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(54) Combustible compositions containing coal, water and surfactant.

(57) Combustible compositions consist of pulverised coal, water and a dispersing agent which is the product of successive reaction of an alkylphenol or an alkanol with propylene oxide and ethylene oxide.

COMBUSTIBLE COMPOSITIONS CONTAINING COAL, WATER AND SURFACTANT

This invention relates to stabilised aqueous slurries of pulverised coal, more particularly to such slurries which are stabilised by means of specified agents, which are valuable aids towards achieving the optimum fuel utilisation of coal.

With the increasing cost and anticipated eventual scarcity of crude oil and its refined products, renewed emphasis is being placed on the use of coal as a fuel.

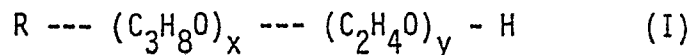
The physical form of coal, however, places severe limitations on its direct use if this is to be done in an efficient and environmentally acceptable manner, and consequently several techniques are currently being explored whereby these

limitations may be overcome or minimised. Mention may be made, for example, of coal gasification processes and the reduction of the coal to finely divided form in suspension in oil, methanol or water. Coal-in-water slurries, in particular, offer a number of conceptual and practical advantages, notably low cost, ease of handling and low transportation costs as compared with dry pulverised coal, comparatively high burning efficiency and lower ash yield after combustion. The slurries are prepared by admixing the finely pulverised coal with water, usually in the presence of dispersing agents and suspension stabilisers. The role of the dispersing agent is to prevent flocculation or coagulation of the coal particles during the mixing process, whilst the suspension stabiliser serves to prevent settling out of the dispersed particles on storage of the slurry. Clearly, for economic reasons, it is desirable to maximise the coal content of the slurries, so as to minimise the absorption of heat due to evaporation of the water during combustion. High coal solids contents, however, generally lead to the slurries having extremely high viscosities, which in turn render very difficult or impossible the handling and transfer of the slurries, especially by pumping.

We have now found that, through the use of certain defined dispersing agents, coal-in-water slurries of high coal content can be prepared which nevertheless have viscosities low enough to avoid or minimise these problems.

According to the present invention we provide a combustible composition consisting of a stabilised suspension of pulverised coal in water, the composition comprising

- (i) from 30 to 90 parts by weight of pulverised coal,
- (ii) from 0.05% to 3%, based on the dry weight of the pulverised coal, of a dispersing agent having the general formula



wherein R is an alkyl group containing from 5 to 22 carbon atoms, or an alkylphenyl group in which the alkyl group contains from 5 to 22 carbon atoms, x is an integer from 3 to 30 and y is an integer at least 10, and

- (iii) sufficient water to bring the total composition weight to 100 parts.

The dispersing agents used are thus block copolymer condensates of aliphatic alcohols or alkylphenols with propylene oxide and ethylene oxide respectively. The poly(oxyethylene) block occupies the terminal position in the poly(oxyalkylene) chain. The group R in formula (I) may be a linear or branched alkyl group containing from 8 to 30 carbon atoms, preferably 16 to 20 atoms, for example the mixed C_{16}/C_{18} alkyl groups derived from commercial stearyl alcohol. Alternatively, the group R may be a linear or branched chain alkylphenyl group in which the alkyl group contains from 6 to 12 carbon atoms, for example a hexyl, octyl, nonyl or dodecyl group.

Preferably the value of x in formula (I) is 10 to 20, and the value of y is 10 to 150, for example 80 to 120.

The dispersing agents are readily obtained by the successive reaction of the appropriate aliphatic alcohol or of nonylphenol successively with propylene oxide and with ethylene oxide.

The proportion of dispersing agent used preferably lies in the range 0.5% to 1.5% of the dry weight of the coal in the composition ; there may be used either a single dispersing agent or a mixture of two or more agents as defined.

The pulverised coal for incorporation in the compositions of the invention may be obtained by techniques already well known such as by the use of tumbling mills or ball mills with recirculation of the ground material until the desired particle size distribution is obtained. The particle size of the coal is not critical for the purposes of the invention, but the preferred grade is that in which at least 80% of the particles are of a size below 75 microns.

As already stated, the coal content of the compositions may vary between 30 parts and 90 parts by weight out of a total composition weight of 100 parts ; more typically, it will lie in the range 50 parts to 80 parts by weight.

The dispersing agents as hereinabove defined are in general effective not only in facilitating the initial dispersing of the coal in the water but also in stabilising the dispersions against settling out of the coal particles on storage. However, if desired, the compositions of the invention may also contain conventional suspending or anti-settling agents.

The compositions are conveniently prepared by the steps of

- (a) dissolving or dispersing the dispersing agent in the water,
- (b) adding the pulverised coal and
- (c) subjecting the mixture to the action of a mixer for a sufficient period of time to produce a dispersion, usually of the order of 2 minutes using a high speed mixer. It is normally satisfactory to carry out these operations at or near room temperature. In certain cases it may be desirable to add an anti-foaming agent to prevent excessive foam formation during the mixing operation.

The compositions of the invention exhibit substantially lower viscosities at comparable coal solids contents than do known coal-in-water slurries prepared with the aid of conventional surfactants such as sodium or calcium lignin sulphonates or condensed naphthalene-formaldehyde sulphonates or sodium polyacrylates. They also show improved stability towards settling out of the coal particles on storage. They are therefore very suitable for use as fuels in process heaters and in industrial and other types of boiler.

The invention is illustrated by the following examples, in which parts and percentages are by weight.

EXAMPLES

General Procedure

The dispersing agent indicated was dissolved or dispersed in water to yield the stated concentration based on dry weight of coal, and to the solution or dispersion was added pulverised coal in the stated proportion; the mixture was then subjected to the action

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of a high-speed mixer for 2 minutes. After each slurry had stood for approximately 15 minutes at room temperature to permit deaeration, its viscosity was measured on a Brookfield viscometer (immediately before measurement, each sample was homogenised by gentle hand stirring).

The coal samples used in certain of the Examples had the following characteristics :

	particle Size (weight average microns)	Ash Content (% w/w)	Oxygen content (% w/w)
	-----	-----	-----
Coal No. 1 -	41.5	14	12.3
Coal No. 2	48.6	13.3	9.4
Coal No. 3	-	3.8	7.8

For comparison, the procedure was repeated in the absence of the dispersing agent as herein defined and also, in certain instances, with the dispersing agent replaced by an equal amount of a conventional anionic surfactant. The compositions of the slurries and their viscosities are shown in the individual Examples.

Example 1

Coal sample : No. 1

Dispersing agent : Agent A (nonylphenol condensed successively with 15.5 molar proportions of propylene oxide and 33 molar proportions of ethylene oxide.

Dispersing Agent	Agent Content (% w/w)	Coal Content (% w/w)	Brookfield RVT viscosity (cps) at 0.5 rpm
-----	-----	-----	-----
None	0.0	50	13440
Lignin sulphonate	0.5	50	2160
Disodium dinaphtal- ene sulphonate	0.5	50	1120
Agent A	0.5	50	960

Example 2

Coal sample : No. 2

Dispersing agent : Agent A, as in Example 1.

Dispersing Agent	Agent Content (% w/w)	Coal Content (% w/w)	Brookfield RVT viscosity (cps) at 0.05 rpm
-----	-----	-----	-----
None	0.0	60	26000
Agent A	0.5	60	6800

Example 3

Coal sample : No. 1

Dispersing agent : Agent B (nonyl phenol condensed successively
- with 16 molar proportions of propylene oxide
and 120 molar proportions of ethylene oxide).

Dispersing Agent	Agent Content (% w/w)	Coal Content (% w/w)	Brookfield RVT viscosity (cps) at 0.05 rpm
-----	-----	-----	-----
None	0.0	50	13440
Agent B	0.5	50	640

Example 4

Coal sample : No. 3

Dispersing agents : Agent A and B as in Examples 1 and 3.

Dispersing Agent	Agent Content (% w/w)	Coal Content (% w/w)	Brookfield RVT viscosity (cps) at 0.05 rpm
-----	-----	-----	-----
None	0.0	60	23840
Disodium di-naphth. sulph.	0.5	60	1680
Agent A	0.5	60	480
None	0.0	65	solid
Disodium di-naphth. sulph.	0.5	65	21600
Agent B	0.5	65	400

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Example 5

Coal sample : a non-beneficiated coal having an ash content of 15 - 20% by weight and an inorganic sulphur content of 2 - 4% by weight. 80% of the particles were of a size below 75 microns.

Dispersing agents : Agent C (nonylphenol condensed successively with 7.4 molar proportions of propylene oxide and 28.0 moles of ethylene oxide).

Agent D (nonylphenol condensed successively with 7.6 molar proportions of propylene oxide and 45.5 moles of ethylene oxide).

Dispersing Agent	Agent Content (% w/w)	Coal Content (% w/w)	Brookfield RVT viscosity (cps) at 0.5 rpm
-----	-----	-----	-----
Agent C	0.3	68.7	18400
Agent D	0.3	68.7	14600

Example 6

Coal sample: a beneficiated coal; 80% of the particles were of a size below 75 microns.

Dispersing agent : Agent D, as in Example 5.

Composition of slurry : agent content : 0.3%
 coal content : 64.5%
 Brookfield RVT viscosity (cps) at 0.5 rpm : 2200

Example 7

Coal sample : a non-beneficiated coal ; 75.8% of the particles were of a size below 75 microns.

Dispersing agents : Agent E (commercial stearyl alcohol condensed successively with the 15 molar proportions of propylene oxide and 100 molar proportions of ethylene oxide).

Agent A, as in Example 1 :

Dispersing agent	Agent Content (% w/w)	Coal Content (% w/w)	Brookfield RVT viscosity (cps) at 0.5 rpm
Agent E	2.0	65	2400 *
Agent E	2.0	70	14000 *
Agent A	2.0	65	3000 *
Agent A	2.0	70	40000 **

* Results obtained using No. 3 spindle.

** Results obtained using No. 6 spindle.

EXAMPLE 8

Coal sample: Coal sample No. 3 as described above was used for this series of experiments.

Dispersing agents: Agent F (nonylphenol condensed successively with 13.5 molar proportions of propylene oxide and 30 molar proportions of ethylene oxide.)

Agent G (oleyl alcohol condensed successively with 15 molar proportions of propylene oxide and 100 molar proportions of ethylene oxide.)

For comparative purposes, to show the advantage of using block copolymer additives, tests were carried out using polymers containing only ethylene oxide.

Agent H (nonylphenol condensed with 30 molar proportions of ethylene oxide.)

Agent I (stearyl alcohol condensed with 100 molar proportions of ethylene oxide.)

Dispersions were made up using 1% (based on dry weight of coal) and viscosity was measured with a Brookfield viscometer at 0.5 rpm using a No.3 spindle.

Dispersing Agent	Agent content (% w/w)	Coal content (% w/w)	Brookfield RVT viscosity (cps)
-----	-----	-----	-----
Agent F	1.0	65	1145
	1.0	68	3730
Agent G	1.0	65	305
	1.0	69	595
	1.0	70	630
Agent H	1.0	65	2505
	1.0	68	NM
Agent I	1.0	65	220
	1.0	69	690
	1.0	70	NM

NM = too high to measure

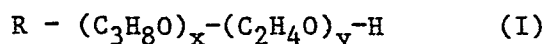
Comparison of the results with Agents F and H shows that a reduced viscosity at 65% coal content is obtained using the block copolymer compared with the simple ethoxylate at the same coal content. At 68% coal content the composition containing the simple ethoxylate is unusable.

Comparison of the results obtained using Agents G and I shows that use of the block copolymer allows a higher solids content than with the simple ethoxylate. Thus additives of general formula (I) in which R is a C₁₆ to C₂₀ alkyl group, x is 10 to 20 and y is 80 to 120 may be used to make compositions in which, using 0.5 to 1.5% by weight additive based on the weight of coal, there is present from 67.5 to 70.5% weight of coal.

COMBUSTIBLE COMPOSITIONS CONTAINING COAL, WATER AND SURFACTANT.CLAIMS

1. A combustible composition of coal, water and surfactant comprising:-

- (i) from 30 to 90 parts by weight of pulverised coal,
- (ii) from 0.05% to 3%, based on the dry weight of the pulverised coal of a dispersing agent having the general formula



wherein R is an alkyl group containing from 5 to 22 carbon atoms, or an alkylphenyl group in which the alkyl group contains from 5 to 22 carbon atoms,

x is an integer from 3 to 30 and

y is an integer and is at least 10, and

- (iii) sufficient water to bring the total composition weight to 100 parts.

2. A composition according to claim 1 in which y is from 10 to 150.

3. A composition according to claim 1 or claim 2 in which the particle size of the coal is such that at least 80% of the particles are below 75 microns.

4. A composition according to claim 3 which comprises:-

- (i) from 68.5 to 70.5% by weight of pulverised coal,
- (ii) from 0.5 to 1.5%, based on the dry weight of the coal of a dispersing agent of formula I wherein

R is an alkyl group containing from 16 to 20 carbon atoms

x is from 10 to 20

y is from 80 to 120

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(iii) sufficient water to bring the total composition weight to 100 parts.

5. A method of preparing a composition according to any one of claims 1 to 4 by the steps of:-

- (a) dissolving or dispersing the dispersing agent in water,
- (b) adding the pulverised coal and
- (c) mixing the composition to produce the dispersion.