CLAIMS

1. An electrochemical flow cell comprising:

a reaction chamber;

a first electrode;

a second electrode; and

a separator disposed between the first and second electrodes, the separator at least partially defining a first channel within the reaction chamber configured to accommodate a first fluid stream in contact with the first electrode and a second channel within the reaction chamber configured to accommodate a second fluid stream in contact with the second electrode,

wherein the separator comprises a permeable membrane that allows electrical communication between the first and second electrodes via the fluid streams while restricting fluid exchange between the fluid streams,

wherein the first electrode is a static mixer electrode comprising an electrically conductive integral scaffold provided by a lattice of interconnected segments defining a plurality of passage sections configured for enhancing mixing by redistributing the first fluid stream in directions transverse to the main flow by splitting structures that split the first fluid stream into a plurality of sub-streams at a plurality of locations along a length of the first electrode;

wherein the electrochemical flow cell is a continuous flow tubular reactor; and

wherein the static mixer electrode is co-axially aligned substantially along the axis of the continuous flow tubular reactor.

2. The electrochemical flow cell according to claim 1, wherein the scaffold of the static mixer electrode is electrically conductive.

3. The electrochemical flow cell according to claim 1 or claim 2, wherein the scaffold is a metal or metal alloy.

4. The electrochemical flow cell according to any one of claims 1 to 3, wherein the static mixer electrode comprises an electrically conductive coating.

5. The electrochemical flow cell according to any one of claims 1 to 4, wherein a diameter of the integral scaffold of the first electrode is approximately equal to a diameter of the first channel.

6. The electrochemical flow cell according to any one of claims 1 to 5, wherein the first electrode is arranged in contact with the separator.

7. The electrochemical flow cell according to any one of claims 1 to 6, wherein the separator and second electrode are substantially cylindrical.

8. The electrochemical flow cell according to any one of claims 1 to 7, wherein the second electrode forms at least part of a wall of the reaction chamber.

9. The electrochemical flow cell according to any one of claims 1 to 8, wherein the first electrode comprising the integral scaffold is configured for operating within the first channel to provide a volumetric flow rate for the first fluid stream of at least about 0.1 ml/min.

10. An electrochemical flow system comprising at least a first electrochemical flow cell according to any one of claims 1 to 9.

11. The electrochemical flow system of claim 10 further comprising:

a second electrochemical flow cell according to any one of claims 1 to 9; and

a plurality of flow lines connecting the first electrochemical flow cell to the second electrochemical flow cell such that the first channel of the first electrochemical flow cell is in fluid communication with the second channel of the second electrochemical flow cell, and the second channel of the first electrochemical flow cell is in fluid communication with the first channel of the second electrochemical flow cell.

12. The electrochemical flow system according to claim 10 or 11 further comprising:

a pump for providing fluidic flow of the fluid streams;

a power supply for controlling current through, or voltage applied to, the electrodes;

a controller for controlling one or more parameters of the system comprising concentration, flow rate, temperature, pressure, and residence time.

13. A method for electrochemical treatment of a fluid stream comprising an electrochemical flow cell according to any one of claims 1 to 9 or system according to any one of claims 10 to 12; providing at least a first fluidic stream to the electrochemical flow cell; operating the electrochemical flow cell; and obtaining an output stream.

14. The method of claim 13, wherein said treatment is waste water treatment comprising removal of dissolved metal ions from a fluid stream, or recovery of metal from a fluid stream.

15. The method of according to claim 13 or claim 14, wherein the electrochemical flow cell is operated to provide one or more of:

enhance chaotic advection by splitting the first fluid stream by more than 200 m^{-1}, corresponding to a number of times the first fluid stream is split within a given length along the integral scaffold of the first electrode;

a Peclet (Pe) number of at least about 10,000;

a volumetric flow rate for the first fluid stream of at least about 0.1 ml/min;

wherein the first fluid stream comprises a dissolved metal species at a concentration of less than about (in mol/L) 0.01;

a recovery efficiency of a contaminant or metal species in the first fluid stream of at least about 90 % of the contaminant or metal species initially present in the first fluid stream; and/or

current densities on the static mixer electrode and counter electrode in a range from 1 $\mu A\ m^{-2}$ to about 1000 $A\ m^{-2}$.

16. The method according to any one of claims 13 to 15, comprising operation of a first and second electrochemical flow cell according to any one of claims 1 to 9,

wherein a plurality of flow lines connects the first electrochemical flow cell to the second electrochemical flow cell such that the first channel of the first electrochemical flow cell is in fluid communication with the second channel of the second electrochemical flow cell,

and the second channel of the first electrochemical flow cell is in fluid communication with the first channel of the second electrochemical flow cell.

17. A method for electrochemical synthesis of a product comprising an electrochemical flow cell according to any one of claims 1 to 9 or system according to any one of claims 10 to 12;

providing at least a first fluidic reactant to the electrochemical flow cell via a reactant inlet; operating the electrochemical flow cell, to provide flow and reaction of the at least first fluidic reactant through the static mixer electrode; and obtaining an output stream comprising a product of a reaction of the at least first reactant.