Claims:

1. A carbon allotrope-silica composite material comprising:

- a silica microcapsule comprising:

- a silica shell having a thickness of from 50 nm to 500 µm, and a plurality of pores,

said shell forming a capsule having a diameter from 0.2 µm to 1500 µm, and having a density of 0.001 g/cm^3 to 1.0 g/cm^3,

wherein said shell comprises from 0% to 70% Q3 configuration, and from 30% to 100% Q4 configuration, or

wherein said shell comprises from 0% to 60% T2 configuration and from 40% to 100% T3 configuration, or

wherein said shell comprises a combination of T and Q configurations thereof, and

wherein an exterior surface of said capsule is covered by a functional group;

- a carbon allotrope attached to said silica microcapsule, wherein said carbon allotrope is selected from the group consisting of a graphite, a graphene, a carbon nanofiber, a carbon nanotubes, a C60 fullerene, a C70 fullerene, a C76 fullerene, a C82 fullerene, a C84 fullerene, and a combination thereof.

2. The carbon allotrope-silica composite material of claim 1, wherein said thickness of said silica shell is from 50 nm to 240 µm.

3. The carbon allotrope-silica composite material of claim 1, wherein said diameter of said silica microcapsule is from 0.2 µm to 500 µm.

4. The carbon allotrope-silica composite material of claim 1, wherein said density of said silica microcapsule is from 0.01 g/cm^3 to 0.5 g/cm^3.

5. The carbon allotrope-silica composite material of any one of claims 1 - 2, wherein said carbon allotrope is attached covalently to said functional group of said silica microcapsule.

6. The carbon allotrope-silica composite material of any one of claims 1 - 2, wherein said carbon allotrope is attached non-covalently to the surface of said silica microcapsule.

7. The carbon allotrope-silica composite material of any one of claims 1 - 2, wherein said functional group of said silica microcapsule is a hydroxyl group, a carboxylic acid group, a thiol group, an amino group, a benzylamino group, a chloropropyl group, a disulfide group, an epoxy group, a methacrylate group, a vinyl group, and combinations thereof.

8. The carbon allotrope-silica composite material of any one of claims 1 - 7, wherein said carbon allotrope is functionalized or not functionalized.

9. The carbon allotrope-silica composite material of any one of claims 1 - 8, wherein said carbon allotrope comprises a functional group chosen from a nitrogen-containing functional group, an oxygen containing functional group, a sulfur-contaning functional group, a halogen-containing functional group and a combination thereof.

10. The carbon allotrope-silica composite material of claim 9, wherein said nitrogen-containing functional group is an amine group, a ketimine group, an aldimine group, an imide group, an azide group, an azo group, a cyanate group, an isocyanate group, a nitrate group, a nitrile group, a nitrite group, a nitroso group, a nitro group, a pyridyl group and a combination thereof.

11. The carbon allotrope-silica composite material of claim 9, wherein said sulfur-containing functional group is an sulfhydryl group, a sulfide group, a

disulfide group, a sulfinyl group, a sulfonyl group, a sulfo group, a thiocyanate group, carbonothioyl group, carbonothioyl group and a combination thereof.

12. The carbon allotrope-silica composite material of claim 9, wherein said oxygen-containing functional group is an hydroxyl group, a carbonyl group, an aldehyde group, a carboxylate group, a carboxyl group, an ester group, a methoxy group, a peroxy group, an ether group, a carbonate ester and a combination thereof.

13. The carbon allotrope-silica composite material of claim 9, wherein said halogen-containing functional group is a fluoro, a chloro, a bromo, an iodo and a combination thereof.

14. The carbon allotrope-silica composite material of any one of claims 1, and 6 - 13, wherein said silica shell of said silica microcapsule comprises from 40% Q3 configuration and 60% Q4 configuration, or from 100% Q4 configuration.

15. The carbon allotrope-silica composite material of any one of claims 1, and 6 - 14, wherein said pores of said silica microcapsule have pore diameters from 0.5 nm to 100 nm.

16. The carbon allotrope-silica composite material of claim 1 to 15, wherein said functional group of said silica microcapsules is provided by an organosilane chosen from a trimethoxysilane, a triethoxysilane, a tripropoxysilane, 3-aminopropyltriethoxysilane, vinyltriacetoxy silane, a vinyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane, 3-methacryloxypropyltrimethoxysilane, 3-chloropropyltriethoxysilane, a bis-(triethoxysilylpropyl)tetrasulfane, a methyltriethoxysilane, a n-octyltriethoxysilane, and a phenyltrimethoxysilane and combinations thereof.

17. The carbon allotrope-silica composite material of any one of claims 1 to 16, wherein said carbon allotrope-silica composite material is loaded with a molecule.

18. The carbon allotrope-silica composite material of claim 17, wherein said molecule is a fluorescent molecule, a magnetic molecule, a catalyst molecule, a biological macromolecule, or a combination thereof.

19. The carbon allotrope-silica composite material of claim 18, wherein said magnetic molecule is a magnetic nanoparticle.

20. A process for the preparation of a carbon-allotrope silica composite material in solution comprising:

a) contacting an oxidized carbon allotrope with a silica microcapsule for a time sufficient and at a temperature sufficient obtain a formed carbon-allotrope silica composite material in a liquid phase.

21. The process of claim 20, wherein said time sufficient is from 15 minutes to 48 hours.

22. The process of any one of claims 20-21, wherein said temperature sufficient is from room temperature to 100ºC.

23. The process of any one of claims 20-22, wherein said oxidized carbon allotrope is chosen from oxidized graphite, oxidized graphene, an oxidized carbon nanofiber, an oxidized carbon nanotubes, an oxidized C60 fullerene, an oxidized C70 fullerene, an oxidized C76 fullerene, an oxidized C82 fullerene, an oxidized C84 fullerene, and a combination thereof.

24. The process of any one of claims 20 to 23, further comprising step b) after step a)

b) washing said formed carbon-allotrope silica composite material to remove an impurity, to obtain washed carbon-allotrope silica composite material.

25. The process of claim 24, further comprising step c) after step b):

c) separating said washed carbon-allotrope silica composite material from said liquid phase.

26. The process of claim 25 further comprising step d) after step c):

d) drying said washed carbon-allotrope silica composite material to obtain dried a carbon-allotrope silica composite material.

27. The process of any one of claims 20 to 26, wherein said silica microcapsule comprises:

- a silica shell having a thickness of from 50 nm to 500 µm, and a plurality of pores,

said shell forming a capsule having a diameter from 0.2 µm to 1500 µm, and having a density of 0.001 g/cm^3 to 1.0 g/cm^3,

wherein said shell comprises from 0% to 70% Q3 configuration, and from 30% to 100% Q4 configuration, or

wherein said shell comprises from 0% to 60% T2 configuration and from 40% to 100% T3 configuration, or

wherein said shell comprises a combination of T and Q configurations thereof, and

wherein an exterior surface of said capsule is covered by a functional group;

28. The process of claim 27, wherein said thickness of said silica microcapsule is from 50 nm to 240 µm.

29. The process of claim 27, wherein said diameter of said silica microcapsule is from 0.2 μm to 500 μm.

30. The process of claim 27, wherein said density of said silica microcapsule is from 0.01 g/cm^3 to 0.5 g/cm^3.

31. The process of claim 27, wherein said shell comprises from 40% Q3 configuration and 60% Q4 configuration, or from 100% Q4 configuration.

32. The process of claim 27, wherein said pores have pore diameters from 0.5 nm to 100 nm.

33. The process of any one of claims 27-32, wherein said functional group is a hydroxyl group, an amino group, a benzylamino group, a chloropropyl group, a disulfide group, an epoxy group, a mercapto group, a methacrylate group, a vinyl group, and combinations thereof.

34. The process of claim 33, wherein said functional group is provided by an organosilane chosen from a trimethoxysilane, a triethoxysilane, a tripropoxysilane, 3-aminopropyltriethoxysilane, vinyltriacetoxy silane, a vinyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane, 3-methacryloxypropyltrimethoxysilane, 3-chloropropyltriethoxysilane, a bis-(triethoxysilylpropyl)tetrasulfane, a methyltriethoxysilane, a n-octyltriethoxysilane, and a phenyltrimethoxysilane and combinations thereof.

35. A process for the preparation of a carbon-allotrope silica composite material using a plasma deposition process, comprising:

a) contacting a silica microcapsule with a plasmagenic gas comprising a carbon precursor, or a carbon precursor in the presence of a nitrogen precursor, an oxygen precursor, or a sulfur precursor, or a combination thereof,

for a time sufficient, at a power sufficient, a concentration, and a pressure sufficient to deposit a carbon allotrope onto the surface of said silica microcapsule to form said carbon-allotrope silica composite material, wherein said carbon allotrope is selected from the group consisting of a graphite, a graphene, a carbon nanofiber, a carbon nanotubes, a C60 fullerene, a C70 fullerene, a C76 fullerene, a C82 fullerene, a C84 fullerene, and a combination thereof.

36. The process of claim 35, wherein said carbon precursor is chosen from a cyclic hydrocarbon, an aliphatic hydrocarbon, a branched hydrocarbon, a halogenated hydrocarbon, and mixtures thereof.

37. The process of claim 36, wherein said aliphatic hydrocarbon is methane.

38. The process of claim 37, wherein said carbon precursor is injected at a pressure of 13,33 kPa to 80 kPa.

39. The process of any one of claim 35-38, wherein a flow rate of said plasmagenic gas is from 0,1 slpm to 1.5 slpm.

40. The process of claim 39, wherein said flow rate of said plasmagenic gas is from 0,4 slpm to 0,9 slpm.

41. The process of any one of claims 35 to 40, further comprising injecting in said plasmagenic gas a sulfur-containing precursor, a nitrogen-containing precursor, an oxygen-containing precursor, a halogen-containing precursor, or a combination thereof.

42. The process of claim 41, wherein said sulfur-containing precursor is chosen from a sulfate, a persulfate, a sulfide, a sulfite, a sulfur oxide, a organosulfur compound, a thionyl compound, a thiosulfates, a thiocyanate, a

isothiocyanate, a sulfuryl compound, a sulfonium compound, or a combination thereof.

43. The process of claim 41, wherein said nitrogen-containing precursor is chosen from nitrogen (gas N_2), ammonia, an amine, an amide, an imine, an ammonium compound, an azide, a cyanate, a cyanide, a hydrazine, a nitrate, a nitrite, a nitride, a nitrosyl compound, an isocyanate, a nitrogen halide, an organonitrogen compound, a thiocyanate, a thioureas, or a combination thereof.

44. The process of claim 41, wherein said oxygen-containing precursor is chosen from oxygen (gas O_2), a oxide, a peroxide, an alcohol, an ether, a ketone, an aldehyde, a carboxylic acid, an ether, an acid anhydride, an amides, or a combination thereof.

45. The process of claim 41, wherein said halogen-containing precursor is chosen from a bromide compound, a chlorine compound, a fluororine compound, an iodine compound, an halide, an interhalogen compound, or a combination thereof.

46. The process of any one of claims 35-43, wherein said process comprises a sheath gas and said sheath gas is chosen from He, Ne, Ar, Xe, N_2, and a combination thereof.

47. The process of claim 46, wherein said sheath gas is Ar.

48. The process of any one of claims 46 to 47, wherein said sheath gas is injected at a pressure of from 172,37 kPa to 517,11 kPa.

49. The process of claim 48, wherein said sheath gas is injected at a pressure of from 275,79 kPa to 413,69 kPa.

50. The process of any one of claims 35 to 49, wherein a carrier gas comprises from 1.7% to 8% v/v carbon precursor vapor.

51. The process of claim 50, wherein said carrier gas comprises from 4% to 8% v/v carbon precursor vapor.

52. The process of any one of claims 35 to 50, wherein said power sufficient is from 1 to 50 kW.

53. The process of claim 52, wherein said power sufficient is from 5 to 20 kW.

54. The process of any one of claims 35 to 53, wherein said pressure sufficient is from 13,33 kPa to 61,33 kPa.

55. The process of any one of claims 35 to 54, wherein said time sufficient is from 1 to 60 minutes.

56. A material comprising:

- a carbon allotrope-silica composite material according to any one of claims 1 to 19 , and
- a cell, an enzyme, a viral particle, or a combination thereof.

57. The material of claim 56, wherein said material is for carrying a cell, an enzyme, a viral particle or a combination thereof.

58. The material of claim 56, wherein said cell is a prokaryotic cell or a eukaryotic cell.

59. The material of claim 56, wherein said prokaryotic cell is chosen from a bacterial cell, and an archaea cell.

60. The material of claim 58, wherein said eukaryotic cell is chosen from a fungal cell, a protozoan cell, an insect cell, a plant cell, and a mammalian cell.

61. A process for the preparation of a material comprising:

a) contacting a carbon allotrope-silica composite material of any one of claims 1 to 19, with a cell, an enzyme, or a viral particle, and incubating for a time sufficient for binding of said cell, enzyme, or viral particle to said carbon allotrope-silica composite material, said silica microcapsule or said combination thereof.

62. The process of any one of claims 61 - 62, wherein said cell is chosen from a prokaryotic cell or a eukaryotic cell.

63. The process of claim 62, wherein said prokaryotic cell is chosen from a bacterial cell, and an archaea cell.

64. The process of claim 62, wherein said eukaryotic cell is chosen from a fungal cell, a protozoan cell, an insect cell, a plant cell, and a mammalian cell.

65. The process of claim 63, wherein said bacterial cell is chosen from the following phyla: an *Acidobacteria*, an *Actinobacteria*, an *Aquificae*, an *Bacteroidetes*, an *Caldiserica*, an *Chlamydiae*, an *Chlorobi*, an *Chloroflexi*, an *Chrysiogenetes*, an *Cyanobacteria*, an *Deferribacteres*, an *Deinococcus-Thermus*, an *Dictyoglomi*, an *Elusimicrobia*, an *Fibrobacteres*, an *Firmicutes*, an *Fusobacteria*, an *Gemmatimonadetes*, an *Lentisphaerae*, an *Nitrospira*, an *Planctomycetes*, an *Proteobacteria*, an *Spirochaetes*, an *Synergistetes*, an *Tenericutes*, an *Thermodesulfobacteria*, an *Thermotogae*, an *Verrucomicrobia*, or a combination thereof.

66. The process of claim 63, wherein said bacterial cell is chosen from the following genera: *Pseudomonas, Rhodopseudomonas, Acinetobacter,*

Mycobacterium, Corynebacterium, Arthrobacterium, Bacillius, Flavorbacterium, Nocardia, Achromobacterium, Alcaligenes, Vibrio, Azotobacter, Beijerinckia, Xanthomonas. Nitrosomonas, Nitrobacter, Methylosinus, Methylococcus, Actinomycetes and *Methylobacter*.

67. The process of claim 63, wherein said archaeal cell is chosen from the following phyla: an Euryarchaeota, an Crenarchaeota, an Korarchaeota, an Nanoarchaeota, or a combination thereof.

68. The process of claim 64, wherein said fungal cell is chosen from phyla including a Blastocladiomycota, a Chytridiomycota, a Glomeromycota, a Microsporidia, a Neocallimastigomycota, an Ascomycota, a Basidiomycota, or a combination thereof.

69. The process of claim 64, wherein said fungal cell is chosen from the following genera : Saccaromyces, Pichia, Brettanomyces, Yarrowia, Candida, Schizosaccharomyces, Torulaspora, Zygosaccharomyces Aspergillus, Rhizopus, Trichoderma, Monascus, Penicillium, Fusarium, Geotrichum, Neurospora, Rhizomucor, and Tolupocladium.

70. The process of claim 63, wherein said protozoan cell is chosen from the following phyla : Percolozoa, Euglenozoa, Ciliophora, Mioza, Dinoza, Apicomplexa, Opalozoa, Mycetozoa, Radiozoa, Heliozoa, Rhizopoda, Neosarcodina, Reticulosa, Choanozoa, Myxosporida, Haplosporida, Paramyxia.

71. The process of claim 64, wherein said eukaryotic cell is from an algae.

72. The process of claim 61, wherein said enzymes is chosen from a oxidoreductase, a transferase, a hydrolase, a lyase, an isomerase, a ligase, a polymerase or a combination thereof.

73. The process of any one of claims 61 - 72, wherein said process is carried in a biological reactor.

74. The process of claim 73, wherein said biological reactor is chosen from a fermentation batch reactor, an enzymatic batch reactor, a nitrification reactor, a digester reactor, a membrane bioreactor (MBR), a moving bed bioreactor (MBBR), a fluid bed reactor (FBR), a continuous stirred reactor (CSTR), a plug flow reactor (PFR) and a sequential batch reactor (SBR).

75. The process of any one of claims 61 - 74, wherein said method is an anaerobic or an aerobic method.

76. A method of cell growth comprising incubating a material according to any one of claims 56 to 60, in a sterile growth medium to obtain said cell.

77. A method for performing an enzymatic reaction comprising incubating a material according to any one of claims 56 to 60, in a reaction medium.

78. A method for performing a fermentation reaction comprising incubating a material according to any one of claims 56 to 60, in a fermentation reaction medium to obtain a fermentation product.

79. The method of claims 76, wherein said growth is a sporulation reaction to obtain spores.

80. A method for decontamination of a contaminated fluid comprising incubating a material according to any one of claims 56 to 60, in said contaminated fluid.

81. The method of any one of claims 76 - 80, wherein said method is carried in a biological reactor.

82. The method of claim 81, wherein said biological reactor is chosen from a fermentation batch reactor, an enzymatic batch reactor, a nitrification reactor, a digester reactor, a membrane bioreactor (MBR), a moving bed bioreactor (MBBR), a fluid bed reactor (FBR), a continuous stirred reactor (CSTR), a plug flow reactor (PFR) and a sequential batch reactor (SBR).

83. A process for the preparation of a material comprising:

a) contacting a carbon allotrope-silica composite material of any one of claims 1 to 19 with a molecule for adsorption of said molecule to said carbon allotrope-silica composite material, said silica microcapsule or said combination thereof.

84. The process of claim 83, wherein said molecule is a fluorescent molecule, a magnetic molecule, a catalyst molecule, a biological macromolecule, or a combination thereof.