applications, and future potential in biomedical research.

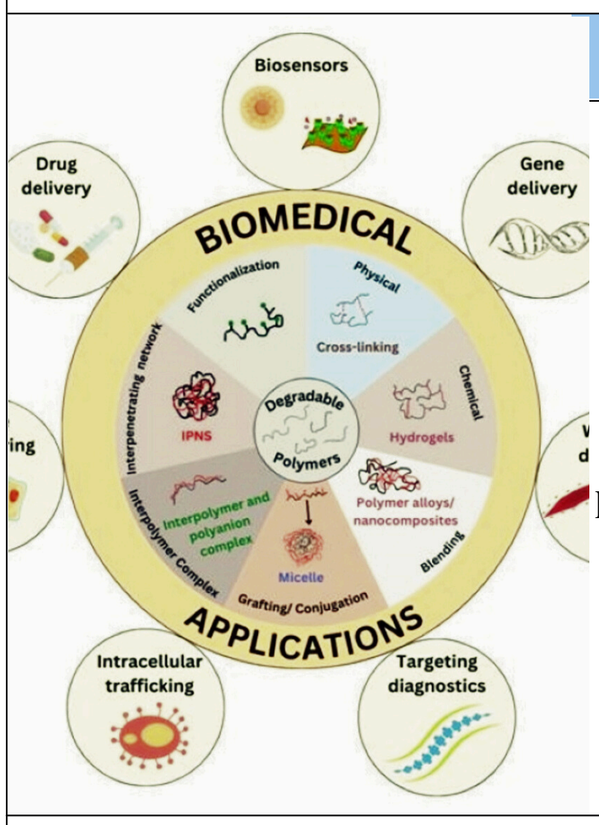
METHODOLOGY

This review examines recent studies from PubMed, ScienceDirect, and Scopus, focusing on nanostructured and biodegradable coatings. Key aspects like composition, fabrication, biocompatibility, and drug delivery were analyzed, with emphasis on hybrid coatings and future trends.



RESULTS/FINDINGS

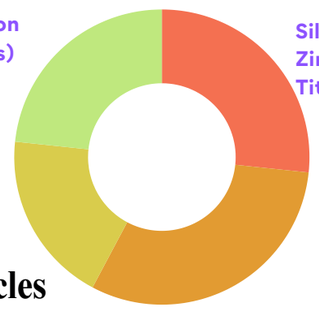
1. **Enhanced Biocompatibility** – Nanostructured coatings improve cell adhesion, antimicrobial properties, and mechanical strength, while biodegradable coatings (PLA, PCL, chitosan) enable controlled degradation, reducing surgical interventions.
2. **Improved Drug Delivery** – These coatings ensure sustained, localized drug release, minimizing side effects. Hybrid coatings offer precise control over release kinetics, benefiting implants and scaffolds.
3. **Multifunctional Hybrid Coatings** – Combining nanostructured and biodegradable materials enhances stents, orthopedic implants, and biosensors, supporting personalized medicine.



MATERIALS IN NANOSTRUCTURED AND BIODEGRADABLE BIOMEDICAL COATINGS

Carbon-Based Nanomaterials
23.3%
Graphene oxide, Carbon nanotubes (CNTs)

Metallic Nanoparticles
26.7%
Silver (Ag), Gold (Au), Zinc Oxide (ZnO), Titanium Dioxide (TiO_2)

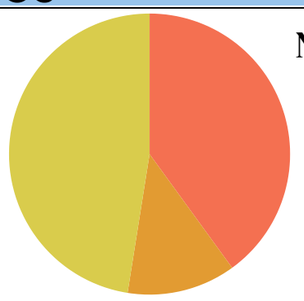


Polymeric Nanoparticles
18.9%
Poly(lactic-co-glycolic acid) (PLGA), Chitosan, Polyethylene glycol (PEG)

Ceramic Nanoparticles
31.1%
Hydroxyapatite (HA), Silica (SiO_2), Alumina (Al_2O_3)

Nanostructured Coatings

Synthetic Polymers
47.5%
Polylactic Acid (PLA), Polycaprolactone (PCL), Polyglycolic Acid (PGA), PLGA



Natural Polymers
40%
Chitosan, Gelatin, Collagen, Alginate

Hydroxyapatite (HA)
12.5%

Biodegradable Coatings

Hybrid Coatings(Ongoing Research)

PLGA/Chitosan Nanocomposites – drug release, antimicrobial activity
Hydroxyapatite/Collagen – bone regeneration
Graphene-Modified Biodegradable Polymers – enhanced mechanical and electrical properties

ANALYSIS & DISCUSSION

1. **Nanostructured Coatings:** These coatings enhance mechanical strength, antimicrobial activity, and biointegration. Metallic (Ag, ZnO) and ceramic (HA) nanoparticles improve implant longevity, while carbon-based materials (graphene, CNTs) boost strength and conductivity. However, toxicity concerns require careful control.
2. **Biodegradable Coatings:** Polymers like PLA, PCL, and chitosan enable controlled drug release and bioresorption, reducing surgical removal. Synthetic polymers offer predictable degradation, while natural ones support tissue healing but may lack strength.

CONCLUSION

Nanostructured and biodegradable coatings offer enhanced biocompatibility, antimicrobial properties, and controlled degradation, revolutionizing biomedical applications. Despite some challenges in toxicity, mechanical stability, and immune responses, hybrid coatings present a promising approach to combining nanotechnology and biodegradable materials for next-generation implants and drug delivery systems. Future research should focus on scalability, clinical translation, and smart functionalization to optimize their application in personalized medicine and regenerative therapies.

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