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ABSTRACT:

Graphene-Based Coatings for Corrosion Protection of Copper Wires: From Surface Chemistry to Functional Performance

Krzysztof Lis[1,2], Grażyna Gryglewicz[1], Mark H. Rümmeli[3], Alicja Bachmatiuk[1,3]
[1]Faculty of Chemistry, Wroclaw University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wroclaw, Poland
[2]KGHM CUPRUM sp. z o.o. Research and Development Centre
[3]Electron Beam Emergent Additive Manufacturing (EBEAM) Centre, Centre for Nanotechnlogy (CNT), Centre for Energy and Environmental Technologies (CEET), VŠB-Technical University of Ostrava, 17. Listopadu 15, 70800 Ostrava, Czech Republic

Thin protective coatings often appear deceptively simple in their final form, yet their performance is governed by subtle interplays between surface chemistry, structural integrity, and processing pathways. In this work, we explore graphene-based coatings as ultrathin barriers for copper conductors, focusing on how synthesis route, morphology, and aging conditions define their protective functionality.
The study compares graphene coatings produced via plasma-enhanced chemical vapor deposition (PECVD) and graphene oxide (GO) deposited from solution with conventional commercial varnish coatings. By subjecting submillimeter copper wires to controlled salt spray aging, we evaluate corrosion resistance under application-relevant conditions. Surface-sensitive techniques, including X-ray photoelectron spectroscopy and electron microscopy, reveal that both graphene-based approaches provide measurable protection against oxidation, with PECVD-grown graphene offering the most uniform and effective barrier due to its controlled layer formation and strong surface adhesion.
Beyond static protection, the work highlights the role of coating continuity and structural stability in maintaining functionality under environmental and thermal stress. Raman spectroscopy of transferred coatings confirms the persistence of graphitic structures after aging, while resistivity measurements demonstrate that graphene-coated wires retain electrical performance comparable to or better than commercially coated counterparts, particularly at elevated temperatures up to 320 °C.
The current perspective emerging from this study emphasizes graphene as a scalable, few-atomic-layer solution for corrosion mitigation in conductive systems. At the same time, the results point toward broader opportunities in integrating atomically thin coatings into industrial wire processing, where minimal thickness, high flexibility, and multifunctionality can be combined. Future directions include

tailoring coating uniformity and mechanical resilience, as well as extending these approaches toward more complex environments and device-relevant architectures.