operation is involved because the elevated temperatures can accelerate polymerization.

[0005] The manufacture of ethylenically unsaturated monomers typically comprises three stages: reaction, recovery, and purification. Distillation operations at elevated temperatures are often involved in the recovery and the purification stages. Polymerization of the ethylenically unsaturated monomer during manufacture is generally unwanted because the resulting polymer can precipitate out of the process stream, deposit on the process equipment surfaces, and impair the proper functioning of the equipment. Thus, polymerization inhibitors have conventionally been used when carrying out the monomer manufacturing processes.

[0006] Phenolic and phenylenediamine antioxidants, nitroxide stable free radicals, and phenothiazine derivatives are commonly used reagents for polymerization inhibition in the industry. Hydroquinone (HQ), phenothiazine (PTZ), phenylenediamine (PDA), and 4-hydroxy-2,2,6,6-tetramethyl piperidinyl oxy (HTMPO) are examples of some of the most commonly used polymerization inhibitors in the industry. However, a conventional inhibitor treatment often does not provide adequate protection from the polymerization-induced fouling. Furthermore, use of the conventional inhibitors often poses logistic, economic, and safety concerns.

BRIEF SUMMARY

[0007] Compositions are provided for inhibiting polymerization of monomers. The present disclosure relates to a composition for inhibiting polymerization of monomers comprises at least one hydroxylamine of a nitroxide and at least one phenylenediamine.

[0008] Methods of inhibiting the polymerization of monomers are also provided herein. The present disclosure relates to a method of inhibiting polymerization of a monomer comprises providing a fluid comprising an ethylenically unsaturated monomer and adding an effective amount of a polymerization inhibitor composition to the fluid. The polymerization inhibitor composition comprises an effective amount of at least one hydroxylamine of a nitroxide

and an effective amount of at least one phenylenediamine. Addition of the polymerization inhibitor composition to the fluid will thereby inhibit polymerization of the ethylenically unsaturated monomer.

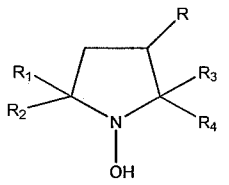
[0008a] In one aspect, there is provided a method of inhibiting polymerization of an ethylenically unsaturated monomer comprising:

providing a fluid comprising an ethylenically unsaturated monomer;

adding an effective amount of a polymerization inhibitor composition to the fluid, wherein the polymerization inhibitor composition comprises an effective amount of at least one hydroxylamine of a nitroxide and an effective amount of at least one phenylenediamine; and

inhibiting polymerization of the ethylenically unsaturated monomer,

wherein the at least one hydroxylamine of a nitroxide comprises the following structure:



wherein each R_1, R_2, R_3 and R_4 is independently selected from an alkyl group and R is selected from the group consisting of hydrogen, oxygen, alkyl, hydroxyl, alkoxyl, amino, N-alkylamino, amido, N-alkylamido, carboxylate and carboxyl.

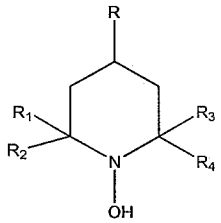
[0008b] In another aspect, there is provided a method of inhibiting polymerization of an ethylenically unsaturated monomer comprising:

providing a fluid comprising an ethylenically unsaturated monomer;

adding an effective amount of a polymerization inhibitor composition to the fluid, wherein the polymerization inhibitor composition comprises an effective amount of at least one hydroxylamine of a nitroxide and an effective amount of at least one phenylenediamine; and

inhibiting polymerization of the ethylenically unsaturated monomer,

wherein the at least one hydroxylamine of a nitroxide comprises the following structure:



wherein each R_1, R_2, R_3 and R_4 is independently selected from an alkyl group and R is selected from the group consisting of hydrogen, oxygen, alkyl, hydroxyl, alkoxyl, amino, N-alkylamino, amido, N-alkylamido, carboxylate and carboxyl.

[0009] The foregoing has outlined rather broadly the features and technical advantages of the present disclosure in order that the detailed description that follows may be better understood. Additional features and advantages of the disclosure will be described hereinafter that form the subject of the claims of this application. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other embodiments for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent embodiments do not depart from the spirit and scope of the disclosure as set forth in the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0010] A detailed description of the invention is hereafter described with specific reference being made to the drawings in which:

[0011] FIG. 1 shows laboratory equipment used to carry out an experimental analysis of the presently disclosed polymerization inhibitor compositions;

[0012] FIG. 2 is a graphical analysis comparing aspects of the presently disclosed polymerization inhibitor compositions with conventional inhibitors; and

[0013] FIG. 3 is a graphical analysis showing synergism between two components of the presently disclosed polymerization inhibitor compositions.

DETAILED DESCRIPTION

[0014] Various embodiments of the present disclosure are described below. The relationship and functioning of the various elements of the embodiments may better be understood by reference to the following detailed description. However, embodiments are not limited to those explicitly described herein and it should be understood that in certain