tralization salts is greatly reduced. In addition, said neutralization salts of choline hydroxide are strongly hygroscopic and therefore are capable to absorb even traces of moisture to readily form flowable solutions, which allow easy removal of the salts from process streams.

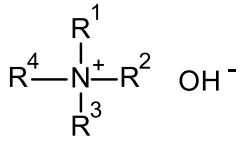
[0004] However, the use of choline hydroxide for mitigating fouling and corrosion also entails several disadvantages. Firstly, aqueous solutions of choline hydroxide have limited thermal stability at temperatures above 180°C and additionally develop unpleasant odors and discolor during extended storage.

[0005] Despite the advances made in the field of prevention and control of corrosion as well as fouling, there is still an ongoing need for an effective and economically viable method for combating corrosion and fouling in chemical processes, especially chemical processes, where high temperatures will occur. It is therefore the object of the present invention to provide such a method, which in particular features all the advantages of the aforementioned prior art procedures using choline hydroxide to mitigate corrosion and fouling, but also avoids the limitations of these procedures. Thus, the corrosion and fouling reducing or preventing compound used in this method, as well as aqueous solutions thereof, should have sufficient thermal and storage stabilities and should in particular withstand temperatures well above 180°C without undergoing significant decomposition. Such temperatures prevail, for example, in some fluid or gaseous streams of refinery and petrochemical systems, such as hydrodesulfurization plants. Said compound should additionally have improved basicity and a superior ability to dissolve ammonium salts in comparison to choline hydroxide.

[0006] The object is achieved by the method described in detail below.

SUMMARY

[0006a]In an aspect, there is provided a method for reducing or preventing corrosion or fouling in an apparatus for carrying out a chemical process, where corrosion or fouling is caused by acidic compounds present in the chemical process, which is a crude oil refinery process, a petrochemical process or a steam generating process, which comprises the addition of at least one quaternary ammonium hydroxide of the formula (I) to the apparatus, wherein the chemical process is carried out:



(I)

where

R^1, R^2, R^3 are each independently C_1-C_6 alkyl;

R^4 is C_2-C_{18} alkyl;

R^3 and R^4 together with the nitrogen atom may also form a 5 or 6-membered, saturated nitrogen heterocycle, which is unsubstituted or carries 1 or 2 methyl groups;

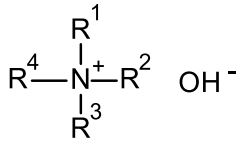
where the chemical process is a crude oil refinery process or a petrochemical process and comprises the addition of the compound of the formula (I) into at least one unit selected from the crude oil atmospheric distillation unit, the crude oil vacuum distillation unit, the visbreaker unit, the delayed coker unit, the fluidized catalytic cracking unit, the reformer unit, the hydrocracker unit, the alkanolamine unit, the sulfinol unit and the hydrodesulfurization unit,

or where the chemical process is a steam generating process and comprises the addition of the compound of the formula (I) into the aqueous system of the boiler or steam generator;

and where the acidic compounds causing corrosion or fouling in the chemical process are selected from the group consisting of hydrogen halides, hydrogen sulfide, hydrogen cyanide, thiocyanic acid, sulfuric acid, SO_2, SO_3, acidic ammonium salts and mixtures thereof.

[0007] In an example, the present disclosure relates to a method for reducing or preventing corrosion or fouling in an apparatus for carrying out a chemical process, where corrosion or fouling is caused by acidic compounds present in the chemical process, which comprises the addition of at least one quaternary ammonium hydroxide of the formula (I) to the apparatus, wherein the chemical process is carried out:

[Chem.1]



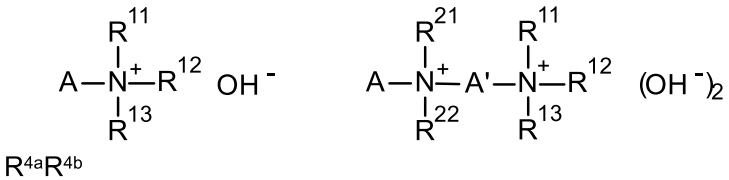
(I)

where

R^1, R^2, R^3 are each independently C_1-C_{10} alkyl;

R^4 is selected from the group consisting of C_1-C_{18} alkyl, benzyl, monocycloalkyl having 5, 6, 7 or 8 carbon atoms, bicycloalkyl having 6 to 8 carbon atoms, tricycloalkyl having 7 to 10 carbon atoms, where monocycloalkyl, bicycloalkyl and tricycloalkyl are unsbustituted or substituted by 1 or 2 methyl groups, and groups of the formulae R^{4a} and R^{4b};

[Chem.2]



where

A is C_2-C_8 alkandiyl;

A' is C_2-C_8 alkandiyl; and

R^{11}, R^{12}, R^{13}, R^{21}, R^{22} are each independently C_1-C_4 alkyl;

R^1 and R^2 together with the nitrogen atom may also form a 5 or 6-membered, saturated nitrogen heterocycle, which is unsubstituted or carries 1 or 2 methyl groups; and/or

R^3 and R^4 together with the nitrogen atom may also form a 5 or 6-membered, saturated nitrogen heterocycle, which is unsubstituted or carries 1 or 2 methyl groups.

[0008] The disclosure further relates to the use of the quaternary ammonium hydroxide of formula (I) for reducing or preventing corrosion or fouling in an apparatus for carrying out a chemical process, where corrosion or fouling is caused by acidic compounds present in the chemical process.

Brief Description of Drawings

[0009] [fig.1]Figure 1 is GC/MS partial chromatogram of DEDMA-Cl pyrolysis products formed under the conditions of example 10.

DETAILED DESCRIPTION OF THE INVENTION

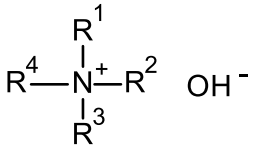
[0010] In the context of the present invention, the terms and phrases used herein generically are defined as follows:

The prefix "C_x-C_y" denotes the number of possible carbon atoms in the particular case.

[0011] The term "C_1-C_{18}-alkyl" as used herein refers to saturated straight-chain or branched hydrocarbon radicals having 1 to 4 ("C_1-C_4-alkyl"), 1 to 6 ("C_1-C_6-alkyl"), 1 to 10 ("C_1-C_{10}-alkyl") or 1 to 18 ("C_1-C_{18}-alkyl") carbon atoms. C_1-C_4-Alkyl is methyl, ethyl, n-propyl, isopropyl, n-butyl, 1-methyl-n-propyl (sec-butyl), 2-methyl-n-propyl (isobutyl)

Claims:

1. A method for reducing or preventing corrosion or fouling in an apparatus for carrying out a chemical process, where corrosion or fouling is caused by acidic compounds present in the chemical process, which is a crude oil refinery process, a petrochemical process or a steam generating process, which comprises the addition of at least one quaternary ammonium hydroxide of the formula (I) to the apparatus, wherein the chemical process is carried out:



(I)

where

R^1, R^2, R^3 are each independently C_1-C_6 alkyl;

R^4 is C_2-C_{18} alkyl;

R^3 and R^4 together with the nitrogen atom may also form a 5 or 6-membered, saturated nitrogen heterocycle, which is unsubstituted or carries 1 or 2 methyl groups;

where the chemical process is a crude oil refinery process or a petrochemical process and comprises the addition of the compound of the formula (I) into at least one unit selected from the crude oil atmospheric distillation unit, the crude oil vacuum distillation unit, the visbreaker unit, the delayed coker unit, the fluidized catalytic cracking unit, the reformer unit, the hydrocracker unit, the alkanolamine unit, the sulfinol unit and the hydrodesulfurization unit,

or where the chemical process is a steam generating process and comprises the addition of the compound of the formula (I) into the aqueous system of the boiler or steam generator;

and where the acidic compounds causing corrosion or fouling in the chemical process are selected from the group consisting of hydrogen halides, hydrogen sulfide, hydrogen cyanide, thiocyanic acid, sulfuric acid, SO_2, SO_3, acidic ammonium salts and mixtures thereof.

2. The method of claim 1, where in formula (I)
R^1, R^2, R^3 are each independently C_1-C_6 alkyl and
R^4 is C_2-C_6 alkyl.

3. The method of claim 1, where the compound of formula (I) is selected from the group consisting of diethyldimethylammonium hydroxide, ethyltrimethylammonium hydroxide, dimethyldipropylammonium hydroxide, triethylmethylammonium hydroxide, tetraethylammonium hydroxide, tetra-n-propylammonium hydroxide, tetra-n-butylammonium hydroxide, hexamethonium hydroxide and N,N-dimethylpyrrolidinium hydroxide.

4. The method of claim 1, where the compound of formula (I) is selected from the group consisting of diethyldimethylammonium hydroxide, ethyltrimethylammonium hydroxide, dimethyldipropylammonium hydroxide, triethylmethylammonium hydroxide, tetraethylammonium hydroxide, tetra-n-propylammonium hydroxide and tetra-n-butylammonium hydroxide.

5. The method of claim 1, where the acidic compounds present in the chemical process include at least one acidic compound selected from the group consisting of acidic ammonium salts selected from ammonium halides, ammonium hydrogensulfide, ammonium sulfide, ammonium hydrogensulfate and ammonium sulfate.

6. The method of claim 1, where the chemical process is a crude oil refinery process or a petrochemical process, which comprises the addition of the compound of the formula (I) into at least one unit selected from the the visbreaker unit, the delayed coker unit, the fluidized catalytic cracking unit, the reformer unit, the hydrocracker unit, the alkanolamine unit, the sulfinol unit and the hydrodesulfurization unit.

7. The method of claim 1, where the chemical process is a steam generating process, where the compound of the formula (I) is added into the fluid or gaseous stream of the steam generating process.

8. The method of claim 1, where the compound of the formula (I) is added into the fluid or gaseous stream of the chemical process.

9. The method of claim 8, where the fluid or gaseous stream is subjected to a temperature of at least 100 °C, frequently at least 150°C and especially at least 180°C during or after the addition of the compound of formula (I).

10. The method of claim 8, where the compound of the formula (I) is added in an amount of 1 to 1000 ppm by weight, based on the amount of the fluid or gaseous stream of the chemical process.

11. The method of claim 1, where the compound of the formula (I) is added into the chemical process as a solution of a compound of the formula (I).

12. The method of claim 11, where the at least one compound of the formula (I) is dissolved in a solvent selected from C_1-C_4 alkanols, water and mixtures thereof.

13. The method of claim 11, where the total concentration of the compound of the formula (I) in the solution is in the range from 10 to 60 % by weight.