solidifies at room temperature. As such, there is a need to utilize a process for the production of hydroxyethylpiperazine that allows for the continuous monitoring of the molar ratio of ethylene oxide to piperazine, so as to minimize these concerns associated with high and lower molar ratios of ethylene oxide to piperazine.

[0004] International Publication No. WO/2017/011283 discloses a process for producing hydroxy alkyl piperazine compounds that includes (i) feeding a feed stream of piperazine at a first location into a reactive distillation column, and (ii) feeding a feed stream of a C_2 to C_8 alkylene oxide at one or more second location into the reactive distillation column. While use of reactive distillation may favor the mono-hydroxyethyl piperazine and/or eliminate the need for a separate multistep distillation, alternative methods are sought that utilize standard equipment in a continuous process to further enable the ability to cost-effectively produce large quantities of hydroxyethylpiperazine at a commercial scale.

Summary

[0005] ~~Embodiments~~ There is provided ~~may be realized by~~ a continuous process for the production of hydroxyethylpiperazine that includes feeding neat piperazine, recycled piperazine, and ethylene oxide to a reactor to form crude hydroxyethylpiperazine, in which the reactor is a continuous stirred tank reactor or a plug flow reactor. The process further includes continuously feeding the crude hydroxyethylpiperazine from the reactor to a distillation system that includes at least one distillation column, the distillation system produces at least a recycled piperazine stream and a hydroxyethylpiperazine stream, the recycled piperazine stream includes the recycled piperazine that is fed to the reactor to form the crude hydroxyethylpiperazine, and the hydroxyethylpiperazine stream includes at least 60 wt% of hydroxyethylpiperazine based on a total weight of the hydroxyethylpiperazine stream.

[0005a] In one aspect, there is provided a continuous process for the production of hydroxyethylpiperazine, the process comprising: feeding neat piperazine, recycled piperazine, and ethylene oxide to a reactor to form crude hydroxyethylpiperazine, the reactor being a continuous stirred tank reactor or a plug flow reactor, wherein a molar ratio of ethylene oxide to neat piperazine is greater than 1.10; and continuously feeding

the crude hydroxyethylpiperazine from the reactor to a distillation system that includes at least one distillation column, the distillation system producing at least a recycled piperazine stream and a hydroxyethylpiperazine stream, the recycled piperazine stream including the recycled piperazine that is fed to the reactor to form the crude hydroxyethylpiperazine and the hydroxyethylpiperazine stream including at least 60 wt% of hydroxyethylpiperazine based on a total weight of the hydroxyethylpiperazine stream.

Brief Description of the Drawings

[0006] Features of the embodiments will become more apparent to those of ordinary skill in the art by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

Listing of the Claims:

1. A continuous process for the production of hydroxyethylpiperazine, the process comprising:

feeding neat piperazine, recycled piperazine, and ethylene oxide to a reactor to form crude hydroxyethylpiperazine, the reactor being a continuous stirred tank reactor or a plug flow reactor, wherein a molar ratio of ethylene oxide to neat piperazine is greater than 1.10; and

continuously feeding the crude hydroxyethylpiperazine from the reactor to a distillation system that includes at least one distillation column, the distillation system producing at least a recycled piperazine stream and a hydroxyethylpiperazine stream, the recycled piperazine stream including the recycled piperazine that is fed to the reactor to form the crude hydroxyethylpiperazine and the hydroxyethylpiperazine stream including at least 60 wt% of hydroxyethylpiperazine based on a total weight of the hydroxyethylpiperazine stream.

~~2. The process as claimed in claim 1, wherein a molar ratio of ethylene oxide to neat piperazine added to the reactor is greater than 1.01.~~

~~3~~2. The process as claimed in claim 1 ~~or claim 2~~, wherein a molar ratio of ethylene oxide to total piperazine, including neat piperazine and recycled piperazine, is from 0.10 to 1.01.

~~4~~3. The process as claimed in ~~any one of~~ claim~~s~~ 1 ~~to 3~~or claim 2, wherein the recycled piperazine includes from 30 wt% to 99 wt% of piperazine.

~~5~~4. The process as claimed in any one of claims 1 to ~~4~~3, wherein the distillation system includes three distillation columns, a first distillation column receives the crude hydroxyethylpiperazine from the reactor, a second distillation column receives a top stream of the first distillation column and separates water from piperazine, and a third distillation column receives a bottom stream from the first distillation column and separates hydroxyethylpiperazine from dihydroxyethylpiperazine.

~~6~~5. The process as claimed in any one of claims 1 to ~~5~~4, wherein the distillation system further produces a dihydroxyethylpiperazine stream that includes at least 35 wt% dihydroxyethylpiperazine based on a total weight of the dihydroxyethylpiperazine stream.

~~7~~6. The process as claimed in claim ~~6~~5, wherein in the distillation system the recycled piperazine stream is separated first before the dihydroxyethylpiperazine stream and the hydroxyethylpiperazine stream are separated from each other.

~~8~~7. The process as claimed in any one of claims 1 to ~~7~~6, wherein the recycled piperazine stream diluted with water is continuously fed directly to the reactor.

~~9~~8. The process of claims in any one of claims 1 to ~~8~~7, wherein the reactor is a plug flow reactor.

~~10~~9. A hydroxyethylpiperazine product prepared according to the process as claimed in any one of claims 1 to ~~9~~8.