the penetration of water and the dissolved oxygen or ions it carries through the coating.

There is provided a composition suitable for coating a metallic substrate that is susceptible to corrosion characterised in that the composition comprises a carrier medium, 2D material/graphitic platelets, and one or both of conductive carbon black particles and carbon nanotubes in which the 2D material/graphitic platelets comprise: nanoplates of one or more 2D materials and or nanoplates of one or more layered 2D materials and or graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers, the conductive carbon black particles have a mean particle size in the range of 1 nm to 1000 nm, and the carbon nanotubes are single or multiwalled

In an aspect, there is provided acomposition suitable for coating a metallic substrate that is susceptible to corrosion, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, wherein the composition comprises a carrier medium, 2D material/graphitic platelets, and one or both of conductive carbon black particles and carbon nanotubes, in which the 2D material/graphitic platelets comprise nanoplates of one or more 2D materials and or nanoplates of one or more layered 2D materials and or graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers, the conductive carbon black particles have a mean particle size in the range of 1 nm to 1000 nm, and the carbon nanotubes are single or multiwalled, in which the 2D material/ graphitic platelets are comprised of one or more of graphene, layered graphene, and or graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers, and in which at least 50% of the graphene, layered graphene, and or graphite flakes have an electrical conductivity greater than around 2.15×10^7 S/m at 20°C, in which the carrier medium is electrically non-conductive.

In another aspect, there is provided a coating system for a metallic substrate that is susceptible to corrosion, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, for creation of a first coating on the metallic substrate, and, subsequently, a second coating over the first coating characterised in that the first coating comprises a composition as defined above, and the second coating is

formed from a second composition which comprises a carrier medium and 2D material/graphitic platelets in which the 2D material/graphitic platelets comprise more than 0.1 wt% of the second composition.

In another aspect, there is provided a method of treatment of a metallic substrate, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, in which the substrate is coated with a composition as defined above.

In another aspect, there is provided a method of treatment of a metallic substrate, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, in which the substrate is treated with the system as defined above.

2D materials (sometimes referred to as single layer materials) are crystalline materials consisting of a single layer of atoms. Layered 2D materials consist of layers of 2D materials weakly stacked or bound to form three dimensional structures. Nanoplates of 2D materials and layered 2D materials have thicknesses within the nanoscale or smaller and their other two dimensions are generally at scales larger than the nanoscale.

2D materials used in the composition of the present invention may be graphene (C), graphyne (C), phosphorene (P), borophene (B), or a 2D in-plane heterostructure of two or more of the aforesaid materials.

Layered 2D materials may be layers of graphene (C), graphyne (C), phosphorene (P), borophene (B), or a 2D vertical heterostructure of two or more of the aforesaid materials.

The preferred 2D material is graphene.

Preferred graphene materials are graphene nanoplates, bilayer graphene nanoplates, trilayer graphene nanoplates, few-layer graphene nanoplates, and graphene nanoplates of 6 to 10 layers of carbon atoms. Graphene nanoplates

CLAIMS

1 A composition suitable for coating a metallic substrate that is susceptible to corrosion, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, wherein the composition comprises a carrier medium, 2D material/graphitic platelets, and one or both of conductive carbon black particles and carbon nanotubes, in which the 2D material/graphitic platelets comprise nanoplates of one or more 2D materials and or nanoplates of one or more layered 2D materials and or graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers, the conductive carbon black particles have a mean particle size in the range of 1 nm to 1000 nm, and the carbon nanotubes are single or multiwalled, in which the 2D material/ graphitic platelets are comprised of one or more of graphene, layered graphene, and or graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers, and in which at least 50% of the graphene, layered graphene, and or graphite flakes have an electrical conductivity greater than around 2.15×10^7 S/m at 20°C, in which the carrier medium is electrically non-conductive.

2 A composition according to claim 1 in which the 2D material/ graphitic platelets are comprised of one or more of graphene, graphyne, phosphorene, borophene, a 2D in-plane heterostructure of two or more of graphene graphyne phosphorene and or borophene, layered graphene, layered graphyne, layered phosphorene, layered borophene, a 2D vertical heterostructure of two or more of graphene graphyne phosphorene and or borophene, and or graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers.

3 A composition according to claim 1 or 2 in which the 2D material/ graphitic platelets and conductive carbon black particles and or carbon nanotubes in combination comprise between 0.002 wt% and 0.09 wt% of the composition, between 0.002 wt% and 0.004 wt% of the composition, between 0.0026 wt% and 0.04 wt% of the composition, between 0.0026 wt% and 0.0035 wt% of the composition, between 0.006 wt% and 0.009 wt% of the composition, around 0.003 wt% of the composition, or around 0.03 wt% of the composition

4 A composition according to claim 1 or 2 in which the 2D material/ graphitic platelets comprise between 0.002 wt% and 0.09 wt% of the composition, between 0.002 wt% and 0.004 wt% of the composition, between 0.0026 wt% and 0.04 wt% of the composition, between 0.0026 wt% and 0.0035 wt% of the composition, between 0.006 wt% and 0.009 wt% of the composition, around 0.003 wt% of the composition, or around 0.03 wt% of the composition.

5 A composition according to any of claims 1 to 4 in which the ratio of the weight of the 2D material/graphitic platelets to the total weight of the 2D material/graphitic platelets and conductive carbon black particles and or carbon nanotubes is 50%, 60%, 70%, 80%, 20%, 30%, 40 %, between 50 and 60%, between 50 and 70%, between 50 and 80%, between 20 and 50%, between 30 and 50%, between 40 and 50%, between 20 and 80%, between 30 and 70%, or between 40 and 60%.

6 A composition according to any of claims 1 to 5 in which at least 50% of the 2D material/ graphitic platelets and conductive carbon black particles and or carbon nanotubes are not in physical and or electrical contact with any other 2D material/ graphitic platelets and conductive carbon black particles and or carbon nanotubes.

7 A composition according to any of claims 1 to 6 in which at least one of the 2D material/ graphitic platelets and conductive carbon black particles and or carbon nanotubes have a particle size distribution with a D50 of less than 30 μm, less than 20 μm, or less than 15 μm.

8 A composition according to any of claims 1 to 7 in which the 2D material/ graphitic platelets have an electrical conductivity greater than around $3.5x10^7$ S/m at 20°C.

9 A composition according to any of claims 1 to 8 in which at least 50%of the conductive carbon black particles have an electrical conductivity greater than around $1.0x10^4$ S/m at 20°C.

10 A composition according to any of claims 1 to 8 in which at least 50% of the carbon nanotubes have an electrical conductivity greater than around $1.00x10^6$ S/m at 20°C.

11 A composition according to any of claims 1 to 10 in which at least 50 wt% of the 2D material/ graphitic platelets are comprised of graphite flakes with nanoscale dimensions and 25 or less layers.

12 A composition according to any of claims 1 to 11 in which the carrier medium is selected from crosslinkable resins, non-crosslinkable resins, thermosetting acrylics, aminoplasts, urethanes, carbamates, polyesters, epoxies, silicones, polyureas, silicates, polydimethyl siloxanes, and mixtures and combinations thereof.

13 A composition according to any of claims 1 to 12 in which the carrier medium is plastically deformable once it has set / cured

14 A composition according to any of claims 1 to 13 in which the composition further comprises a solvent.

15 A composition according to any of claims 1 to 14 in which the composition further comprises a dispersant.

16 A coating system for a metallic substrate that is susceptible to corrosion, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, for creation of a first coating on the metallic substrate, and, subsequently, a second coating over the first coating characterised in that the first coating comprises a composition according to any of claims 1 to 15, and the second coating is formed from a second composition which comprises a carrier medium and 2D material/graphitic platelets in which the 2D material/graphitic platelets comprise more than 0.1 wt% of the second composition.

17 A coating system according to claim 16 in which the 2D material/graphitic platelets of the second composition one of or a mixture of two or more of graphene,

graphene oxide, reduced graphene oxide nanoplates, hexagonal boron nitride, molybdenum disulphide, tungsten diselenide, silicene, germanene, Graphyne, borophene, phosphorene, a 2D in-plane heterostructure of two or more of graphene, graphene oxide, reduced graphene oxide nanoplates, hexagonal boron nitride, molybdenum disulphide, tungsten diselenide, silicene, germanene, Graphyne, borophene, phosphorene, bilayer graphene, bilayer graphene oxide, bilayer reduced graphene oxide nanoplatelets, few-layer graphene, few-layer graphene oxide, few-layer reduced graphene oxide nanoplatelets, graphite flakes in which the graphite flakes have one nanoscale dimension and 25 or less layers, layered hexagonal boron nitride (hBN), molybdenum disulphide (MoS_2), tungsten diselenide (WSe_2), silicene (Si), germanene (Ge), Graphyne (C), borophene (B), phosphorene (P), and or a 2D vertical heterostructure of two or more of the aforesaid materials.

18 A coating system according to claim 16 or 17 in which the 2D material/graphitic platelets of the second composition comprise between 0.1 wt% and 20 wt% of the composition, between 0.1 wt% and 6.0 wt% of the composition, or between 0.1 wt% and 0.5 wt% of the composition.

19 A coating system according to any of claims 16 to 18 in which more than 50% of the 2D material/graphitic platelets of the second composition have an electrical conductivity which is less than the electrical conductivity of more than 50% of the graphene platelets of the first composition.

20 A coating system according to any of claims 16 to 19 in which more than 50% of the 2D material/graphitic platelets of the second composition have an electrical conductivity of around or less than $2.0x10^{-5}$ S/m at 20°C.

21 A method of treatment of a metallic substrate, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, in which the substrate is coated with a composition according to any of claims 1 to 15.

22 A method of treatment of a metallic substrate, in which the substrate is aluminium, an aluminium alloy, or a magnesium based alloy, in which the substrate is treated with the system according to any of claims 16 to 20.