

Claims

1. A process for producing functionalized organic molecules having 1 to 3 carbon atoms, in particular selected from the group consisting of ethanol, methanol, formic acid, acetic acid, malonic acid, acetone and a mixture of at least two of the afore-said functionalized organic molecules, comprising the step of
- 5 - contacting carbon dioxide as the only gas or a gas mixture comprising or consisting of carbon dioxide and methane in presence of water with a catalyst comprising or consisting of permanently polarized hydroxyapatite.
2. The process according to claim 1, characterized in that the permanently polarized hydroxyapatite has
- a crystallinity > 65 %, in particular > 70 %, preferably > 75 %, more preferably from 65 % to 99 %, and/or
- a proportion of amorphous calcium phosphate < 18 % by weight, in particular from 0.1 % by weight to 17 % by weight, based on the total weight of the permanently polarized hydroxyapatite, and/or
- 10 - a proportion of β -tricalcium phosphate < 36 % by weight, in particular from 0.1 % by weight to 35 % by weight, based on the total weight of the permanently polarized hydroxyapatite, and/or
- a bulk resistance from $10^7 \Omega \text{ cm}^2$ to $10^5 \Omega \text{ cm}^2$, in particular $10^6 \Omega \text{ cm}^2$ to $10^5 \Omega \text{ cm}^2$, wherein the bulk resistance preferably increases by only 4 % to 73 %, in particular 4 % to 63 %, preferably by 4%, after 3 months, and/or
- 15 - a surface capacitance decreasing less than 8%, in particular from 8 % to 0.1 %, preferably 5 % to 3 %, after 3 months.
3. The process according to claim 1 or 2, characterized in that the permanently polarized hydroxyapatite is obtained by a process comprising the steps of
- 20 (a) preparing samples of hydroxyapatite,
- (b) sintering the samples prepared in step (a) at a temperature between 700 °C and 1200 °C,
- (c) applying a constant or variable DC voltage between 250 V and 2500 V, in particular for at least 1 minute at a temperature between 900 °C and 1200 °C, to the samples obtained in step (b) or to shaped bodies thereof or
- 25 applying an equivalent electric field between 1.49 kV/cm and 15 kV/cm, in particular for at least 1 minute at a temperature between 900 °C and 1200 °C, to the samples obtained in step (b) or to shaped bodies thereof or

- applying an electrostatic discharge between 2500 V and 1500000 V, in particular for less than 10 minutes at a temperature between 900 °C and 1200 °C, to the samples obtained in step (b) or to shaped bodies thereof or
- applying an equivalent electric field between 148.9 kV/cm and 8928 kV/cm, in particular for less than 10 minutes at a temperature between 900 °C and 1200 °C, to the samples obtained in step (b) or to shaped bodies thereof and
- (d) cooling the samples obtained in step (c) maintaining the DC voltage or the equivalent electric field or
- cooling the samples obtained in step (c) maintaining or without maintaining the electrostatic discharge or the equivalent electric field.
4. The process according to any of the preceding claims, characterized in that the permanently polarized hydroxyapatite is obtained by a process comprising the steps of
- (a) preparing samples of hydroxyapatite,
- (b) sintering the samples prepared in step (a) at a temperature of 1000 °C, in particular for 2 h,
- (c) applying an equivalent electric field of 3 kV/cm at a temperature of 1000 °C, in particular for 1 h, to the samples obtained in step (b) or to shaped bodies thereof and
- (d) cooling the samples obtained in step (c) maintaining the equivalent electric field, in particular for 30 minutes.
5. The process according to any of the preceding claims, characterized in that the contacting step is carried out in the presence of liquid water.
6. The process according to any of the preceding claims, characterized in that the contacting step is carried out with a volumetric ratio of the permanently polarized hydroxyapatite to water, in particular liquid water, of 1000:1 to 0.01:1, in particular 500:1 to 100:1, preferably 300:1 to 350:1.
7. The process according to any of the preceding claims, characterized in that the contacting step is carried out with a volumetric ratio of carbon dioxide to methane of 200:1, in particular 3:1, preferably 1:1.
8. The process according to any of the preceding claims, characterized in that the contacting step is carried out under a total pressure of 0.1 bar to 100 bar, in particular 1 bar to 10 bar, preferably of 6 bar.

9. The process according to any of the preceding claims, characterized in that the contacting step is carried out under a pressure of carbon dioxide of 0.035 bar to 100 bar, in particular 1 bar to 6 bar, preferably of 6 bar.
10. The process according to any of the preceding claims, characterized in that the contacting step is carried out under a partial pressure of carbon dioxide of 0.035 bar to 90 bar, in particular 1 bar to 3 bar, preferably of 3 bar, and/or under a partial pressure of methane of 0.00017 bar to 5 bar, in particular 1 bar to 3 bar, preferably of 3 bar.
11. The process according to any of the preceding claims, characterized in that the contacting step is carried out with a molar ratio of carbon dioxide to permanently polarized hydroxyapatite of 0.1 to 0.5, in particular 0.2 to 0.5, preferably 0.3 to 0.5, and/or with a molar ratio of methane to permanently polarized hydroxyapatite of 0.1 to 0.5, in particular 0.2 to 0.5, preferably 0.3 to 0.5.
12. The process according to any of the preceding claims, characterized in that the contacting step is carried out under UV irradiation or UV-Vis irradiation having a wavelength from 200 nm to 850 nm, in particular 240 nm to 400 nm, preferably 250 nm to 260 nm, more preferably of 253.7 nm.
13. The process according to any of the preceding claims, characterized in that the contacting step is carried out under UV irradiation and or Visible light irradiation, in particular having a irradiance from 0,1 W/m² to 200 W/m², in particular 1 W/m² to 50 W/m², preferably 2 W/m² to 10 W/m².
14. The process according to any of the preceding claims, characterized in that the contacting step is carried out at a temperature of 25 °C to 250 °C, in particular 95 °C to 140 °C, preferably of 95 °C.
15. Use of a process according to any of the preceding claims for producing ethanol, or a mixture comprising or consisting of ethanol and at least one further functionalized organic molecule selected from the group consisting of methanol, formic acid, acetic acid, malonic acid and acetone, or a mixture comprising or consisting of ethanol, methanol, formic acid, acetic acid and acetone, in particular with ethanol as a major reaction product, or a mixture comprising or consisting of ethanol, methanol, acetic acid, malonic acid and acetone, in particular with ethanol as a major reaction product.

16. Use of a process according to any of the preceding claims for removing carbon dioxide from the atmosphere.
