

Preparation of atomic layer deposition alumina/graphene porous hybrids with high adsorption capacity of Congo red

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Nanomaterials have the potential to contribute substantially to combat climate change. Hybrids based on the combination of metal oxide nanoparticle or thin films with carbon nanomaterials have attracted high attention in recent years due to their potential of use for energy conversion and pollution remediation technologies. However, a good control of homogeneity of the metal oxide deposit on the carbon surface is required to be able to provide reliable synthesis approaches of these hybrids. In this paper, atomic layer deposition (ALD) is used as a non-standard approach to deposit alumina on the surface of self-assembled graphene nanosheets. By transmission electron microscopy focused ion beam (TEM-FIB) coupling technique, we show that the graphene nanosheet walls even at the internal surface of the macroscopic material is covered by alumina. Contrary to commonly used metal-based particles or film deposit methods like impregnation, ALD approach is proved to provide a facile access to the internal porosity of the complex morphology of macroscopic porous graphene. The mechanism we propose involves the presence of the enough seeding sites on graphene for its full coverage which is rarely observed in literature without using additives such as polymers, or surfactants. The prepared ALD alumina/graphene porous hybrids with a surface as high as $284 \text{ m}^2 \text{ g}^{-1}$ have shown a remarkable Congo red (CR) adsorption capacity reaching 98 % at the second cycle of adsorption. That means that for the developed alumina/graphene 3D hybrids, the mass transfer of CR dye molecules between liquid solution and alumina surface is certainly not a limiting factor due to the multi-porosity they offer guaranteeing an ease of access to the adsorption sites.