**CLAIMS**

1. An apparatus for conducting an electro-Fenton reaction for decomposing organic, preferably aromatic, chemical compounds in polluted waste water, comprising at least one electrochemical cell having a cathode, and an anode,
wherein at least the area of the cathode which comes into contact with the polluted waste water when in use, is covered by at least one graphene layer having a nanoporous structure, wherein the pore size of the graphene layer ranges from 1 nm to 10 nm.

2. The apparatus according to claim 1, wherein the graphene layer over the cathode has a thickness between 2 nm and 70 μm.

~~3. The apparatus according to claim 1 or 2, wherein the pore size of the graphene layer ranges from 1 nm to 10 nm.~~

43. The apparatus according to ~~any of the preceding~~ claims 1 or 2, wherein the graphene layer is a sheet material, a coating layer attached to metal plate, or 3D graphene (carbon) foam.

54. The apparatus according to any of the preceding claims, wherein at least the area of the cathode and/or the anode which comes into contact with the polluted waste water when in use, is covered by a protective layer.

65. The apparatus according to claim ~~5~~4, wherein the protective layer over the cathode is located between the graphene layer and the cathode.

76. The apparatus according to claim ~~5~~ 4 or ~~6~~5, wherein the protective layer comprises a sintered powder of any metal selected from the following group, any oxide of such metal or any combination thereof: titanium, tantalum, zirconium, vanadium, niobium, hafnium, aluminium, silicon, tin, chromium, molybdenum, tungsten, lead, manganese, beryllium, iron, cobalt, nickel, platinum, palladium, osmium, iridium, rhenium, technetium, rhodium, ruthenium, gold, silver, cadmium,

copper, zinc, germanium, arsenic, antimony, bismuth, boron, scandium and any metals of the lanthanide and actinide series.

87. The apparatus according to any of the preceding claims, wherein the space between the cathode and the anode within the electrochemical cell is divided by a membrane or spacer to form a cathode chamber and an anode chamber, respectively.

98. The apparatus according to any of the preceding claims, comprising two or more electrochemical cells in series.

109. The apparatus according to any of the preceding claims, in a plate-frame design.

1110. The apparatus according to any of claims 1 to 98, in a spiral wound design.

1112. The apparatus according to claim 1110, wherein the spiral wound design is a packing structure embedding the electrodes in a packing material.

1213. The apparatus according to claim 1211, wherein the packing material is selected from fibreglass , ceramic and fluoro-polymer materials.

1314. A system for cleaning polluted waste water from organic chemical compounds comprising an apparatus according to any of the preceding claims.

1415. A process for conducting an electro-Fenton reaction in the apparatus according to any of claims 1 to 13-12 or in the system according to claim 1413, wherein the operation current density applied to the electrochemical cell(s) is between 0.1 $A/m^2$ and 4000 $A/m^2$.

1615. The process according to claim 1514, wherein the operation pH range in the electrochemical cell(s) is between 1 and 10.

1716. The process according to claim 15-14 or 1615, wherein the polluted waste water is pre-

treated, before entry into the electrochemical cell(s), by plasma gas or direct arc discharge through a high frequency power supply at 50 Hz to 30 kHz for a period of 1 to 120 minutes.

~~18~~17. The process according to claim ~~17~~16, wherein the pre-treated step of the process is conducted inside the apparatus according to any of claims 1 to ~~13~~12.

~~19~~18. The process according to any of claims ~~15~~ 16~~to 17~~, wherein the pre-treatment step of the process is conducted outside the apparatus according to any of claims 1 to ~~13~~12.

## CLAIMS

1. An apparatus for conducting an electro-Fenton reaction for decomposing organic, preferably aromatic, chemical compounds in polluted waste water, comprising at least one electrochemical cell having a cathode, and an anode,
wherein at least the area of the cathode which comes into contact with the polluted waste water when in use, is covered by at least one graphene layer having a nanoporous structure, wherein the pore size of the graphene layer ranges from 1 nm to 10 nm.

2. The apparatus according to claim 1, wherein the graphene layer over the cathode has a thickness between 2 nm and 70 μm.

3. The apparatus according to claims 1 or 2, wherein the graphene layer is a sheet material, a coating layer attached to metal plate, or 3D graphene (carbon) foam.

4. The apparatus according to any of the preceding claims, wherein at least the area of the cathode and/or the anode which comes into contact with the polluted waste water when in use, is covered by a protective layer.

5. The apparatus according to claim 4, wherein the protective layer over the cathode is located between the graphene layer and the cathode.

6. The apparatus according to claim 4 or 5, wherein the protective layer comprises a sintered powder of any metal selected from the following group, any oxide of such metal or any combination thereof: titanium, tantalum, zirconium, vanadium, niobium, hafnium, aluminium, silicon, tin, chromium, molybdenum, tungsten, lead, manganese, beryllium, iron, cobalt, nickel, platinum, palladium, osmium, iridium, rhenium, technetium, rhodium, ruthenium, gold, silver, cadmium,

copper, zinc, germanium, arsenic, antimony, bismuth, boron, scandium and any metals of the lanthanide and actinide series.

7. The apparatus according to any of the preceding claims, wherein the space between the cathode and the anode within the electrochemical cell is divided by a membrane or spacer to form a cathode chamber and an anode chamber, respectively.

8. The apparatus according to any of the preceding claims, comprising two or more electrochemical cells in series.

9. The apparatus according to any of the preceding claims, in a plate-frame design.

10. The apparatus according to any of claims 1 to 8, in a spiral wound design.

11. The apparatus according to claim 10, wherein the spiral wound design is a packing structure embedding the electrodes in a packing material.

12. The apparatus according to claim 11, wherein the packing material is selected from fibreglass , ceramic and fluoro-polymer materials.

13. A system for cleaning polluted waste water from organic chemical compounds comprising an apparatus according to any of the preceding claims.

14. A process for conducting an electro-Fenton reaction in the apparatus according to any of claims 1 to 12 or in the system according to claim 13, wherein the operation current density applied to the electrochemical cell(s) is between 0.1 $A/m^2$ and 4000 $A/m^2$.

15. The process according to claim 14, wherein the operation pH range in the electrochemical cell(s) is between 1 and 10.

16. The process according to claim 14 or 15, wherein the polluted waste water is pre-

treated, before entry into the electrochemical cell(s), by plasma gas or direct arc discharge through a high frequency power supply at 50 Hz to 30 kHz for a period of 1 to 120 minutes.

17. The process according to claim 16, wherein the pre-treated step of the process is conducted inside the apparatus according to any of claims 1 to 12.

18. The process according to any of claims 16, wherein the pre-treatment step of the process is conducted outside the apparatus according to any of claims 1 to 12.