removal adsorbents, and Johnson Matthey's Puraspec™ and Puracare™ granulated absorbents for the removal of mercury from naphtha and / or gaseous hydrocarbon streams.

[006] US Patent Application Nos. 2010/0032344 and 2010/0032345 disclose a process for removing elemental mercury concentration with a liquid / gas contactor, with simulations showing 90% mercury removal at a pressure from < 1 to -3 Bars and a temperature of greater than 150°C, conditions common at crude oil well sites. It is indicated that the liquid / gas contact is carried out in a vessel that provides direct contact of the treated gas stream with the liquid hydrocarbon stream without contacting any other materials or devices, giving 90% removal rate.

[007] Studies have been conducted to measure mercury levels in crude oil as well as the percentage of mercury in the forms of particles, which can be removed by filtration or centrifugation. It was shown that in crude oils containing more than 50 ppbw mercury, the percent mercury in particles which can be removed by laboratory filtration or centrifugation is over 25% with an average of 73%. It is believed that the remaining 27% mercury is primarily in the form of fine particles. It was also shown that in most samples of crude oils and condensates, the predominant form of mercury is non-volatile, and not in the form of elemental mercury Hg^0 which is volatile. It is well known in the art that volatile mercury is readily removed from hydrocarbons upon stripping or sparging with a low mercury gas stream. Quantitative Reitveld XRD analysis of the recovered solids from a crude sample show the only mercury phase to be meta-cinnabar (HgS) and this is assumed to be the predominant mercury species in crude oil.

[008] As adsorption technology does not work well for crude oils and condensates with low levels of mercury, and particularly crude oils containing the non-volatile form of mercury, which has not been well addressed in the prior art. There is a need for improved methods for the removal of mercury from liquid hydrocarbon steams, particularly non-volatile form of mercury.

SUMMARY OF THE ~~INVENTION~~DISCLOSURE

[009] In one aspect, the ~~invention~~ disclosure relates to an improved method to treat a crude oil to reduce its mercury concentration. The method comprises: mixing an effective amount of a reducing agent with the crude oil feed to convert at least a portion of the non-volatile mercury into a volatile mercury; and removing the volatile mercury by at least one of stripping,

scrubbing, adsorption, and combinations thereof to obtain a crude oil having a reduced concentration of mercury which is less than 50% of the first concentration of mercury.

[009a] In another aspect, there is provided a method for reducing a trace amount of mercury in a crude oil feed, comprising:

providing a crude oil feed having a first concentration of non-volatile mercury,

mixing an effective amount of a reducing agent with the crude oil feed to convert at least a portion of the non-volatile mercury into a volatile mercury;

removing at least a portion of the volatile mercury by at least one of stripping, scrubbing, adsorption, and combinations thereof to obtain a crude oil having a reduced concentration of mercury;

wherein the reducing agent is selected from sulfur compounds containing at least one sulfur atom having an oxidation state less than +6; ferrous compounds; stannous compounds; oxalates; cuprous compounds; organic acids which decompose to form CO_2 upon heating; hydroxylamine compounds; hydrazine compounds; sodium borohydride; diisobutylaluminium hydride; thiourea; transition metal halides; sulfites, bisulfites and metabisulfites; and mixtures thereof.

[010] In another aspect, the ~~invention~~ disclosure relates to an improved process to removal mercury from a crude oil stream containing mercury. In the process to be improved, the process comprises the steps of: a) providing a crude oil stream containing mercury; b) separating the crude oil stream into a gaseous hydrocarbon stream comprising hydrocarbons, mercury and water, and a liquid hydrocarbon stream comprising hydrocarbons and volatile mercury; c) charging a mercury-containing gas feed, including in part at least a portion of the gaseous hydrocarbon stream, to a mercury removal unit for removal of mercury from the mercury-containing gas feed, thereby forming a treated gas stream; d) contacting a recycle gas stream comprising a portion of the treated gas stream with at least a portion of said liquid hydrocarbon stream for transfer of at least a portion of the elemental mercury contained in the liquid hydrocarbon stream to the recycle gas stream; thereby forming a mercury rich gas stream, and a treated liquid hydrocarbon stream; and e) passing the mercury rich gas stream to the mercury removal unit as a portion of the mercury-containing gas feed. The improvement comprises converting at least at portion of the mercury in the crude oil stream into volatile mercury, wherein the improvement comprising mixing an effective amount of a reducing agent with the crude oil stream to convert at least a portion of the mercury into a volatile mercury; and wherein

the mixing into the crude oil stream is prior to separating the crude oil stream into a gaseous hydrocarbon stream and a liquid hydrocarbon stream.

[010a] In another aspect, there is provided an improved process to removal mercury from a crude oil stream containing mercury, the process comprising: a) separating the crude oil stream into a gaseous hydrocarbon stream and a liquid hydrocarbon stream; b) removing mercury from the gaseous hydrocarbon stream to provide a treated gas stream; c) contacting the treated gas stream with the liquid hydrocarbon stream to transfer mercury from the liquid hydrocarbon stream to the treated gas stream and thereby form a treated liquid stream and a mercury rich gas stream; and d) removing mercury from the mercury rich gas stream,

wherein the improvement comprises:

mixing into the crude oil stream an effective amount of a reducing agent to convert at least a portion of the mercury into a volatile mercury;

wherein the mixing into the crude oil stream is prior to separating the crude oil stream into a gaseous hydrocarbon stream and a liquid hydrocarbon stream.

DETAILED DESCRIPTION

[011] The following terms will be used throughout the specification and will have the following meanings unless otherwise indicated.

[012] "Crude oil" refers to a liquid hydrocarbon material. As used herein, the term crude refers to both crude oil and condensate. Crude, crude oil, crudes and crude blends are used interchangeably and each is intended to include both a single crude and blends of crudes. "Hydrocarbon material" refers to a pure compound or mixtures of compounds containing hydrogen and carbon and optionally sulfur, nitrogen, oxygen, and other elements. Examples include crude oils, synthetic crude oils, petroleum products such as gasoline, jet fuel, diesel fuel, lubricant base oil, solvents, and alcohols such as methanol and ethanol.