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Growth of nano-textured graphene coatings across highly porous stainless steel supports towards corrosion resistant coatings

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ABSTRACT

In this paper, we demonstrated for the first time the growth of 3D networks of graphene nano-flakes across porous stainless steel substrates of micron sized metal fibres, and its anti-corrosion properties. The controlled formation of graphene-grade coatings in the form of single sheets to complex and homogeneously distributed 2–4 μm long nano-pillars is demonstrated by Scanning Electron Microscopy. The morphology and stability of these structures are shown to be particularly related to the temperature and feed gas flow rate during the growth. The number of layers across the graphene materials was calculated from the Raman spectra and is shown to range between 3 and more than 15 depending on the growth conditions and to be particularly related to the time and flow rate of the experiment. The presence of the graphene was shown to massively enhance the specific surface area of the material and to contribute to the increased corrosion resistance and electrical conductivity of the material without compromising the properties or structure of the native stainless steel materials. This new approach opens up a new route to the facile fabrication of advanced surface coatings with potential applications in developing new thermal exchangers, separation and bio-compatible materials.

1. Introduction

Metal based materials are particularly prone to surface oxidation and corrosion which leads to premature degradation of metal structures and loss of mechanical strength. Developing more environmentally friendly and cheaper corrosion resistant materials [1–3] will provide alternatives to current anti-corrosion technologies, including toxic hexavalent chromium

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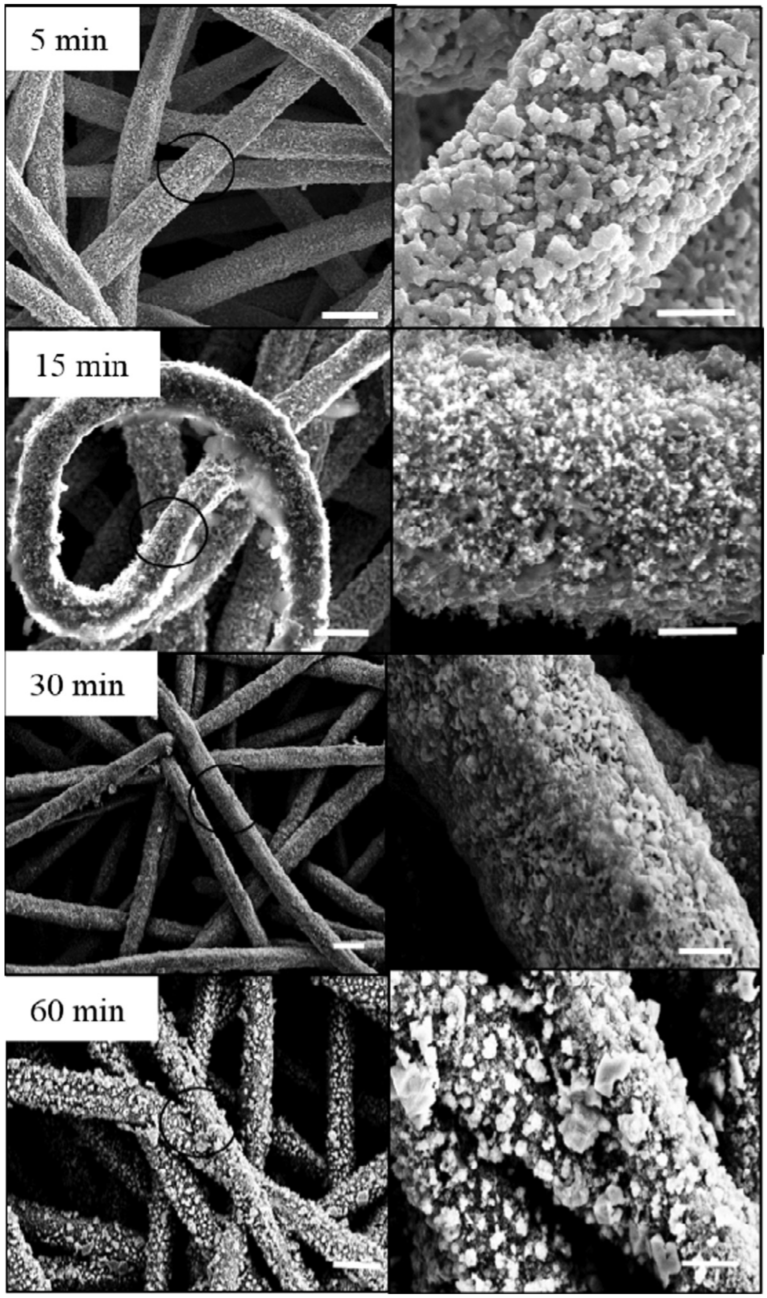

Fig. 1 – Representative SEMs of the hybrid stainless steel graphene samples as a function of the growth time (900 °C and 20 ccm hexane flow rate). The area highlighted with a black circle on the left column of images corresponds to the higher magnification on the right hand side column. Scale bars are 50 μm and 5 μm respectively.

coatings or electroplating which typically have large environmental and process footprints and lead to the generation of large volumes of toxic liquid waste [4,5]. A strategy of developing new protective coatings is the incorporation of new materials that are able to atomically bind with metals and which can improve the behaviour of the interfaces with the surrounding media or the surface properties without compromising the metal thermal or electromechanical properties [6–8].

Graphene offers highly promising opportunities for the development of active platforms with potential applications in nano-electronics, molecular separation, high strength composites, and the surface coating industries [9,10]. Recently, graphene oxide (GO) and graphene, either deposited or directly grown onto pre-formed surfaces have been shown to prevent electrochemical corrosion by acting as highly efficient impermeable barriers to corrosive species [11,12]. Corrosion is a complex phenomenon that is affected by environmental factors and metal surface conditions such as surface roughness, exposed surface area, surface energy, and the stability of oxides which is intrinsically related to the target material including its composition, purity,