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Graphene based coatings for corrosion protection

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Owing to its superior impermeability,[1] graphene shows great potential for application in anticorrosive coatings as a barrier material. Despite the initial success,[2] graphene has been eventually reported to be ineffective at long-term corrosion protection.[3] Intrinsic defects, graphene´s high conductivity and weak adhesion on metal surfaces are the main issues that hamper the use of graphene in coating technology. We have recently reported that a multilayer graphene (MLGr) coating grown via chemical vapor deposition (CVD) can effectively slow down the corrosion of Ni-seeded stainless steel (SS) in neutral media under harsh conditions[4]. This result was explained in terms of the long diffusion pathway provided by the MLGr film. Yet, this approach, although effective in long-term protection, has still various limitations. Firstly, many commercially relevant metals and alloys cannot withstand the high temperature required for CVD graphene growth. Moreover, we have reported that the MLGr coating can eventually fail to protect metals from corrosion in a different environment, i.e., acidic media.[5] As acidic species diffuse through graphene defects, they react with the nickel substrate to produce hydrogen, which is generated and trapped at metal-graphene interface. This gas build-up eventually will delaminate the coating completely from the metal surface due to the weak adhesion of MLGr film on nickel. To address these shortages of anticorrosive coatings based on CVD-grown graphene, we report a polymer-graphene hybrid coating, where single layer graphene (SLGr) sheets are sandwiched between polymer layers. These coatings exhibit outstanding long-term (120 days) protection of commercially relevant aluminum alloys in simulated seawater. Coatings fabricated with graphene layers being sandwiched with polymer layers consistently show much better corrosion performance than graphene-free reference ones. The number of graphene layers is crucial for the corrosion performance of the coating. Results show that polymer-graphene-polymer coating cannot effectively protect aluminum alloy from corrosion after 30 days of immersion, but the coating that consists of 2 graphene sheets in-between three polymer layers can perfectly protect aluminum from corrosion even after 120 days. The graphene-free reference samples, on the other hand, show signs of heavy degradation already after only 30 days of immersion. We also demonstrate that our coatings are effective corrosion barriers even when applied on steel and brass, hence highlighting the flexibility and universality of our approach. We anticipate that this type of polymer-graphene composite could provide a high-performance coating for corrosion protection of various industrially-relevant metals and alloys.

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