Claims

1. A liquid-liquid extraction system (1) adapted for the flow of two or more liquids therein comprising:

(i) a mixer settler sub-system (100) comprising:

one or more mixer settlers (110) connected in series,

a first inlet (111) for a first liquid feed stream (121),
a second inlet (112) for a second liquid feed stream (122),

a first outlet (131) for a first product stream (141),
a second outlet (132) for a first byproduct stream (142),

(ii) a counter-current liquid-liquid extraction column (200) and comprising within one common vessel (210):

a first inlet (221) for a third liquid feed stream (231),
a second inlet (222) for a fourth liquid feed stream (232),

a first outlet (241) for a second product stream (251),
a second outlet (242) for a second byproduct stream (252),

a mixing section (260) comprising an agitation means (261) and a
static section (280) comprising an internal (281),

wherein the first outlet (131) of the mixer settler sub-system(100) is in fluid communication with the first inlet (221) of the column (200),

wherein the second inlet (112) of the mixer settler sub-system (100) is in fluid communication with the second inlet (222) of the counter-current liquid-liquid extraction column (200), and wherein either

i) the first inlet (221) of the column (200), the static section (280) of the column (200) and the second outlet (242) of the column (200) are all substantially located within a bottom portion (201) of the column (200), and wherein the second inlet (222) of the column (200), the mixing section (260) of the column (200), and the first outlet (241) of the column (200) are all substantially located within a top portion (202) of the column (200), wherein the first inlet (111) of the sub-system (100) and the second outlet (132) of the sub-system (100) are both substantially located within a bottom portion (151) of the sub-system (100), and wherein the second inlet (112) of the sub-system (100) and the first outlet (131) of the sub-system (100) are both substantially located within a top portion (150) of the sub-system (100), or

ii) the first inlet (221) of the column (200), the static section (280) of the column (200) and the second outlet (242) of the column (200) are all substantially located within a top portion (202) of the column (200), and wherein the second inlet (222) of the column (200), the mixing section (260) of the column (200), and the first outlet (241) of the column (200) are all substantially located within a bottom portion (201) of the column (200), wherein the first inlet (111) of the sub-system (100) and the second outlet (132) of the sub-system (100) are both substantially located within a top portion (150) of the sub-system (100), and wherein the second inlet (112) of the sub-system (100) and the first outlet (131) of the sub-system (100) are both substantially located within a bottom portion (151) of the sub-system (100).

2. The system (1) of claim 1, wherein the mixer settler sub-system (100) contains only two mixer settlers (110) connected in series.

3. The system (1) of either claim 1 or claim 2 for the separation of a first liquid feed stream

(121) that has a lower density than a second liquid feed stream (122), wherein the column (200) additionally comprises a collector (290) and/or a distributor (291).

4. The system (1) of either claim 1 or claim 2 for the separation of a first liquid feed stream (121) that has a higher density than a second liquid feed stream (122), wherein the column (200) additionally comprises a collector (290) and/or a distributor (291).

5. The system (1) of any one of claims 1 to 4, wherein the internal (281) comprises trays, a random packing, a structured packing, or combinations thereof.

6. The system (1) of any one of claims 1 to 5, wherein the column (200) additionally comprises a third inlet (243) located between the first inlet (221) of the column (200) and the second inlet (222) of the column (200) and for the addition of a fifth liquid feed stream (253).

7. A counter-current liquid-liquid extraction process, wherein to a system (1) of any one of claims 1 to 6,

a first liquid feed stream (121) is fed by means of the first inlet (111) of the sub-system (100) and a second liquid feed stream (122) of the subsystem (100) is fed by means of the second inlet (112), liquid-liquid contact occurs between the stream (121) and the stream (122) within the mixer settler sub-system (100) to form a first product stream (141) and a first byproduct stream (142),

and the first product stream (141) is removed by means of the first outlet (131), and the first byproduct stream (142) is removed by means of the second outlet (132) of the sub-system (100),

the first product stream (141) is fed as a third liquid feed stream (231) to the column (200) by means of the first inlet (221) of the column (200) and a fourth liquid feed stream (232) is fed by means of the second inlet (222) of the column (200),

liquid-liquid contact occurs between the stream (231) and the stream (232) within the column (200) to form a second product stream (251) and a second byproduct stream (252),

and the second product stream (251) is removed by means of the first outlet (241) of the column (200), and the second byproduct stream (252) is removed by means of the second outlet (242) of the column (200),

wherein the second liquid feed stream (122) to the mixer settler subsystem (100) is in fluid communication with the fourth liquid feed
stream (232) to the column (200)

wherein

i) the density of the first liquid feed stream (121) is less than the density of the second liquid feed stream (122),

wherein the first inlet (221) of the column (200), the static section (280) of the column (200), and the second outlet (242) of the column (200) are all substantially located within a bottom portion (201) of the column (200), and wherein the second inlet (222) of the column (200), the mixing section (260) of the column (200), and the first outlet (241) of the column (200) are all substantially located within a top portion (202) of the column (200),

and wherein the first inlet (111) of the sub-system (100) and the second outlet (132) of the sub-system (100) are both substantially located within a bottom portion (151) of the sub-system (100), and wherein the second inlet (112) of the sub-system (100) and the first outlet (131) of the sub-system (100) are both substantially located within a top portion (150) of the sub-system (100), or

ii) wherein the density of the first liquid feed stream (121) is greater than the density of the second liquid feed stream (122),

wherein the first inlet (221) of the column (200), the static section (280) of the column (200), and the second outlet (242) of the column (200) are all substantially located within a top portion (202) of the column (200), and wherein the second inlet (222) of the column (200), the mixing section (260) of the column (200), and the first outlet (241) of the column (200) are all substantially located within a bottom portion (201) of the column (200),

and wherein the first inlet (111) of the sub-system (100) and the second outlet (132) of the sub-system (100) are both substantially located within a top portion (150) of the sub-system (100), and wherein the second inlet (112) of the sub-system (100) and the first outlet (131) of the sub-system (100) are both substantially located within a bottom portion (151) of the sub-system (100).

8. The process of claim 7, wherein a fifth liquid feed stream (253) is added to the column (200) by means of an inlet (243) located between 5 the first inlet (221) and the second inlet (222) of the column (200).

9. The process of claim 7 or 8, wherein one each of the pairs of streams (121) and (122), (141) and (142), (231) and (232), and (251) and (252) comprises one or more organic compounds, preferably two or more 10 organic compounds, most preferably consists essentially of organic compounds, and the other stream in each of the pairs comprises water, preferably consists essentially of water.

10. The process of either:

claim 7, alternative i), wherein the streams (121), (141), (231) and (251) each comprise one or more organic compounds, preferably two or more organic compounds, most preferably consists essentially of organic compounds and the streams (122), (142), (232) and (252) each comprise water, preferably consists essentially of water, or

claim 7, alternative ii), wherein the streams (122), (142), (232) and 25 (252) each comprise one or more organic compounds, preferably two or more organic compounds, most preferably consists essentially of organic compounds and the streams (121), (141), (231) and (251) each comprise water, preferably consists essentially of water.

11. The process of claim 7, alternative i), wherein the streams (122) and (232) each comprise a solvent, preferably the same solvent, and the streams (121) and (231) each comprise an oil and an aromatic compound, preferably the same oil and the same aromatic compound,

wherein the aromatic compound is extracted from the stream (121) by counter-current contact with stream (122) within the sub-system (100) and the aromatic compound is extracted from

the stream (231) by counter-current contact with stream (232) within the column (200) to yield a purified oil,

wherein the extracted aromatic compound is removed with the solvent as part of the byproduct streams (142) and (252) by means of outlet (132) located within a bottom portion (151) of the sub-system (100) and by means of outlet (242) located within a bottom portion (201) of the column (200), and wherein the purified oil is removed as part of the product streams (141) and (251) by means of outlet (131) located within the top portion (150) of the sub-system (100) and by means of outlet (241) located within the top portion (202) of the column (200).

12. Use of the system (1) of any one of claims 1 to 6, in removing aromatic compounds from organic streams, in treating an oil stream of a refinery, or in a liquid-liquid extraction process in which one of the third or fourth liquid feed stream (231 or 232) and one of the second product or byproduct stream (251 or 252) are both substantially located within the top (202) or bottom portion (201) of the column (200) and their viscosity difference is greater than 0.1 cP, or their density difference is less than 60 kg/m^3, or their interfacial tension is less than 20 mN/m.