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Editorial

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Surface Innovations

Editorial: Nanomaterial-driven surface engineering and multifunctional composite coatings for emerging wearable and protective technologies

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In materials science, scientists around the world are trying to improve our lives every day by improving the longevity of materials by adapting and applying different technologies and engineering to them. Current research in materials science focuses on surface engineering, nanotechnology, functional coatings, composites, and smart and wearable materials for advanced applications in aerospace and the human body. The focus has shifted from merely improving materials to tailoring them for specific and advanced applications, combining engineering and design for multi-property enhancement. These possibilities have opened doors for advanced protection technology and device development tailored down to the nanoscale.

In this context, micro-arc oxidized silane composite layers (MAO-S) and their modified versions play an important role in the effective modification of surfaces, which is applied to a variety of metallic materials (e.g. Al alloys, Mg alloys, and steels). Thanks to their unique combination of thickness, mechanical properties, improved adhesion and surface protection, they can survive in a variety of harsh environments. Non-ferrous alloys are of particular interest due to their versatile applications in sectors such as transport, aerospace, electronics, communication and medicine. This is why improving their properties, especially their surface and corrosion resistance, is the predominant focus of current studies. For example, in Al alloys, one possibility for protecting the surface is structurally tunable anodic aluminum oxide, which can significantly improve the alloy's long-term corrosion resistance and durability.[1]

On the other hand, coatings and surface technologies are also revolutionizing medicine with the development of smart textiles and wearable sensors that provide direct health and condition monitoring. In addition, such technology is increasingly also developed for performance monitoring that is applicable for sports, protection services (i.e. fire, radiation, contamination protection gear). Smart and integrated wearable technology is thus crucial advanced technology, specifically in areas where direct monitoring of biological and external factors are essential, but are limited due to space, weight or comfort constrictions. Consequently, there is always a requirement to create new functional materials that can be effortlessly incorporated into garments, skin patches and other wearable devices, delivering exceptional sensitivity, weightlessness, mechanical malleability and enduring stability.[2]

One arising topic in this field is the integration of MXene-based composites that deliver cross-coupled electrical and thus functional properties. Combined with hydrogels and polymers in composite design, the functional MAX phases can be complemented with self-healing and mechanically flexible properties with specialized interface properties. In addition, the composite design enables flexibility in further functionalization of the composite material through selective etching, surface modification and intricate nanoscale structuring. Altogether this enables direct integration into garments, devices, and patches with direct skin contact.[3] Another example of smart wearable technology that will certainly change the trend in material science provides an alternative pathway, by rather than creating an entirely new material, the surface of known fabric materials is functionalized. As an example, the application of electrically conductive reduced graphene oxide onto silk fabric enables direct functionalization in both controllable and sustainable manner. Through the use of inherent properties of silk and surface compatibility with graphene oxide, this combination creates a sustainable, fully functional coating of the silk material with fewer crystal structure defects. This specific layering is made possible by an efficient, sustainable finishing technique that makes textiles more eco-friendly, while enabling high functionality of the entire wearable technology.[4]

The recent progress in materials science illustrates the increasing significance of surface engineering with nanomaterials and composite coatings for improving the functional performance of textile and metallic substrates. The reviewed studies together underscore the potential of innovative methods that utilize from MAO-S coatings, MXene-based composites, to cerium-derived hydrophobic films, and graphene oxide conductive treatments to markedly enhance corrosion resistance, electrical conductivity, mechanical stability, and sensing capabilities.

By integrating such functional nanomaterials and designs, it is possible to create multifunctional systems that boast enhanced durability, usability, adaptability, and long-term efficacy. Hybrid coating structures and surface modification strategies, in particular, enhance interfacial interactions, sealing behavior, conductivity, and environmental resistance. These advancements highlight sustainable and

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resource-efficient processing methods, especially in the fields of wearable electronics and smart textiles. Moreover, the research illustrates how the function of advanced composite architectures is growing in relation to issues of durability, hydrophobicity, biocompatibility, sustainability, and multifunctionality.

In summary, these findings indicate that combining nanotechnology with surface engineering holds promise for creating the next generation of high-performance materials suitable for corrosion protection, flexible electronics, smart sensors, and multifunctional wearable technologies in both industrial and biomedical applications.

REFERENCES

1. Zhang D, Tian X, Wang Y *et al.* (2026) Preparation and performance study of micro-arc oxidation/silane composite film layer. *Surface Innovations* **14(4)**: 164–177, 10.1680/jsuin.25.00052.
2. Mai Z, Zhu Q, Guan Y *et al.* (2026) One-step electrodeposition of cerium stearate on AAO to improve the corrosion resistance. *Surface Innovations* **14(4)**: 178–193, 10.1680/jsuin.25.00100.
3. Hasan MZ, Zahid M, Ünal M *et al.* (2026) Recent advances in MXene based wearable sensors: a mini review. *Surface Innovations* **14(4)**: 194–211, 10.1680/jsuin.25.00080.
4. Fu C, Zhang X, Li W *et al.* (2026) Non-aqueous conductive finishing of silk fabrics with graphene oxide. *Surface Innovations* **14(4)**: 212–221, 10.1680/jsuin.26.00006z.

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