CLAIMS

1. An electrode module operable for electrodialysis, the electrode module comprising:

a substrate; and

an array of electrodes arranged on the substrate, wherein each of the electrodes is shaped as a planar sheet and each planar sheet is a segment of the array of electrodes, wherein each segment is arranged apart from another segment, and wherein each segment has a different planar surface area from another segment.

2. The electrode module of claim 1, wherein each of the electrodes comprises a metal, a metal chloride, a metal cyanide, a metal thiocyanide, a metal sulfide, a metal hydroxide, and/or a metal oxide.

3. The electrode module of claim 1 or 2, wherein each of the electrode comprises silver, mercury, and/or a chloride thereof.

4. The electrode module of any one of claims 1 to 3, wherein each of the electrodes comprises a layer of an insoluble salt, wherein:

the insoluble salt produces an anion upon receiving negative electrical charges when the electrode module operates as a cathode; or

each of the electrodes accepts anions to form the layer of insoluble salt upon releasing negative electrical charges when the electrode module operates as an anode;

wherein the insoluble salt comprises silver chloride or mercury (I) chloride.

5. The electrode module of claim 4, wherein each segment is operable to have a different voltage applied to facilitate deposition of the anions at each electrode operating as the anode.

6. The electrode module of claim 4 or 5, wherein the anions deposited at the electrodes define an anion quantity ratio which is proportional to a ratio of the different planar surface area of the segments.

~~7. The electrode module of any one of claims 1 to 6, wherein the substrate comprises an electrically non-conductive and water insoluble material, wherein the electrical non-conductive and water insoluble material comprise a polymer, a glass, a ceramic, or a combination thereof.~~

~~8. The electrode module of any one of claims 1 to 7, further comprising a pair of conductometric electrodes, wherein the pair of conductometric electrodes is disposed in a space between two segments.~~

~~9. The electrode module of claim 8, wherein the pair of conductometric electrodes each comprises a conductive material, wherein the conductive material comprises platinum, gold, stainless steel, conductive carbon material, or Ag/AgCl.~~

~~10. The electrode module of any one of claims 1 to 9, wherein the electrode module is operable as an anode or a cathode at a voltage ranging from 0 mV to 300 mV.~~

~~11~~1. An electrodialysis system comprising:

one or more electrodialysis cells, wherein each of the one or more electrodialysis cells comprise:

an anode electrically coupled to a cathode, wherein each of the anode and the cathode comprises ~~the~~an electrode module ~~of any one of claims 1 to 8~~operable for electrodialysis, the electrode module comprising:

a substrate; and

an array of electrodes arranged on the substrate, wherein each of the electrodes is shaped as a planar sheet and each planar sheet is a segment of the array of electrodes, wherein each segment is arranged apart from another segment, and wherein each segment has a different planar surface area from another segment;

and

a cation-selective membrane arranged between the anode and the cathode to define a concentrate channel and a diluate channel, wherein the anode

and the cathode are arranged for segments of the anode and segments of the cathode having identical planar surface area face each other.

~~12~~2. The electrodialysis system of claim ~~11~~1, wherein each of the one or more electrodialysis cells is operable to have a first voltage applied thereto in a first direction which produces the anion in the concentrate channel from the layer of insoluble salt at the cathode.

~~13~~3. The electrodialysis system of claim ~~11~~1 or ~~12~~2, wherein each of the one or more electrodialysis cells is operable to have a second voltage applied thereto in a second direction which regenerates the layer of insoluble salt at the anode.

~~14~~4. The electrodialysis system of any one of claims ~~11~~1 to ~~13~~3, wherein the concentrate channel and/or the diluate channel comprise a thickness ranging from 10 µm to 1000 µm.

~~15~~5. The electrodialysis system of any one of claims ~~11~~1 to ~~14~~4, wherein a spacer is disposed in the concentrate channel and/or the diluate channel.

~~16~~6. The electrodialysis system of any one of claims ~~11~~1 to ~~15~~5, wherein each of the anode and the cathode has a conductive paste or a conductive film disposed in contact therewith.

~~17~~7. The electrodialysis system of any one of claims ~~11~~1 to ~~16~~6, wherein the electrodialysis system is operable for desalination of seawater, or as a pre-treatment prior to desalination of seawater, or as a battery.

~~18~~8. A method of controlling desalination efficiency in electrodialysis comprising:

applying a voltage to one or more electrodialysis cells, wherein each of the one or more electrodialysis cells comprise:

an anode electrically coupled to a cathode, wherein each of the anode and the cathode comprises ~~the~~an electrode module ~~of any one of claims 1 to 8~~operable for electrodialysis, the electrode module comprising:

a substrate; and

an array of electrodes arranged on the substrate, wherein each of the electrodes is shaped as a planar sheet and each planar sheet is a segment of the array of electrodes, wherein each segment is arranged apart from another segment, and wherein each segment has a different planar surface area from another segment;

and

a cation-selective membrane arranged between the anode and the cathode to define a concentrate channel and a diluate channel, wherein the anode and the cathode are arranged for segments of the anode and segments of the cathode having identical planar surface area face each other; and

operating a pair of segments of the array of electrodes at a different potential difference from another pair of segments, wherein one pair of segments comprises a segment from the anode and another segment of identical planar surface area from the cathode.

~~19~~9. The method of claim ~~18~~8, wherein applying the voltage comprises applying a first voltage in a first direction which produces the anion in the concentrate channel from the layer of insoluble salt at the cathode.

~~20~~10. The method of claim ~~18~~8 or ~~19~~9, wherein applying the voltage comprises applying a second voltage in a second direction which regenerates the layer of insoluble salt at the anode.

~~21~~11. The method of any one of claims ~~18~~8 to ~~20~~10, wherein operating a pair of segments of the array of electrodes at a different potential difference from another pair of segments comprises:

operating a first pair of segments at a first potential difference ranging from 60 mV to 90 mV;

operating a second pair of segments at a second potential difference ranging from 120 mV to 160 mV;

operating a third pair of segments at a third potential difference ranging from 180 mV to 230 mV; and

operating a fourth pair of segments at a fourth potential difference ranging from 240 mV to 300 mV.