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(54) **EXTRACTION OF ALKALINE EARTH
METAL HYDROXIDES FROM PRODUCED
OILFIELD BRINE**

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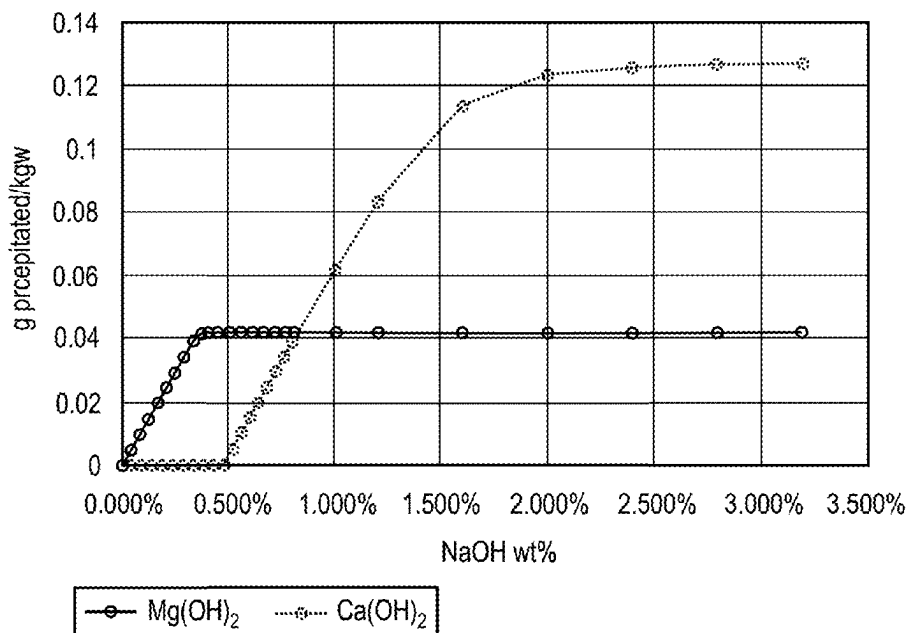
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(57) **ABSTRACT**

Method of producing hydroxides for use in carbon dioxide mineralization, the method including adding a first amount of sodium hydroxide to a produced oilfield brine to precipitate Mg(OH)₂, adding a second amount of sodium hydroxide to precipitate Ca(OH)₂, filtering the precipitates, and adding an amount of the filtered precipitates to an aqueous carbon dioxide solution.

8 Claims, 3 Drawing Sheets



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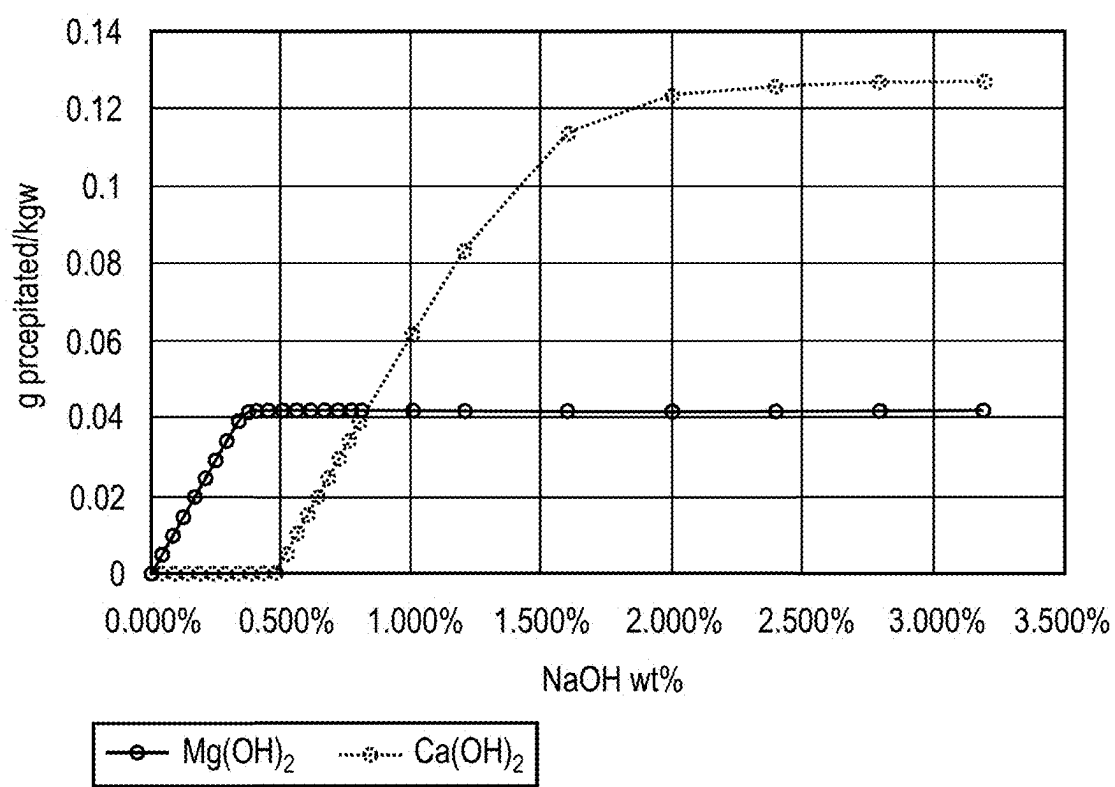


FIG. 1

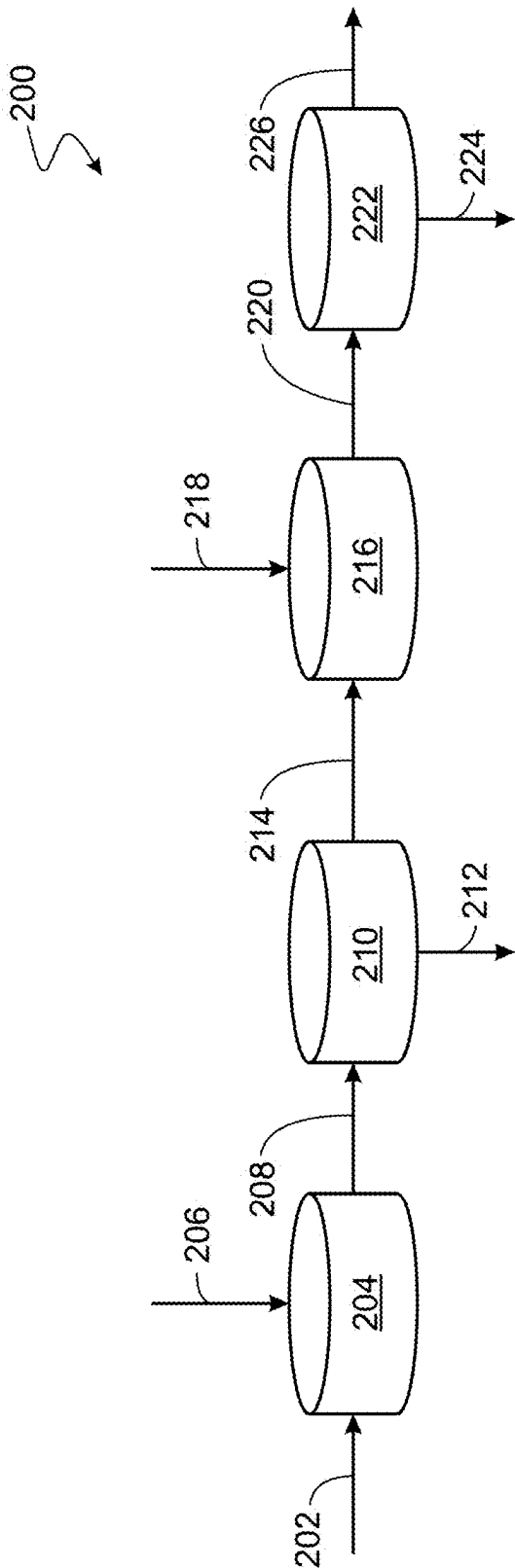


FIG. 2

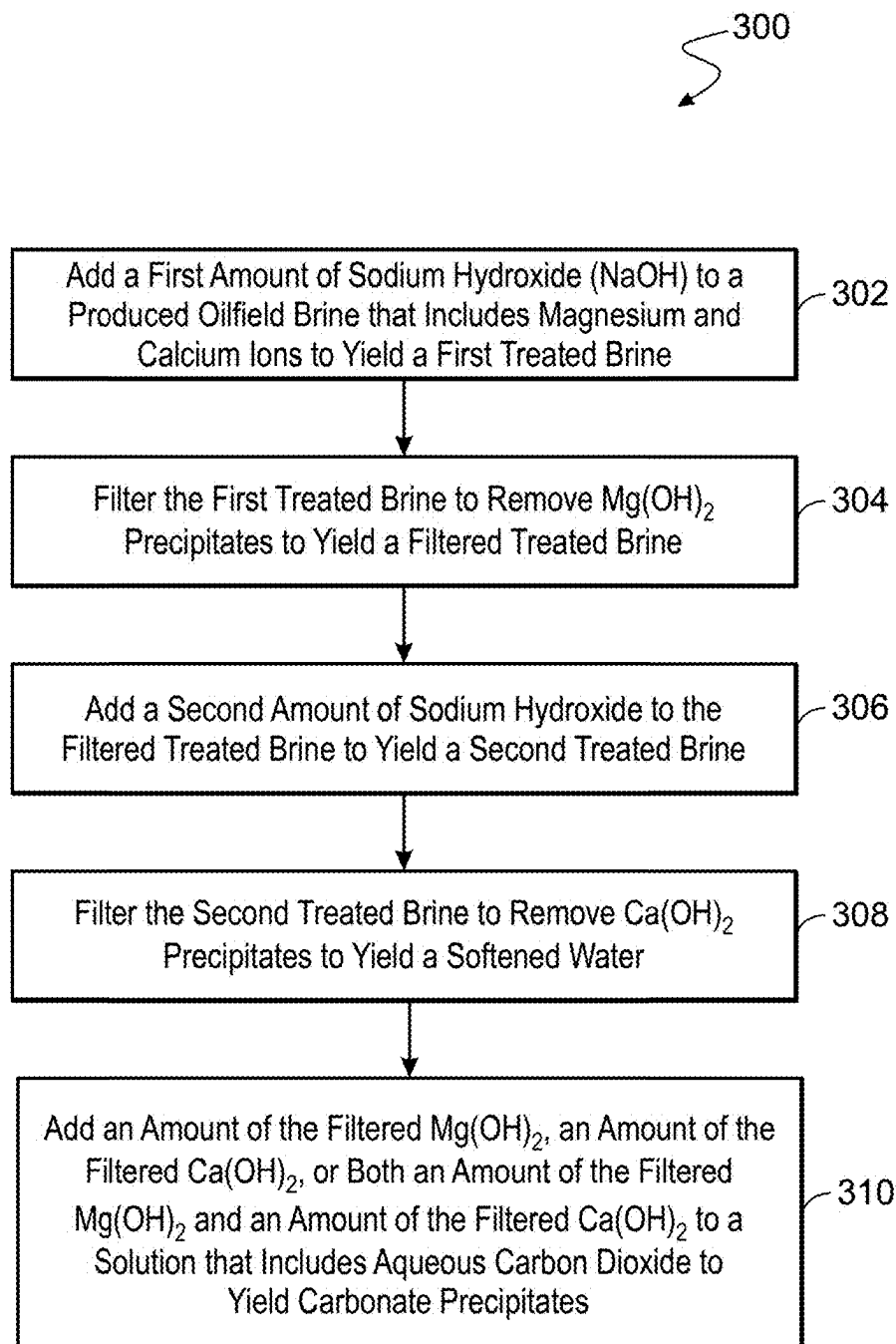


FIG. 3

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EXTRACTION OF ALKALINE EARTH METAL HYDROXIDES FROM PRODUCED OILFIELD BRINE

TECHNICAL FIELD

This document relates to methods and system used in extracting alkaline earth metals from produced oilfield brine, and methods and systems of using the extracted alkaline earth metals in CO₂ mineralization.

BACKGROUND

Produced oilfield brine is hypersaline and also rich in divalent cations such as calcium and magnesium. Effective utilization, recycling, and the use of produced water in carbon capture remains an ongoing area of investigation.

SUMMARY

This disclosure describes methods and systems used in extracting alkaline earth metals from produced oilfield brine, and methods and systems of using the extracted alkaline earth metals in CO₂ mineralization.

In some embodiments, a method of producing hydroxides for use in carbon dioxide mineralization includes adding a first amount of sodium hydroxide (NaOH) to a produced oilfield brine, wherein the produced oilfield brine comprises magnesium and calcium ions, to yield a first treated brine, wherein the first treated brine comprises Mg(OH)₂ precipitates, filtering the Mg(OH)₂ precipitates from the first treated brine to yield a filtered treated brine, adding a second amount of NaOH to the filtered treated brine to yield a second treated brine, wherein the second treated brine comprises Ca(OH)₂ precipitates, filtering the Ca(OH)₂ precipitates from the second treated brine to yield a softened water, and adding an amount of the filtered Mg(OH)₂ precipitates, an amount of the filtered Ca(OH)₂ precipitates, or a combination thereof to a solution comprising aqueous carbon dioxide to yield carbonate precipitates.

The details of one or more implementations of the disclosure are set forth in the accompanying drawings and the description that follows. Other features, objects, and advantages of the disclosure will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

FIG. 1 shows an example PREEQC model of Mg(OH)₂ and Ca(OH)₂ precipitation as a function of NaOH wt %.

FIG. 2 shows a schematic of a system for precipitating and selectively recovering calcium and magnesium hydroxides.

FIG. 3 is a flowchart of an example method of producing hydroxides for use in carbon dioxide mineralization.

Like reference symbols in the various drawings indicate like elements.

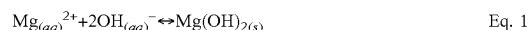
DETAILED DESCRIPTION

Reference will now be made in detail to certain embodiments of the disclosed subject matter, examples of which are illustrated in part in the accompanying drawings. While the disclosed subject matter will be described in conjunction with the enumerated claims, it will be understood that the exemplified subject matter is not intended to limit the claims to the disclosed subject matter.

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Provided in this disclosure are methods and systems used in extracting alkaline earth metals from produced oilfield brine, and methods and systems of using the extracted alkaline earth metals in CO₂ mineralization.

Magnesium and calcium ions are divalent ions. When sodium hydroxide (NaOH) is added to a solution that includes magnesium ions and calcium ions, the magnesium ions are more reactive than the calcium ions. The reactions of magnesium ions and calcium ions with hydroxide ions are shown in equations 1 and 2.



The equilibrium constant for reaction 1 is higher than reaction 2 and therefore thermodynamically more favorable. This difference in reactivity can be exploited to selectively extract first Mg(OH)₂ followed by Ca(OH)₂. This process has a high selectivity, ensuring that the extracted salts have a high purity. FIG. 1 shows an example PREEQC model of Mg(OH)₂ and Ca(OH)₂ precipitation as a function of NaOH wt %. As shown in FIG. 1, initially Mg(OH)₂ is precipitated exclusively. As the amount of NaOH increases, Ca(OH)₂ begins to precipitate. Accordingly, Mg(OH)₂ and Ca(OH)₂ can be selectively precipitated and selectively removed from a solution by controlling the amount of NaOH in a solution. The precipitated hydroxides can be sold or used in subsequent industrial processes. For example, Mg(OH)₂ has a higher commercial value than MgCO₃. Accordingly, the Mg(OH)₂ can be sold rather than used in subsequent processes, such as carbon dioxide mineralization.

In some embodiments, Mg(OH)₂ and Ca(OH)₂ are selectively extracted from produced oilfield brine as a function of hydroxide concentration. The extracted Mg(OH)₂ and Ca(OH)₂ can be used to mineralize CO₂. CO₂ mineralization is a process by which dissolved CO₂ is precipitated as a carbonate. At low pH, dissolved CO₂ is hydrated to carbonic acid, as shown in Equation 3. Addition of a base can deprotonate the carbonic acid to form carbonate, as shown in Equation 4. The carbonate in a solution can react with calcium ions, as shown in Equation 5, or with magnesium ions, as shown in Equation 6. The calcium and magnesium ions produced by precipitation with NaOH can be used as both a hydroxide source to raise the pH of the solution and a source of calcium and magnesium ions. This represents a cost-efficient way to produce the reactants for a carbon dioxide mineralization process.



The resulting calcium carbonate and/or magnesium carbonate sequesters CO₂ that might otherwise have been released into the atmosphere or be present in a water source. The solid CaCO₃ and MgCO₃ can be stored or used for other industrial purposes. In addition, the solid CaCO₃ and MgCO₃ are thermodynamically stable, resulting in almost permanent carbon abatement. Further, these salts can be used for different applications, for example, the formulation of drilling fluids.

The process of precipitating magnesium and calcium ions from produced water and subsequently utilizing the produced hydroxides to mineralize carbon dioxide has several advantages. First, the process softens the produced water.

Produced water is often unusable due to the high concentration of divalent ions. In contrast, softened produced water can be re-used in agriculture, drilling operations, fracturing operations, or other industrial processes. Accordingly, the process described herein creates a usable product (i.e., softened water) out of a waste product (i.e., produced brine). In addition, the produced hydroxides are used to sequester carbon dioxide via mineralization. This can be used to reduce the CO₂ output of industrial processes and therefore help mitigate excess atmospheric carbon. Therefore, the combination of precipitating divalent ions and using the resulting hydroxides for CO₂ mineralization has the two-fold, synergistic advantage of transforming a waste product into useable water as well as mitigating CO₂ output.

In addition, produced oilfield brines often include dissolved H₂S and hydrocarbons. The addition of NaOH to a produced oilfield brine can remove both dissolved H₂S and hydrocarbons. For example, increasing the pH of an oilfield brine can convert dissolved H₂S to sulfides (S²⁻). The sulfides can react with divalent ions in the produced oilfield brine and precipitate. In another example, dissolved oil reacts with NaOH in an in-situ saponification reaction, which generates carboxylate surfactants that will emulsify the hydrocarbons.

A method of treating produced oilfield brine according to the present disclosure includes adding sodium hydroxide to the produced oilfield brine to yield a first hydroxide treated brine. The first hydroxide treated brine can include up to 1.0 wt % NaOH. For example, the first hydroxide treated brine can include up to 1 wt %, up to 0.8 wt %, up to 0.7 wt %, up to 0.6 wt %, up to 0.5 wt %, up to 0.4 wt %, up to 0.3 wt %, up to 0.2 wt %, or up to 1.0 wt % NaOH. The first hydroxide treated brine can include a first slurry. The first slurry can include solid hydroxide precipitates. In some embodiments, the majority of the hydroxide precipitates are Mg(OH)₂ precipitates. For example, the hydroxide precipitates can be greater than 60% Mg(OH)₂ by weight, greater than 70% Mg(OH)₂ by weight, greater than 80% Mg(OH)₂ by weight, greater than 90% Mg(OH)₂ by weight, greater than 95% Mg(OH)₂ by weight, or greater than 99% Mg(OH)₂ by weight.

In the methods of the present disclosure, the first hydroxide treated brine is filtered to extract Mg(OH)₂ precipitates. In some embodiments, the first hydroxide treated brine is filtered at an NaOH wt % of 1.0 wt % or less. For example, the brine can be filtered at 1.0 wt %, 0.8 wt %, 0.7 wt %, 0.6 wt %, 0.5 wt %, 0.4 wt %, 0.3 wt %, 0.2 wt %, or 0.1 wt % NaOH. After selectively extracting the Mg(OH)₂ precipitates, additional sodium hydroxide can be added to the filtered treated brine to yield a second hydroxide treated brine. The second hydroxide treated brine can include between 1.0 wt % and 3.5 wt % NaOH. For example, the second hydroxide treated brine can include 1.0 wt %, 1.5 wt %, 2.0 wt %, 2.5 wt %, 3.0 wt %, or 3.5 wt % NaOH. The second hydroxide treated brine includes a second slurry. The second slurry can include solid hydroxide precipitates. In some embodiments, the majority of the hydroxide precipitates are Ca(OH)₂ precipitates. For example, the hydroxide precipitates can be greater than 60% Ca(OH)₂ by weight, greater than 70% Ca(OH)₂ by weight, greater than 80% Ca(OH)₂ by weight, greater than 90% Ca(OH)₂ by weight, greater than 95% Ca(OH)₂ by weight, or greater than 99% Ca(OH)₂ by weight. The second hydroxide treated brine can be filtered to remove Ca(OH)₂ precipitates.

In some embodiments, drum filters are utilized to filter the first hydroxide and second hydroxide treated brines. In some embodiments, the NaOH is added to produced oilfield brine

and/or the first hydroxide treated brine in a continuously stirred tank reactor (CSTR). The precipitation reactions as shown in Equations 1 and 2 are limited by molecular diffusion rather than kinetics, so continuous stirring can improve the efficiency of the process.

The method of the present disclosure includes utilizing the recovered Mg(OH)₂ and Ca(OH)₂ for carbon mineralization. For example, the recovered Mg(OH)₂ and Ca(OH)₂ can be used for carbon mineralization in a bubble column. A slurry is prepared that includes the recovered Mg(OH)₂ and/or Ca(OH)₂. The slurry is introduced to a pressurized bubble column containing CO₂, resulting in the precipitation of calcium and magnesium carbonates as shown in equations 3-6.

A system for extracting Mg(OH)₂ and Ca(OH)₂ from produced oilfield brine includes a series of continuously stirred tank reactors (CSTRs) and drum filters. The produced oilfield brine is introduced via a pipe to the first continuously stirred tank reactor. Sodium hydroxide is added to the produced oilfield brine in the first CSTR via a first hydroxide delivery pipe. The addition of NaOH to the produced water results in a first hydroxide treated brine. In some embodiments, the first hydroxide treated brine includes up to 1% by weight NaOH. The first hydroxide treated brine includes a first slurry. The first slurry includes solid hydroxide precipitates. In some embodiments, the majority of the hydroxide precipitates are Mg(OH)₂ precipitates. For example, the hydroxide precipitates can be greater than 60% Mg(OH)₂ by weight, greater than 70% Mg(OH)₂ by weight, greater than 80% Mg(OH)₂ by weight, greater than 90% Mg(OH)₂ by weight, greater than 95% Mg(OH)₂ by weight, or greater than 99% Mg(OH)₂ by weight. The first slurry is then flowed to a first drum filter via a first connecting pipe. The first connecting pipe connects the first CSTR and the first drum filter. In the first drum filter, the first hydroxide treated brine is filtered to remove the solid precipitates. The solid precipitates are removed from the first drum filter via a first precipitate outlet. Removing the solid precipitates yields a filtered treated brine. The filtered treated brine is flowed to a second CSTR via a second connecting pipe. An additional amount of sodium hydroxide is added to the filtered treated brine in the second CSTR. The addition of NaOH to the first filtered brine results in a second hydroxide treated brine. In some embodiments, the second hydroxide treated brine includes between about 1% and about 3.5% NaOH by weight. The second hydroxide brine includes a second slurry. The second slurry includes solid hydroxide precipitates. In some embodiments, the majority of the precipitates are Ca(OH)₂ precipitates. For example, the hydroxide precipitates can be greater than 60% Ca(OH)₂ by weight, greater than 70% Ca(OH)₂ by weight, greater than 80% Ca(OH)₂ by weight, greater than 90% Ca(OH)₂ by weight, greater than 95% Ca(OH)₂ by weight, or greater than 99% Ca(OH)₂ by weight. The second slurry is then flowed to a second drum filter via a second connecting pipe. The second connecting pipe connects the second CSTR and the second drum filter. In the second drum filter, the second hydroxide treated brine is filtered to remove the solid precipitates. The solid precipitates are removed from the second drum filter via a second precipitate outlet. Removing the solid precipitates yields a softened water. The softened water flows from the second drum filter via an outlet pipe.

FIG. 2 shows a schematic of a system 200 for precipitating and selectively recovering calcium and magnesium hydroxides. The system includes an inlet pipe 202. Produced oilfield brine is directed through the inlet pipe 202 to a first continuously stirred tank reactor (CSTR) 204. A first

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hydroxide delivery pipe **206** is fluidly connected to the first CSTR **204**. The first hydroxide delivery pipe **206** is configured to deliver an amount of sodium hydroxide (NaOH) to the first CSTR. Addition of NaOH to the produced oilfield brine in the first CSTR results in a first hydroxide treated brine.

A first connecting pipe **208** is fluidly connected to the first CSTR **204** and to a first drum filter **210**. The first connecting pipe is configured to deliver the first hydroxide treated brine to the first drum filter **210**. The first drum filter **210** is configured to extract solid $\text{Mg}(\text{OH})_2$ precipitates from the first hydroxide treated brine to yield a filtered treated brine. The solid $\text{Mg}(\text{OH})_2$ precipitates are removed from the first drum filter **210** via a first precipitate outlet **212**. The filtered treated brine is then directed to a second CSTR via a second connecting pipe **214**.

A second hydroxide delivery pipe **218** is fluidly connected to the second CSTR **216**. The second hydroxide delivery pipe **218** is configured to deliver an amount of sodium hydroxide to the second CSTR **216**. Addition of NaOH to the filtered treated brine yields a second hydroxide treated brine.

A third connecting pipe **220** is fluidly connected to the second CSTR **216** and to a second drum filter **222**. The third connecting pipe is configured to deliver the second hydroxide treated brine to the second drum filter **222**. The second drum filter **222** is configured to extract solid $\text{Ca}(\text{OH})_2$ from the second hydroxide treated brine to yield a softened water. The solid $\text{Ca}(\text{OH})_2$ precipitates are removed from the second drum filter via a second precipitate outlet **224**. The softened water is removed from the second drum filter **222** via an outlet pipe **226**.

A method of producing hydroxides for use in carbon dioxide mineralization includes adding a first amount of sodium hydroxide to a produced oilfield brine to yield a first treated brine. In some embodiments, adding a first amount of NaOH to a produced oilfield brine includes adding a first amount of NaOH to a produced oilfield brine in a first continuously stirred tank reactor. In some embodiments, the first treated brine is less than 1% NaOH by weight. In some embodiments, the first treated brine includes a first slurry. The first slurry includes hydroxide precipitates. In some embodiments, the hydroxide precipitates in the first slurry are greater than 95% by weight $\text{Mg}(\text{OH})_2$.

The method includes filtering the first treated brine to remove $\text{Mg}(\text{OH})_2$ precipitates and yield a filtered treated brine. In some embodiments, filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine includes filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine using a first drum filter.

The method includes adding a second amount of NaOH to the filtered treated brine to yield a second treated brine. In some embodiments, adding a second amount of NaOH to the filtered treated brine includes adding a second amount of NaOH to the filtered treated brine in a second continuously stirred tank reactor. In some embodiments, the second treated brine is from about 1% to about 3.5% NaOH by weight. In some embodiments, the second treated brine includes a second slurry. The second slurry includes hydroxide precipitates. In some embodiments, the hydroxide precipitates in the second slurry are greater than 95% by weight $\text{Ca}(\text{OH})_2$.

The method includes filtering the second treated brine to remove $\text{Ca}(\text{OH})_2$ precipitates to yield a softened water. In some embodiments, filtering the $\text{Ca}(\text{OH})_2$ precipitates from

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the second treated brine includes filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine using a second drum filter.

The method includes adding an amount of the filtered $\text{Mg}(\text{OH})_2$, an amount of the filtered $\text{Ca}(\text{OH})_2$, or an amount of the filtered $\text{Mg}(\text{OH})_2$ and an amount of the filtered $\text{Ca}(\text{OH})_2$ to a solution that includes aqueous carbon dioxide to yield carbonate precipitates. In some embodiments, the method includes recovering carbonate precipitates from the solution.

FIG. 3 is a flowchart of an example method **300** of producing hydroxides for use in carbon dioxide mineralization. At **302**, a first amount of sodium hydroxide (NaOH) is added to a produced oilfield brine that includes magnesium and calcium ions to yield a first treated brine. In some embodiments, adding a first amount of NaOH to a produced oilfield brine includes adding a first amount of NaOH to a produced oilfield brine in a first continuously stirred tank reactor. In some embodiments, the first treated brine is less than 1% NaOH by weight. In some embodiments, the first treated brine includes a first slurry. The first slurry includes hydroxide precipitates. In some embodiments, the hydroxide precipitates in the first slurry are greater than 95% by weight $\text{Mg}(\text{OH})_2$. At **304**, the first treated brine is filtered to remove $\text{Mg}(\text{OH})_2$ precipitates and yield a filtered treated brine. In some embodiments, filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine includes filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine using a first drum filter. At **306**, a second amount of NaOH is added to the filtered treated brine to yield a second treated brine. In some embodiments, adding a second amount of NaOH to the filtered treated brine includes adding a second amount of NaOH to the filtered treated brine in a second continuously stirred tank reactor. In some embodiments, the second treated brine is less than about 1% to about 3.5% NaOH by weight. In some embodiments, the second treated brine includes a second slurry. The second slurry includes hydroxide precipitates. In some embodiments, the hydroxide precipitates in the second slurry are greater than 95% by weight $\text{Ca}(\text{OH})_2$. At **308**, the second treated brine is filtered to remove $\text{Ca}(\text{OH})_2$ precipitates to yield a softened water. In some embodiments, filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine includes filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine using a second drum filter. At **310**, an amount of the filtered $\text{Mg}(\text{OH})_2$, an amount of the filtered $\text{Ca}(\text{OH})_2$, or an amount of the filtered $\text{Mg}(\text{OH})_2$ and an amount of the filtered $\text{Ca}(\text{OH})_2$ is added to a solution that includes aqueous carbon dioxide to yield carbonate precipitates. In some embodiments, the method includes recovering carbonate precipitates from the solution.

Definitions

The term “about” as used in this disclosure can allow for a degree of variability in a value or range, for example, within 10%, within 5%, or within 1% of a stated value or of a stated limit of a range.

As used in this disclosure, “weight percent” (wt %) can be considered a mass fraction or a mass ratio of a substance to the total mixture or composition. Weight percent can be a weight-to-weight ratio or mass-to-mass ratio, unless indicated otherwise.

A number of implementations of the disclosure have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the disclosure.

1. A method of producing hydroxides for use in carbon dioxide mineralization, the method comprising:
 adding a first amount of sodium hydroxide (NaOH) to a produced oilfield brine, wherein the produced oilfield brine comprises magnesium and calcium ions, to yield a first treated brine, wherein the first treated brine comprises $\text{Mg}(\text{OH})_2$ precipitates;
 filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine to yield a filtered treated brine;
 adding a second amount of NaOH to the filtered treated brine to yield a second treated brine, wherein the second treated brine comprises $\text{Ca}(\text{OH})_2$ precipitates;
 filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine to yield a softened water; and
 adding an amount of the filtered $\text{Mg}(\text{OH})_2$ precipitates, an amount of the filtered $\text{Ca}(\text{OH})_2$ precipitates, or a combination thereof to a solution comprising aqueous carbon dioxide to yield carbonate precipitates.
2. The method of embodiment 1, wherein the first treated brine comprises less than 1% NaOH by weight.
3. The method of embodiment 1 or 2, wherein the second treated brine comprises less than about 1% to about 3.5% NaOH by weight.
4. The method of any one of embodiments 1-3, wherein the first treated brine comprises a first slurry, wherein:
 the first slurry comprises hydroxide precipitates; and
 the hydroxide precipitates comprise greater than 95% by weight $\text{Mg}(\text{OH})_2$.
5. The method of any one of embodiments 1-4, wherein the second treated brine comprises a second slurry, wherein:
 the second slurry comprises hydroxide precipitates; and
 the hydroxide precipitates comprise greater than 95% by weight $\text{Ca}(\text{OH})_2$.
6. The method of any one of embodiments 1-5, wherein filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine comprises filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine using a first drum filter.
7. The method of any one of embodiments 1-6, wherein filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine comprises filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine using a second drum filter.
8. The method of any one of embodiments 1-7, wherein adding a first amount of NaOH to a produced oilfield brine comprises adding a first amount of NaOH to a produced oilfield brine in a first continuously stirred tank reactor.
9. The method of any one of embodiments 1-8, wherein adding a second amount of NaOH to the filtered treated brine comprises adding a second amount of NaOH to the filtered treated brine in a second continuously stirred tank reactor.

10. The method of any one of embodiments 1-9, further comprising recovering carbonate precipitates from the solution.

What is claimed is:

1. A method of producing hydroxides for use in carbon dioxide mineralization, the method comprising:
 adding a first amount of sodium hydroxide (NaOH) to a produced oilfield brine, wherein the produced oilfield brine comprises magnesium and calcium ions, to yield a first treated brine, wherein the first treated brine comprises $\text{Mg}(\text{OH})_2$ precipitates and 0.1% to 1% NaOH by weight;
 filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine to yield a filtered treated brine;
 adding a second amount of NaOH to the filtered treated brine to yield a second treated brine, wherein the second treated brine comprises $\text{Ca}(\text{OH})_2$ precipitates and 1.0% to 3.5% NaOH by weight;
 filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine to yield a softened water; and
 adding an amount of the filtered $\text{Mg}(\text{OH})_2$ precipitates, an amount of the filtered $\text{Ca}(\text{OH})_2$ precipitates, or a combination thereof to a solution comprising aqueous carbon dioxide to yield carbonate precipitates.
2. The method of claim 1, wherein the first treated brine comprises a first slurry, wherein:
 the first slurry comprises hydroxide precipitates; and
 the hydroxide precipitates comprise greater than 95% by weight $\text{Mg}(\text{OH})_2$.
3. The method of claim 1, wherein the second treated brine comprises a second slurry, wherein:
 the second slurry comprises hydroxide precipitates; and
 the hydroxide precipitates comprise greater than 95% by weight $\text{Ca}(\text{OH})_2$.
4. The method of claim 1, wherein filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine comprises filtering the $\text{Mg}(\text{OH})_2$ precipitates from the first treated brine using a first drum filter.
5. The method of claim 1, wherein filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine comprises filtering the $\text{Ca}(\text{OH})_2$ precipitates from the second treated brine using a second drum filter.
6. The method of claim 1, wherein adding the first amount of NaOH to the produced oilfield brine comprises adding the first amount of NaOH to the produced oilfield brine in a first continuously stirred tank reactor.
7. The method of claim 1, wherein adding the second amount of NaOH to the filtered treated brine comprises adding the second amount of NaOH to the filtered treated brine in a second continuously stirred tank reactor.
8. The method of claim 1, further comprising recovering carbonate precipitates from the solution.

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