

methods and the unfavorable reactions of consumers and governments to increased prices. The costs associated with fossil fuels are some of the major factors affecting the world economy.

SUMMARY

[0005] According to first broad example, the present disclosure provides a process for removing sulfides from liquid fossil fuel comprising: mixing the liquid fossil fuel with an oxidizer and catalyst to form a multiphase reaction medium and producing a fluid flow of the multiphase reaction medium; applying ultra sound to the multiphase reaction medium to cause oxidation of sulfides in the liquid fossil fuel to sulfones; and extracting the sulfones to yield an organic phase and aqueous phase. The ultra sound is performed by generating vibrations parallel to the fluid flow of the multiphase reaction medium. The organic phase substantially consists of desulfurized fuel.

[0005a] In one aspect, the present disclosure refers to a process for removing sulfides from liquid fossil fuel comprising: mixing the liquid fossil fuel with an oxidizer and catalyst to form a multiphase reaction medium and producing a fluid flow of the multiphase reaction medium; applying ultra sound to the multiphase reaction medium to cause oxidation of sulfides in the liquid fossil fuel to sulfones; and extracting the sulfones to yield an organic phase and aqueous phase, wherein the ultra sound is performed by generating vibrations parallel to the fluid flow of the multiphase reaction medium, wherein the organic phase substantially consists of desulfurized fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate exemplary embodiments of the invention, and, together with the general description given above and the detailed description given below, serve to explain the features of the invention.

[0007] FIG. 1 is an illustration of an exemplary ultrasonically induced cavitation (UIC) reactor according to one embodiment of the present disclosure.

[0008] FIG. 2 illustrates exemplary reaction zones during the formation of bubble clouds according to one embodiment of the present disclosure.

[0009] FIG. 3 illustrates an exemplary fluid flow within a disclosed reactor according to one embodiment of the present disclosure.

[0010] FIG. 4 illustrates a process scheme according to one embodiment of the present disclosure.

[0011] FIG. 5 illustrates the occurrence of cavitation reproduced through computational fluid dynamics (CFD) simulations according to one embodiment of the present disclosure.

[0012] FIG. 6 illustrates the distribution of sulfur molecules in Arabian Extra Light (AXL) before and after sonication according to one embodiment of the present disclosure.

WHAT IS CLAIMED IS:

1. A process for removing sulfides from liquid fossil fuel comprising:
 mixing the liquid fossil fuel with an oxidizer and catalyst to form a multiphase reaction medium and producing a fluid flow of the multiphase reaction medium;
 applying ultra sound to the multiphase reaction medium to cause oxidation of sulfides in the liquid fossil fuel to sulfones; and
 extracting the sulfones to yield an organic phase and aqueous phase,
 wherein the ultra sound is performed by generating vibrations parallel to the fluid flow of the multiphase reaction medium,
 wherein the organic phase substantially consists of desulfurized fuel.
2. The process of claim 1 comprising:
 separating oxidized molecules using liquid-liquid extraction to produce oxidation of sulfur components in the liquid fossil fuel.
3. The process of claim 1, wherein the liquid fossil fuel is selected from a group of fuel comprising: VRO, HFO, Shale Oil and any other liquid fuel with high sulfur content ($S \text{ wt\%} > 0.2$) and high boiling point ($>480 \text{ K}$).
4. The process of claim 1, comprising:
 applying the ultra sound in an ultrasound reactor.
5. The process of claim 4, wherein the reactor comprises:
 a vessel configured to receive the liquid fossil fuel, oxidizer and catalyst as a multiphase reaction medium; and
 a vibrating probe disposed within walls of the vessel,
 wherein the multiphase reaction medium is configured to flow generally parallel to the probe,
 wherein the probe is configured to produce pressure waves to induce formation of nano-sized bubbles in the multiphase reaction medium along one or more cavitation zones along a length of the probe,
 wherein the vessel walls are at a distance of approximately 0.5 to 5 times the diameter of a smallest diameter of the probe.
6. The process of claim 4, comprising:

determining a ratio of the distance of the vessel walls to the smallest diameter of the probe is based on the flowrate and liquid fossil fuel.

7. The process of claim 4, wherein the probe comprises a sonotrode.
8. The process of claim 7, comprising:
varying a diameter of the sonotrode along its length.
9. The process of claim 7, comprising:
producing the one or more cavitation zones based upon a geometrical configuration along a length of the sonotrode
10. The process of claim 7, comprising:
controlling the temperature and pressure of the reactor using a power output of the sonotrode as feedback.
11. The process of claim 10, wherein a viscosity of the multiphase reaction medium or the temperature in the reactor affects the power of the sonotrode.
12. The process of claim 11, comprising:
adjusting the power output based on a flowrate of the multiphase reaction medium.
13. The process of claim 5, comprising:
adjusting a flowrate of the multiphase reaction medium based on achieving a prescribed residence time.
14. The process of claim 13, wherein the residence time in the reactor does not exceed 2 minutes per pass.
15. The process of claim 14, comprising:
applying up to 10 passes.
16. The process of claim 5, comprising:
vibrating the probe at a frequency ranging from approximately 2×10^5 Hz to 2.2×10^5 Hz.
17. The process of claim 16, wherein an amplitude of the frequency ranges from approximately 50-210 microns.
18. The process of claim 5, comprising:

producing the nano-sized bubbles as micro bubbles having a micron diameter range.

19. The process of claim 5, comprising:
continually processing the multiphase reaction medium.
20. The process of claim 5, comprising:
radially injecting the oxidizer and/or catalyst into the reactor intermittently or continuously.