the amount of 1,4-dioxane that forms. Reducing the SO_3 gas concentration from 4% to 2.5%, for example, has a dramatic effect and cuts the amount of 1,4-dioxane that forms in half. Less dramatic benefits come from running at low mole ratios of SO_3:feed so that conversion of the feed to the sulfated product is less complete. These changes have a dramatic impact on the production capacity and cost-efficiency of a sulfation plant. Moves such as these cut the plant capacity by as much as 50%.

SUMMARY

[0006] According to a process of the present disclosure, a method of removing dioxane from a paste includes pumping a dioxane-containing aqueous paste feedstock to an inlet of an evaporator, supplying heat to the paste in the evaporator, and reducing the vapor pressure in the evaporator, to vaporize dioxane and water from the paste and thereby concentrate the paste, and collecting the resulting concentrated product. The concentrated product can be diluted with water to a desired final concentration, e.g. in a range of about 65 wt.% to about 80 wt.% active sulfate, or 65 wt.% to about 76 wt.% active sulfate. The pH of the concentrated and/or diluted product can be adjusted with a neutralizing agent, including a caustic agent or a buffering agent.

[0007] In a process described herein, the feedstock paste optionally can be an ethoxylated fatty alcohol sulfate paste.

[0007a] In one aspect of the present disclosure, there is provided a method of removing dioxane from an aqueous alkoxylated fatty alcohol sulfate paste, comprising:

pumping a dioxane-containing aqueous paste feedstock to an inlet of an evaporator;

supplying heat to the paste in the evaporator; and

reducing the vapor pressure in the evaporator;

to vaporize dioxane and water from the paste and thereby concentrate the paste, wherein the wt.% increase of the active sulfonate following concentration, based on the total weight of the paste, is at least 5 wt.%, and collecting the resulting concentrated product.

[0008] In one embodiment, the evaporator can include a heated channel. For example, with a channel the process can further include preheating the dioxane-containing paste feedstock to a temperature wherein water would flash from the paste, and selectively applying pressure to the paste to avoid vaporization of water; pumping the paste to an inlet of the channel under a pressure selected to avoid flashing of water; introducing the paste into the channel; supplying heat to the paste in the channel and selectively reducing the pressure along the channel resulting in the flashing of dioxane and water components of the paste, wherein vapor liberated during the flashing acts as a motive force to move the increasingly viscous paste along the channel; collecting the resulting concentrated

product and vaporized dioxane and water components in a separation vessel disposed downstream of an outlet of the channel, wherein the separation vessel operates at a pressure less than an operating pressure of the outlet of each channel; and venting the vaporized dioxane and water components from the separation vessel from an overhead vapor outlet and discharging the residual paste composition from the bottom of the separation vessel.

[0009] In another embodiment, the evaporator vessel can include an agitator. For example, the evaporator can be a wiped film evaporator.

[0028] The process can optionally include the step of sulfating an alkoxylated fatty acid with a mole ratio of sulfur trioxide gas to alkoxylated fatty acid that is relatively high, e.g., at least 1.00, or at least 1.03, or at least 1.04, for example in a range of 1.00 to 1.05 or 1.03 to 1.05, to produce the alkoxylated fatty alcohol sulfate paste.

[0028a] In another aspect of the present disclosure, there is provided a system for removing dioxane from an aqueous paste, comprising: a heated evaporator channel having an inlet and an outlet, a liquid feed pump in fluid communication with the inlet of the evaporator channel, a separation vessel, a diluter, and a vacuum pump, the separation vessel having an inlet in fluid communication with the outlet of the evaporator channel and an outlet in fluid communication with the diluter, and the vacuum pump in fluid communication with the separation vessel.

[0028b] In a further aspect of the present disclosure, there is provided a system for removing dioxane from an aqueous paste, comprising: a wiped film evaporator having a feed inlet, a concentrate product outlet, and at least one vapor outlet, a liquid feed pump in fluid communication with the inlet of the wiped film evaporator, a diluter in fluid communication with the concentrate product outlet, and a vacuum pump in fluid communication with the wiped film evaporator vapor outlet.

[0029] For the methods, apparatus, and compositions described herein, optional features, including but not limited to components, compositional ranges thereof, substituents, conditions, and steps, are contemplated to be selected from the various embodiments, and examples provided herein.

[0030] Further advantages will be apparent to those of ordinary skill in the art from a review of the following detailed description, taken in conjunction with the drawings. While the method, apparatus, and compositions are susceptible of embodiments in various forms, the description hereafter includes specific embodiments with the understanding that the disclosure is illustrative, and is not intended to limit the present disclosure to the specific embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Fig. 1 is a process flow diagram illustrating a solvent removal system for use in the process according to the invention.

[0032] Fig. 2 is a partial, sectional view of a solvent removal apparatus for use in the process according to the invention.

[0033] Fig. 3 is a process flow diagram illustrating an embodiment of an apparatus according to the invention.

[0034] Fig. 4 is a partial, sectional view of a portion of the apparatus shown in Fig. 3.

[0035] Fig. 5 is a partial, sectional view of a second embodiment of an apparatus according to the invention.

[0036] Fig. 5A is an enlarged view of a portion of the embodiment of the apparatus shown in Fig. 5.

[0037] Fig. 6 is a graph of separation factor (Relative Volatility) as a function of pressure.

[0038] Fig. 7 is a graph of separation factor (Relative Volatility) as a function of temperature.

[0039] Fig. 8 shows values of ideal separation factor (I_f) at different concentrations.

[0040] Figs. 9-16 show the Margules factor for different active concentrations with various active molecular weights. The graphs are duplicated with the first group showing the Margules factor verses temperature of the active and the seconds set verses the flash tank pressure.

We Claim:

1. A method of removing dioxane from an aqueous alkoxylated fatty alcohol sulfate paste, comprising:

pumping a dioxane-containing aqueous paste feedstock to an inlet of an evaporator;

supplying heat to the paste in the evaporator; and

reducing the vapor pressure in the evaporator;

to vaporize dioxane and water from the paste and thereby concentrate the paste, wherein the wt.% increase of the active sulfonate following concentration, based on the total weight of the paste, is at least 5 wt.%, and collecting the resulting concentrated product.

2. The process according to claim 1, further comprising diluting the concentrated product with water.

3. The process according to claim 2, comprising diluting the concentrated product to a concentration of about 65 wt.% to about 76 wt.% active sulfate.

4. The process according to claim 2 or 3, further comprising adjusting the pH of the diluted product by addition of a neutralizing agent.

5. The process according to claim 1, wherein the evaporator comprises a wiped film evaporator.

6. The process according to claim 1, wherein the evaporator comprises a channel and further comprising preheating the dioxane-containing paste feedstock to a temperature wherein water would flash from the paste, and selectively applying pressure to the paste to avoid vaporization of water; pumping the paste to an inlet of the channel under a pressure selected to avoid flashing of water; introducing the paste into the channel; supplying heat to the paste in the channel and selectively reducing the pressure along the channel resulting in the flashing of dioxane and water components of the paste, wherein vapor liberated during the flashing acts as a motive force to move the increasingly viscous paste along the channel; collecting the resulting concentrated product and vaporized dioxane and water components in a separation vessel disposed downstream of an outlet of the channel, wherein the separation vessel operates at a pressure less than an operating pressure of the outlet of each channel; and

venting the vaporized dioxane and water components from the separation vessel from an overhead vapor outlet and discharging the residual paste composition from the bottom of the separation vessel.

7. The process of any one of the preceding claims, wherein the feedstock paste comprises an ethoxylated fatty alcohol sulfate.

8. The process according to any one of the preceding claims, wherein the feedstock is preheated to a temperature in a range of about 185°F to 265°F (85 °C to 129 °C), for example 240°F (116 °C).

9. The process according to any one of the preceding claims, wherein the evaporator is heated to a temperature in a range of about 200°F to 265°F (93 °C to 129 °C), for example 240°F(116 °C).

10. The process of any one of the preceding claims, wherein the vapor pressure in the evaporator or collection vessel is less than 1 bar absolute.

11. The process of claim 10, wherein the pressure is in a range of 50 Torr to 300 Torr.

12. The process according to any one of the preceding claims, wherein the concentrated product comprises 76 wt.% to 99 wt.% active ethoxylated fatty alcohol sulfate.

13. The process according to any one of the preceding claims, wherein the concentrated product has a water content of 25 wt.% or less, or 15 wt.% or less, or 5 wt.% or less, or 2 wt.% or less.

14. The process according to any one of the preceding claims, wherein the wt.% increase of the active sulfonate following concentration, based on the total weight of the paste, is at least 10 wt.%.

15. The process according to claim 13, wherein the concentrated product comprises 3-mol ethoxylated fatty alcohol sulfate and the concentrated product comprises 76 wt.% to 88 wt.% active.

16. The process according to claim 13, wherein the concentrated product comprises 7-mol ethoxylated fatty alcohol sulfate and the concentrated product comprises 76 wt.% to 95 wt.% active.

17. The process according to any one of the preceding claims, wherein the ratio of dioxane concentration on 100% active basis in the feedstock paste compared to the product paste is at least 7:1.

18. The process according to any one of the preceding claims, wherein the dioxane content of the concentrated product is less than 20 ppm on 100% active matter basis.

19. The process according to any one of the preceding claims, wherein the dioxane is 1,4-dioxane.

20. The process according to any one of the preceding claims, further injecting a vapor into the evaporator.

21. The process according to claim 20, wherein the vapor is steam.

22. The process according to claim 21, wherein the feedstock paste is an ethoxylated fatty alcohol sulfate paste and the mass ratio of injected steam to active ethoxylated fatty alcohol sulfate is in a range of 0.1 to 1.

23. A system for removing dioxane from an aqueous paste, comprising: a heated evaporator channel having an inlet and an outlet, a liquid feed pump in fluid communication with the inlet of the evaporator channel, a separation vessel, a diluter, and a vacuum pump, the separation vessel having an inlet in fluid communication with the outlet of the evaporator channel and an outlet in fluid communication with the diluter, and the vacuum pump in fluid communication with the separation vessel.

24. A system for removing dioxane from an aqueous paste, comprising: a wiped film evaporator having a feed inlet, a concentrate product outlet, and at least one vapor outlet, a liquid feed pump in fluid communication with the inlet of the wiped film evaporator, a diluter in fluid communication with the concentrate product outlet, and a vacuum pump in fluid communication with the wiped film evaporator vapor outlet.