Graphene-Based Approaches as Innovative Tools for Remedial and Preventive Cultural Heritage Conservation

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Tangible cultural heritage is prone to degradation. For instance, the exposition of paintings to ultraviolet (UV) and visible light, in the presence of oxidising and other harmful agents, is well-known to trigger colour changes, such as yellowing and fading. Degradation of artworks is significantly increased by disadvantageous and unstable climate conditions, lighting and pollution in museums and galleries, hence scientists urge to find novel solutions to reduce the potential for damage of cultural heritage artefacts, which constitute inestimable legacies of mankind. Over the last few years, our group has pioneered the design and the development of graphene-based solutions for the remedial and preventive conservation of tangible cultural heritage. In fact, we have deposited continuous CVD graphene veils over real paintings without altering their visual appearance, demonstrating protection factor against colour fading up to 70% [1]. This reversible and efficient solution can be extended even to paper-based cultural heritage items like – historical documents, ancient manuscripts, graphic works et al [2]. The readability for the document or the optical appearance of the artwork is not altered while graphene membranes act as protective shields, blocking humidity, oxidising agents and harmful radiation. Overall accelerated photo-ageing experiments have shown that a protection factor of 46% can be achieved for neat paper substrates.

Exploiting graphene and related materials in powder form (i.e. GNP, GO), we have also produced paints for use in both art and architecture, with intrinsic anti-fading properties and even other multifunctionalities [3]. It has been found that surface-applied GNP represent a promising, cost-effective, and minimal-intervention strategy for the conservation and re-treatment even of outdoor street-art paints [4]. Moreover, we have developed intelligent solutions for the control and adjustment of environmental conditions on storing/displaying artworks. These solutions are based on the use of graphene sensors for the early detection of humidity and temperature fluctuations and of aggressive species (*especially volatile organic compounds, VOCs*) [5,6] and of graphene aerogels with superior VOCs absorption and antifungal activity to preserve artworks against known threats, such as fungi and other pollutants [7,8].

[1] Kotsidi et al. Nature Nanotechnology 16, 1004 (2021)
[2] Submitted paper to 'Materials Today Communications' (2026)
[3] Kotsidi et al., Nanoscale 15, 5414 (2023)
[4] Submitted paper to 'Progress in Organic Coatings' (2026)
[5] Paterakis et al., Nanomaterials 12, 2684 (2022)
[6] Matsalis et al., Sensors International 5, 100272 (2024)
[7] Gorgolis et al., ChemNanoMat 8, e202200265 (2022)
[8] Gorgolis et al., Materials 17, 3174 (2024)

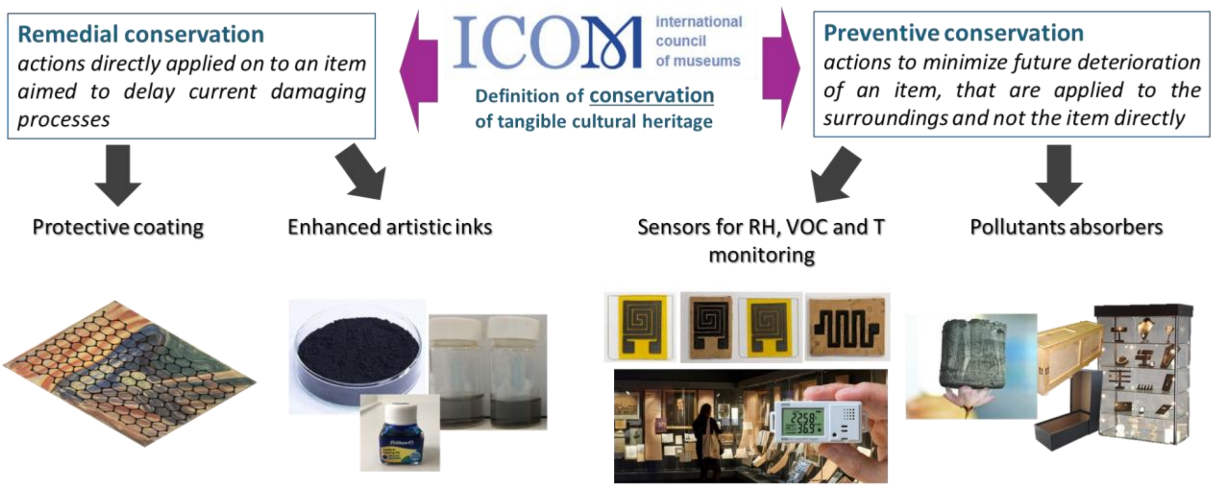

Fig. 1. The four categories of graphene-enabled solutions for the conservation of tangible cultural heritage