Claims

1. A process of forming an organic barrier layer in a porous material in need thereof, the process comprising the steps of:

(a) providing a porous material in need thereof and a bio-gelation mixture, the bio-gelation mixture comprising:

water;

a polysaccharide suitable for crosslinking;

glucose in an amount of from 1 to 3 g/L; and

a bacterial population suitable for converting glucose to a carboxylic acid which is provided as a bacterial suspension having a bacterial density (OD_{600}) of from 0.3 to 0.8 in an amount of from 5 to 30 mL/L; and

(b) injecting the bio-gelation mixture into; or

spraying the bio-gelation mixture onto a surface of the porous material to form an organic barrier layer comprising the polysaccharide crosslinked by a plurality of calcium ions, wherein the plurality of calcium ions are obtained from reaction of the carboxylic acid with a calcium ion source, where the calcium ion source is present in the porous material and/or is added as an additional component within the bio-gelation mixture.

2. The process according to Claim 1, wherein the bio-gelation mixture comprises:

water;

a polysaccharide in a concentration of from 1 to 10 g/L; and

a calcium ion source provided in an amount of from 0 wt%, or in an amount sufficient to provide from 0.5 to greater than 1 wt% in a volume of the porous material that is to form part of the organic barrier layer.

3. The process according to Claim 2, wherein the bio-gelation mixture comprises:

water;

a polysaccharide in a concentration of from 2 to 4 g/L, such as about 3 g/L;

glucose in an amount of about 2 g/L;

a bacterial population suitable for converting glucose to a carboxylic acid which is provided as a bacterial suspension having a bacterial density (OD_{600}) of about 0.60 in an amount of about 15 mL/L; and

a calcium ion source provided in an amount of from 0 wt% to an amount sufficient to provide from 0.8 to 1.8 wt% in a volume of the porous material that is to form part of the organic barrier layer.

4. The process according to any one of the preceding claims, wherein the porous material in need thereof is one or more of the group consisting of a sand, and a soil, optionally wherein the porous material in need thereof is a sand (e.g. Ottawa sand and/or Coral sand).

5. The process according to any one of the preceding claims, wherein the porous material in need thereof comprises from 0.5 to 1.8 wt%, such as from 0.8 to 1.5 wt%, such as from 0.86 to 1 wt% of a calcium ion source.

6. The process according to any one of the preceding claims, wherein the calcium ion source is $CaCO_3$, optionally wherein, when the $CaCO_3$ forms part of the bio-gelation mixture, it has a diameter of less than or equal to 50 μm.

7. The process according to any one of the preceding claims, wherein the polysaccharide suitable for crosslinking is an alginate, optionally wherein the alginate is sodium alginate.

8. The process according to any one of the preceding claims, wherein the bacterial population suitable for converting glucose to a carboxylic acid is derived from activated sludge.

9. The process according to Claim 8, wherein the activated sludge is incubated in an aqueous medium comprising yeast and KH_2PO_4 at pH 7 for about 24 hours and is then centrifuged to provide a bio-mass pellet for resuspension and formation of the bacterial population.

10. The process according to any one of the preceding claims, wherein the bio-gelation mixture is used immediately after its formation, where the bio-gelation mixture is formed by mixing the polysaccharide suitable for crosslinking, glucose, the bacterial population suitable for converting glucose to a carboxylic acid and, when present, the calcium ion source in water.

11. The process according to any one of Claims 1 to 9, wherein the bio-gelation mixture is used after a period of from 1 to 24 hours after its formation, where the bio-gelation mixture is formed by mixing the polysaccharide suitable for crosslinking, glucose, the bacterial population suitable for converting glucose to a carboxylic acid and, when present, the calcium ion source in water.

12. The process according to any one of the preceding claims, wherein in step (b) of Claim 1, the formation of the organic barrier layer occurs over a period of from 1 hour to 4 days, such as from 2 hours to 2 days, such as from 3 hours to 38 hours.

13. The process according to any one of the preceding claims, wherein in step (b) of Claim 1, the porous material in need thereof has a temperature of from 0 to 60 °C, such as from 5 to 50 °C, such as from 10 to 40 °C, such as from 15 to 37 °C, such as from 20 to 25 °C.

14. The process according to any one of the preceding claims, wherein the permeability of the organic barrier layer is in the order of from $1x10^{-8}$ to $1x10^{-5}$ m/s, such as from $1x10^{-7}$ to $1x10^{-6}$ m/s.

15. The process according to any one of the preceding claims for mitigating wave erosion of a beach or a shoreline, the process involving:

(i) spraying the bio-gelation mixture onto a surface of a porous material in need thereof to form the organic barrier layer;

(ii) placing a porous material on top of the formed organic barrier layer; and

(iii) subjecting the porous material placed on top of the formed organic barrier layer to microbially-induced calcium carbonate precipitation to form a calcium enriched layer on top of the organic barrier layer.

16. The process according to any one of claims 1 to 14 for mitigating wave erosion of a beach or a shoreline, the process involving:

(ia) injecting the bio-gelation mixture into a porous material in need thereof at a defined depth to form the organic barrier layer, with a portion of the porous material undisturbed on top of the formed organic barrier layer; and

(iia) subjecting the undisturbed porous material on top of the formed organic barrier layer to microbially-induced calcium carbonate precipitation to form an inorganic barrier layer on top of the organic barrier layer.

17. The process according to any one of the preceding claims, wherein the process does not involve a step of microbially-induced calcium carbonate precipitation process before or during steps (a) and (b) of Claim 1.