NANOPARTICLES FOR USE FOR ENHANCING BRAIN PERFORMANCES OR FOR TREATING STRESS

SUMMARY

The present invention relates to the medical field, in particular to the enhancement of brain performances and to the treatment of pathological stress. In one example, the present invention relates to use of a nanoparticle or nanoparticles' aggregate for the prevention or treatment of a symptom of pathological stress selected from deterioration in learning and memory capacity in a subject, when the nanoparticle or nanoparticles' aggregate is to be exposed to an electric field, wherein the nanoparticle's or nanoparticles' aggregate's material is gold or an insulator material with a band gap Eg equal to or above 3.0 eV and with a relative dielectric constant ε_{ijk} equal to or below 100, the relative dielectric constant ε_{ijk} being measured between 20°C and 30°C and between 10^2 Hz up to the infrared frequency, which is ZrO_2 or HfO_2.

In another example, the present invention relates to use of a composition in the manufacture of a medicament for the prevention or treatment of a symptom of pathological stress selected from deterioration in learning and memory capacity in a subject exposed to an electric field, wherein the composition comprises nanoparticles and/or nanoparticles' aggregates and a pharmaceutically acceptable support, and wherein the nanoparticle's or nanoparticles' aggregate's material gold, or an insulator material with a band gap Eg equal to or above 3.0 eV and with a relative dielectric constant ε_{ijk} equal to or below 100, the relative dielectric constant ε_{ijk} being measured between 20°C and 30°C and between 10^2 Hz up to the infrared frequency, which is ZrO_2 or HfO_2,and the nanoparticles or nanoparticles' aggregates are exposed to an electric field.

BACKGROUND

With advancing comprehension of neuroscience, brain can be thought as an electric network, coding and transmitting information through its electric wires, neurons. Connectivity between neurons is simple and complex at the same time: simple because it lies on influx/efflux of ions inside neurons, which result in action potentials (or "spikes" of electric activity); complex because the brain network is composed of hundreds of billion neurons, which form nodes, hubs and modules that demonstrate

coordinated interactions, at various spatial and temporal scales (*Fornito* et al., *Nature Reviews Neuroscience, 2015, 16, 159-172: The connectomics of brain disorders*). Neural communication depends on the anatomical components that connect individual neurons (structure) and on the process of transmitting information (function). Both aspects affect the overall performance of the nervous system. Neuronal interactions are traduced by oscillations of the brain electric activity pattern, which oscillations are measurable typically by electroencephalogram (EEG). Different frequency bands of oscillations are observed: delta, theta, alpha, beta, gamma (*Ward* et al., *Trends in Cognitive Sciences, 2003, 7(12), 553-559: Synchronous neural oscillations and cognitive processes*). Structurally, the most striking neuroanatomical feature of the brain is the abundant connectivity between neurons, which reflects the importance of neural communication. Synchronization of oscillations ("synchrony") between one brain area and another seems to constitute the last level of information coding [first level (neuron): action potentials; second level (neuronal network(s)): neuronal oscillations] by bringing spatio-temporal coordination (*Engel* et al., *Nature Reviews Neuroscience, 2001, 2, 704-716: Dynamic predictions: oscillations and synchrony in top-down processing*). Importantly, evidence is emerging that a delicately balanced pattern of synchronization and desynchronization in space and time is fundamental to the functional performance of the nervous system (*Schnitzler* et al., *Nature Reviews Neuroscience, 2005, 6, 285-296: Normal and pathological oscillatory communication in the brain*).

CLAIMS

1. Use of a nanoparticle or nanoparticles' aggregate in the manufacture of a medicament for the prevention or treatment of a symptom of pathological stress selected from deterioration in learning and memory capacity in a subject, when the nanoparticle or nanoparticles' aggregate is to be exposed to an electric field, wherein the nanoparticle's or nanoparticles' aggregate's material is gold or an insulator material with a band gap Eg equal to or above 3.0 eV and with a relative dielectric constant ε_{ijk} equal to or below 100, the relative dielectric constant ε_{ijk} being measured between 20°C and 30°C and between 10^2 Hz up to the infrared frequency, which is ZrO_2 or HfO_2.

2. Use according to claim 1, wherein the nanoparticle and/or nanoparticles' aggregate is coated with a biocompatible agent conferring a neutral surface charge, or with a biocompatible agent conferring a negative surface charge.

3. Use according to claim 2, wherein the biocompatible agent conferring a neutral surface charge is a hydrophilic agent displaying a functional group selected from an alcohol (R-OH), an aldehyde (RCOH), a ketone (R-CO-R), an ester (R-COOR), an acid (R-COOH), a thiol (R-SH), a saccharide, glucose, fructose, ribose, an anhydride (RCOOOC-R), or a pyrrole.

4. Use according to claim 3, wherein R is selected from a thiol, a silane, a carboxylic or a phosphate group.

5. Use according to claim 2, wherein the biocompatible agent conferring a negative surface charge is a phosphate or a sulphate.

6. Use according to claim 5, wherein the biocompatible agent conferring a negative surface charge is selected from a polyphosphate, a metaphosphate, or a pyrophosphate.

7. The use according to any one of claims 1 to 6, wherein the electric field is to be applied through transcranial electric stimulation or transcranial magnetic stimulation.

8. The use according to anyone of claims 1 to 7, wherein the nanoparticle or nanoparticles' aggregate also enhances physical performances, sense perception and/or decision making of the subject.

9. Use of a composition in the manufacture of a medicament for the prevention or treatment of a symptom of pathological stress selected from deterioration in learning and memory capacity in a subject exposed to an electric field, wherein the composition comprises nanoparticles and/or nanoparticles' aggregates and a pharmaceutically acceptable support, and wherein the nanoparticle's or nanoparticles' aggregate's material is gold, or an insulator material with a band gap Eg equal to or above 3.0 eV and with a relative dielectric constant ε_{ijk} equal to or below 100, the relative dielectric constant ε_{ijk} being measured between 20°C and 30°C and between 10^2 Hz up to the infrared frequency, which is ZrO_2 or HfO_2, and the nanoparticles or nanoparticles' aggregates are to be exposed to an electric field.

10. The use according to claim 9, wherein the nanoparticle and/or nanoparticles' aggregate is coated with a biocompatible agent conferring a neutral surface charge, or with a biocompatible agent conferring a negative surface charge.

11. The use according to claim 10, wherein the biocompatible agent conferring a neutral surface charge is a hydrophilic agent displaying a functional group selected from an alcohol (R-OH), an aldehyde (RCOH), a ketone (R-CO-R), an ester (R-COOR), an acid (R-COOH), a thiol (R-SH), a saccharide, glucose, fructose, ribose, an anhydride (RCOOOC-R), or a pyrrole.

12. The use according to claim 11, wherein R is selected from a thiol, a silane, a carboxylic or a phosphate group.

13. The use according to claim 10, wherein the biocompatible agent conferring a negative surface charge is a phosphate or a sulphate.

14. The use according to claim 13, wherein the biocompatible agent conferring a negative surface charge is selected from a polyphosphate, a metaphosphate, or a pyrophosphate.

15. The use of any of claims 9 to 14, wherein the composition comprises at least two distinct nanoparticles and/or nanoparticles' aggregates, each nanoparticle or nanoparticles' aggregate consisting of a distinct material selected from gold, ZrO_2 or HfO_2.