MECHANICALLY-GASSED EMULSION EXPLOSIVES AND METHODS RELATED THERETO

TECHNICAL FIELD

[0001] The present disclosure relates generally to the field of explosive compositions. More particularly, the present disclosure relates to mechanically-gassed emulsion explosives and methods related thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The written disclosure herein describes illustrative embodiments that are non-limiting and non-exhaustive. Reference is made to certain of such illustrative embodiments that are depicted in the figures, in which:

[0003] FIG. 1 is a schematic diagram illustrating one embodiment of a process flow for manufacturing mechanically-gassed emulsion explosive.

[0004] FIG. 2 is another schematic diagram illustrating another embodiment of a process flow for manufacturing a mechanically-gassed emulsion explosive.

SUMMARY

[0004A] In a first aspect of the present disclosure, there is provided a method of delivering an emulsion explosive, the method comprising:

obtaining an emulsion matrix comprising a discontinuous phase of oxidizer salt solution droplets in a continuous phase of a fuel, wherein the emulsion matrix has an initial viscosity when measured at 20 °C of 4,000 cP to 20,000 cP;

mechanically introducing gas bubbles into the emulsion matrix to sensitize the emulsion matrix and form an emulsion explosive; and

homogenizing the emulsion explosive to form a homogenized emulsion explosive with a viscosity when measured at 20 °C of greater than or equal to 80,000 cP and that is devoid of a bubble stabilizing agent.

[0004B] In a second aspect of the present disclosure, there is provided a method of delivering an emulsion explosive, the method comprising:

splitting an oxidizer salt solution into a first portion and a second portion;

mixing the first portion of the oxidizer salt solution with a fuel and a pressurized gas to form a low viscosity fuel-rich emulsion explosive, wherein the fuel is substantially devoid of a bubble stabilizing agent;

mixing the second portion of the oxidizer salt solution into the fuel-rich emulsion explosive to form a more-balanced emulsion explosive with increased viscosity by 6000 cP to 20,000 cP relative to the fuel-rich emulsion explosive; and

homogenizing the more-balanced emulsion explosive to form a homogenized emulsion explosive with further increased viscosity.

DETAILED DESCRIPTION

[0005] This disclosure generally relates to water-in-oil (or melt-in-oil) emulsions for use as explosives, along with related methods. The term "water-in-oil" means a dispersion of droplets of an aqueous solution or water-miscible melt (the discontinuous phase) in an oil or water-immiscible organic substance (the continuous phase). The water-in-oil emulsion explosives of this invention contain a water-immiscible organic fuel as the continuous phase and an emulsified inorganic oxidizer salt solution or melt as the discontinuous phase. (The terms "solution" or "melt" hereafter shall be used interchangeably.)

[0006] Emulsion explosives are commonly used in the mining, quarrying, and excavation industries for breaking rocks and ore. Generally, a hole, referred to as a "blasthole" or "borehole," is drilled in a surface, such as the ground. Emulsion explosives may then be pumped or augered into the blasthole. Emulsion explosives are generally transported to a job site or made on the job site as an emulsion that is too dense to completely detonate, referred to as an emulsion matrix. The emulsion matrix is not considered an explosive. In general, the emulsion matrix needs to be "sensitized" in order for the emulsion matrix to detonate successfully. A sensitized emulsion matrix is considered an emulsion explosive.

[0007] Sensitizing is often accomplished by introducing small voids into the emulsion matrix. These voids act as hot spots for propagating detonation. These voids may be introduced by injecting a gas into the emulsion and thereby forming discrete gas bubbles, adding microspheres, other porous media, and/or injecting chemical gassing agents to react in the emulsion and thereby form discrete gas bubbles.

CLAIMS

1. A method of delivering an emulsion explosive, the method comprising:

obtaining an emulsion matrix comprising a discontinuous phase of oxidizer salt solution droplets in a continuous phase of a fuel, wherein the emulsion matrix has an initial viscosity when measured at 20 °C of 4,000 cP to 20,000 cP;

mechanically introducing gas bubbles into the emulsion matrix to sensitize the emulsion matrix and form an emulsion explosive; and

homogenizing the emulsion explosive to form a homogenized emulsion explosive with a viscosity when measured at 20 °C of greater than or equal to 80,000 cP and that is devoid of a bubble stabilizing agent.

2. The method of claim 1, wherein homogenizing the emulsion explosive comprises subjecting the emulsion explosive to shear stress.

3. The method of claim 2, wherein subjecting the emulsion to shear stress comprises delivering the emulsion through a shearing device.

4. The method of any one of claims 1-3, wherein the fuel comprises fuel oil.

5. The method of any one of claims 1-4, wherein fewer than 10% of the gas bubbles that are in the emulsion immediately after homogenization coalesce with other bubbles within 3 minutes after homogenization.

6. The method of any one of claims 1-5, wherein the gas is nitrogen, helium, a noble gas, air, carbon dioxide, or combinations thereof.

7. The method of any one of claims 1-6, wherein mechanically introducing a gas into the emulsion comprises delivering gas bubbles 5 microns or less in diameter or 1 micron or less in diameter.

8. The method of any one of claims 1-7, wherein mechanically introducing a gas into the emulsion comprises delivering compressed gas through a porous member into the emulsion.

9. The method of claim 8, wherein the porous member comprises one or more of a porous ceramic, a sintered steel, or a sintered glass.

10. The method of any one of claims 1-9, wherein the continuous phase comprises an emulsifier, a homogenization agent, or combinations thereof.

11. The method of any one of claims 1-10, further comprising pumping the emulsion matrix to provide at least a portion of the pressure necessary to homogenize the emulsion explosive.

12. The method of any one of claims 1-11, wherein the steps of (1) mechanically introducing gas bubbles into the emulsion matrix to sensitize the emulsion matrix and form an emulsion explosive; and (2) homogenizing the emulsion explosive to form the homogenized emulsion explosive both occur on a single mobile processing unit.

13. The method of any one of claims 1-12, further comprising flowing the homogenized emulsion explosive through a conduit into a borehole.

14. A method of delivering an emulsion explosive, the method comprising:

splitting an oxidizer salt solution into a first portion and a second portion;

mixing the first portion of the oxidizer salt solution with a fuel and a pressurized gas to form a low viscosity fuel-rich emulsion explosive, wherein the fuel is substantially devoid of a bubble stabilizing agent;

mixing the second portion of the oxidizer salt solution into the fuel-rich emulsion explosive to form a more-balanced emulsion explosive with increased viscosity by 6000 cP to 20,000 cP relative to the fuel-rich emulsion explosive; and

homogenizing the more-balanced emulsion explosive to form a homogenized emulsion explosive with further increased viscosity.

15. The method of claim 14, further comprising homogenizing the more-balanced emulsion explosive until the homogenized emulsion explosive has a viscosity when measured at 20 °C of greater than or equal to about 80,000 cP.

16. The method of claim 14 or claim 15, wherein the second portion of the oxidizer salt solution is 45% to 80%, or 50% to 70%, of the total amount of the oxidizer salt solution, on a weight-per-weight basis.

17. The method of any one of claims 14-16, further comprising flowing the homogenized emulsion explosive through a conduit into a borehole.

18. The method of any one of claims 14-17, further comprising pressurizing the oxidizer salt solution to provide at least a portion of the pressure necessary to homogenize the emulsion explosive.

19. The method of any one of claims 14-18, wherein the first portion of the oxidizer salt solution is mixed with the fuel before mixing the first portion and the fuel with the pressurized gas.

20. The method of any one of claims 14-18, wherein the first portion of the oxidizer salt solution is mixed with the fuel and the pressurized gas simultaneously.

21. The method of any one of claims 14-20, wherein the fuel further comprises an emulsifier, a homogenization agent, or combinations thereof.