advantageously exhibit excellent antimicrobial properties. Further advantageously, LDH may have excellent biocompatibility.

There is provided a method of preparing a substrate coated with a surface-modified layered double hydroxide, the method comprising the steps of:

providing a substrate coated with a layered double hydroxide having the following structure (A):

$$[M^{2+}_{(1-x)}N^{3+}_{x}(HO^{-})_{2}]^{x+}[(X^{n-})_{x/n}.yH_{2}O]^{x-} \quad (A)$$

wherein

M^{2+} is a divalent cation;

N^{3+} is a trivalent cation;

x is in the range of 1/6 to 1/2;

y is in the range of 0.5 to 4;

X^{n-} is an anion; and

n is an integer selected from 1, 2 or 3; and

Further advantageously, the modified layered double hydroxide may be coated on a variety of substrates such as glass, plastics, metals, ceramics, silicone and any mixture thereof. This makes the process versatile, with the ability to be adapted to a variety of applications. More advantageously, the coating may adhere strongly to the substrate.

There is provided the use of a layered double hydroxide as an antimicrobial, the layered double hydroxide having the following structure (A):

$$[M^{2+}_{(1-x)}N^{3+}_{x}(HO^{-})_{2}]^{x+}[(X^{n-})_{x/n}.yH_{2}O]^{x-} \qquad (A)$$

wherein

M^{2+} is a divalent cation;

N^{3+} is a trivalent cation;

x is in the range of 1/6 to 1/2;

y is in the range of 0.5 to 4;

X^{n-} is an anion; and

n is an integer selected from 1,2 or 3;

wherein the layered double hydroxide is surface modified with a group 10 element on the Periodic Table of Elements or a compound selected from the group consisting of: a fatty acid, a polymer, and an amino acid.

Advantageously, surface modification may alter the hydrophilicity of the layered double hydroxide, thereby resulting in a reduction in microbial count on the surface. Advantageously, the surface modified layered double hydroxide may achieve up to 7 log reduction of bacteria. Further advantageously, surface modified layered double hydroxide may have good blood clearance and may be well absorbed by the human body, making them extremely biocompatible.

There is provided the use of a calcined layered double hydroxide as an antimicrobial, the layered double hydroxide having the following structure (A):

$$[M^{2+}_{(1-x)}N^{3+}_{x}(HO^{-})_{2}]^{x+}[(X^{n-})_{x/n}.yH_{2}O]^{x-} \qquad (A)$$

wherein

X^{n-} is an anion; and

n is an integer selected from 1, 2 or 3.

In one aspect, there is provided use of a calcined layered double hydroxide as an antimicrobial, the layered double hydroxide (LDH) having the following structure (A):

$$[M^{2+}_{(1-x)}N^{3+}_{x}(HO^{-})_2]^{x+}[(X^{n-})_{x/n}.yH_2O]^{x-} \quad (A)$$

wherein

M^{2+} is a divalent cation;

N^{3+} is a trivalent cation;

x is in the range of 1/6 to 1/2;

y is in the range of 0.5 to 4;

X^{n-} is an anion; and

n is an integer selected from 1, 2 or 3,

wherein the LDH has an average spacing between each piece of adjacent LDH in the range of 300 nm to 550 nm.

Advantageously, the calcined layered double hydroxide may have antimicrobial properties even without any surface modification.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term ‘vertically aligned’, for the purposes of this disclosure, is to be interpreted broadly to refer to the orientation of an individual layered double hydroxide piece with respect to the surface it is on. An LDH is said to be vertically aligned if its longitudinal axis is approximately perpendicular to the surface. Approximately perpendicular means to have an angle, relative to the surface it is on, in the range of about 85º to about 95º, more preferably in the range of about 88º to 92º. A group of LDH is said to be vertically aligned if at least 70% of the LDH in the group are vertically aligned.

The word “substantially” does not exclude “completely” e.g. a composition which is “substantially free” from Y may be completely free from Y. Where necessary, the word “substantially” may be omitted from the definition of the invention.

Unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, unrecited elements.

As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Certain embodiments may also be described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the disclosure. This includes the generic description of the embodiments with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

Claims

1. Use of a calcined layered double hydroxide as an antimicrobial, the layered double hydroxide (LDH) having the following structure (A):

   $[M^{2+}_{(1-x)}N^{3+}_{x}(HO^{-})_2]^{x+}[(X^{n-})_{x/n}.yH_2O]^{x-}$ (A)

   wherein

   M^{2+} is a divalent cation;

   N^{3+} is a trivalent cation;

   x is in the range of 1/6 to 1/2;

   y is in the range of 0.5 to 4;

   X^{n-} is an anion; and

   n is an integer selected from 1, 2 or 3,

   wherein the LDH has an average spacing between each piece of adjacent LDH in the range of 300 nm to 550 nm.

2. The use of claim 1, wherein the divalent cation is selected from a group 2, group 7, group 8, group 9, group 10, group 11 or group 12 element on the Periodic Table of Elements.

3. The use of claim 1 or 2, wherein the divalent cation is selected from the group consisting of Mg^{2+}, Zn^{2+}, Cu^{2+}, Ni^{2+} and Co^{2+}.

4. The use of any one of claims 1 to 3, wherein the trivalent cation is selected from a group 6, group 8, or group 13 element on the Periodic Table of Elements.

5. The use of any one of claims 1 to 4, wherein the trivalent cation is selected from the group consisting of Al^{3+}, Fe^{3+} and Cr^{3+}.

6. The use of any one of claims 1 to 5, wherein the stoichiometric M^{2+}:N^{3+} ratio is in the range of 1:1 to 5:1.

7. The use of any one of claims 1 to 6, wherein X^{n-} is NO_3^- or Cl^- and n is 1.

8. The use of any one of claims 1 to 6, wherein X^{n-} is SO_4^{2-} and n is 2.

9. The use of any one of claims 1 to 8, wherein the layered double hydroxide is vertically aligned.

10. The use of any one of claims 1 to 9, wherein the layered double hydroxide has a hexagonal shape.

11. The use of any one of claims 1 to 10, wherein the layered double hydroxide has an average thickness in the range of 50 nm to 175 nm.

12. The use of any one of claims 1 to 11, wherein the calcined layered double hydroxide has an average thickness in the range of 50 nm to 100 nm.

13. The use of any one of claims 1 to 12, wherein the substrate is selected from the group consisting of glass, plastic, metal or alloy, ceramic, silicone and any mixture thereof.