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(54) **Process for beneficiating coal employing low amounts of additives.**

(57) A process for beneficiating coal is disclosed which comprises:

- a) contacting pulverized coal with water, a polymerization reaction medium comprising a polymerizable monomer and polymerization catalyst therefor under polymerization reaction conditions, and a fluid organic medium facilitating contact of the surface of the coal particles with the polymerization reaction medium, to provide surface-treated coal particles, the total combined quantity of polymerizable monomer and fluid organic medium not exceeding about 2.0% by weight of the coal; and,
 - b) separating surface-treated coal particles from the water.
- The coal beneficiated products resulting therefrom are also disclosed.

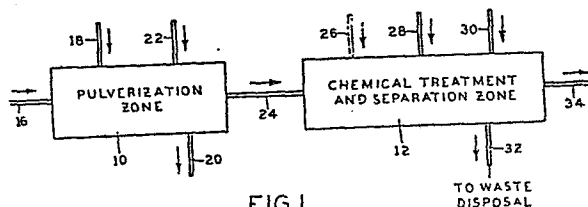


FIG.1

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PROCESS FOR BENEFICIATING COAL EMPLOYING
LOW AMOUNTS OF ADDITIVES

Known world resources of coal and other solid carbonaceous fuel materials are far greater than the known resources of petroleum and natural gas combined. Despite this enormous abundance of coal and related solid carbonaceous materials, reliance on these resources, particularly coal, as primary sources of energy, has been for the most part discouraged. The availability of cheaper, cleaner burning, more easily retrievable and transportable fuels, such as petroleum and natural gas, has in the past, cast coal to a largely supporting role in the energy field.

Current world events, however, have forced a new awareness of global energy requirements and of the availability of those resources which will adequately meet these needs. The realization that reserves of petroleum and natural gas are being rapidly depleted in conjunction with skyrocketing petroleum and natural gas prices and the unrest in the regions of the world which contain the largest quantities of these resources, have sparked a new interest in the utilization of solid carbonaceous materials, particularly coal, as primary energy sources.

As a result, enormous efforts are being extended to make coal and related solid carbonaceous materials equivalent or better sources of energy than petroleum or natural gas. In the case of coal, for example, much of this effort is directed to overcoming the environmental problems associated with its production, transportation and combustion. For example, health and safety hazards associated with coal mining have been significantly reduced with the onset of new legislation governing coal mining. Furthermore, numerous techniques have been explored and developed to make coal cleaner burning, more suitable for burning and more readily transportable.

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1 Gasification and liquefaction of coal are two
such known techniques. Detailed descriptions of various
coal gasification and liquefaction processes may be found,
for example, in the Encyclopedia of Chemical Technology,
5 Kirk-Othmer, Third Edition (1980) Volume 11, pages 410-422
and 449-473. Typically these techniques, however, require
high energy input, as well as the utilization of high
temperature and high pressure equipment, thereby reducing
their widespread feasibility and value.

10 Processes to make coal more readily liquefiable
have also been developed. One such process is disclosed
in U.S. Patent No. 4,033,852 (Horowitz, et al). This
process involves chemically modifying the surface of the
coal, the effect of which renders a portion of the coal
15 more readily liquefiable than the natural forms of coal.

In addition to gasification and liquefaction
other methods for converting coal to more convenient forms
for burning and transporting are also known. For example,
the preparation of coal-oil and coal-aqueous mixtures are
20 described in the literature. Such liquid coal mixtures
offer considerable advantages. In addition to being more
readily transportable than dry solid coal, they are more
easily storable, and less subject to the risks of explosion
by spontaneous ignition. Moreover, providing coal in a
25 fluid form makes it feasible for burning in conventional
apparatus used for burning fuel oil. Such a capability
can greatly facilitate the transition from fuel oil to
coal as a primary energy source. Typical coal
mixtures and their preparation are disclosed in U.S. Patent
30 No. 3,762,887, U.S. Patent No. 3,617,095 and U.S. Patent
No. 4,217,109 and British Patent No. 1,523,193.

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1 Regardless, however, of the form in which the coal
is ultimately employed, the coal must be cleaned because it
contains substantial amounts of sulfur and nitrogen compounds
and mineral matter, including significant quantities of metal
5 impurities. During combustion, these materials enter the
environment as sulfur dioxides, nitrogen oxides and compounds
of metal impurities. If coal is to be accepted as a primary
energy source, it must be cleaned to prevent pollution of
the environment, either by cleaning the combustion products
10 or the coal prior to burning.

10 Accordingly, physical as well as chemical coal
cleaning (beneficiation) processes have been extensively
explored. In general, physical coal cleaning processes
involve pulverizing the coal to release the impurities,
wherein the fineness of the coal generally governs the
15 degree to which the impurities are released. However,
because the costs of preparing the coal rise exponentially
with the amount of fines to be treated, there is an economic
optimum in size reduction. Moreover, grinding to even the
20 finest sizes is not effective in removing all impurities.

20 Based on the physical properties that effect
the separation of the coal from the impurities, physical
coal cleaning methods are generally divided into four
categories: gravity, flotation, magnetic and electrical
25 methods.

25 In contrast to physical coal cleaning, chemical
coal cleaning techniques are in a very early stage of
development. Known chemical coal cleaning techniques
include, for example, oxidative desulfurization of coal
30 (sulfur is converted to a water-soluble form by air oxida-
tion), ferric salt leaching (oxidation of pyritic sulfur
with ferric sulfate), and hydrogen peroxide sulfuric acid
leaching. Other methods are also disclosed in the above-
noted reference to the Encyclopedia of Chemical Technology,
35 Volume 6, pages 314-322.

1 In the chemical coal cleaning processes disclosed
and claimed in U.S. Patent Nos. 4,332,593 and 4,304,573,
and in United States Government Report No. 2694
(Department of Energy) entitled "Fuel Extension by
5 Dispersion of Clean Coal in Fuel Oil", all of which dis-
closures are incorporated by reference herein, raw coal is
first cleaned of rock and/or other extraneous materials as
may be required and then pulverized, preferably in the
presence of water, to a relatively fine average particle
10 size. An aqueous slurry of the finely pulverized coal is
contacted with a polymerization reaction medium comprising
a polymerizable monomer and polymerization catalyst therefor,
and a fluid organic medium such as a distillate fuel for
dispersing the coal and the polymerization reaction medium.
15 As a result of polymerization taking place, the surface of
the coal particles is rendered highly hydrophobic and
oleophilic. While it is not completely understood and
while not wishing to be bound by theory, it is believed
that this surface treatment involves the formation of a
20 polymer or coating on the surface of the coal particles
by molecular grafting of polymeric side chains on the coal
molecules. The surface-treated coal particles are readily
separated from unwanted ash and sulfur-containing components
which are present in the aqueous component of the slurry.
25 Moreover, the hydrophobic coal can be readily further
dehydrated to very low water levels without employing
costly thermal energy. The clean, very low moisture content
coal resulting from this process can then be employed as
is, i.e., as a dry solid product, or further processed
30 to advantageous coal-oil or coal-aqueous mixtures. In an
improvement on this process disclosed and claimed in U.S.

1 patent application Serial No. 230,061 filed January 29, 1981,
the aforescribed processes of beneficiating coal are fur-
ther improved by the use of a frothing agent which, in the
presence of water and a gas such as air, promotes the for-
5 mation of small bubbles which collect the hydrophobic, oleo-
philic coal particles at the surface of the slurry from
which they may be removed by such techniques as skimming.
At the same time impurities pass into the water from which
they are later withdrawn as tailings. In this manner,
10 greater separation of chemically cleaned coal from the
impurities-laden aqueous phase of the slurry can be readily
achieved.

It has now been discovered that the chemical coal
cleaning processes described above such as the processes
15 of aforesaid United States Patent Nos. 4,332,593 and
4,304,573 can be further improved by reducing the total
combined amount of polymerizable monomer and fluid organic
medium employed. Working at relatively low levels of com-
bined monomer and fluid organic medium, it has been ob-
20 served that the amount of impurities present in the coal,
collectively referred to as ash and sulfur, can be signi-
ficantly further reduced. Moreover, since the amount of
moisture retained by the treated coal is also appreciably
reduced, less thermal energy need be expended in drying
25 the coal.

Broadly stated, the present invention provides a
process for beneficiating coal which comprises:

- a) contacting pulverized coal with water, a
polymerization reaction medium comprising
30 a polymerizable monomer and polymerization
catalyst therefor under polymerization
reaction conditions, and a fluid organic
medium facilitating contact of the surface

- 1 of the coal particles with the polymeriza-
tion reaction medium, to provide surface-
treated coal particles, the total combined
5 quantity of polymerizable monomer and fluid
organic medium not exceeding about 2.0% by
weight of the coal; and,
b) separating surface-treated coal particles
from the water.

The term "coal" shall be understood herein to
10 include all solid carbon formations including coal in all
of its varieties, shale oil, tar sands, coke, graphite,
mine tailings, coal fines from mine ponds or tailings
and the like, containing appreciable quantities of one or
more impurities whose removal in whole or in part is de-
15 sired.

The sole figure is a flow diagram of a coal bene-
ficiating process according to an embodiment of the inven-
tion herein.

In accordance with the present invention, coal
20 in pulverized form is combined with water, polymerization
reaction medium and a fluid organic medium which facilitates
contact of the surface of the coal particles with the reac-
tion medium. The average particle size of the coal can vary
widely with finer particle sizes rendering the impurities
25 present in the coal more accessible to removal. The advan-
tage of conducting the process upon very fine particle
size coal can, however, be offset by the cost of the addi-
tional energy required to achieve such particle size. In
general, a particle size of from about 48 to about 200 mesh
30 (Tyler Standard screen size) or greater will provide accept-
able results with a reasonable expenditure of energy. So
far as is known, there is no objection if a larger percentage
of the coal is smaller than 200 mesh but it is preferred

1 if no large percentage is much above the 48 mesh size.
After leaving the size reduction operation, the coal can
be screened to remove particles exceeding 48 mesh which
are then returned for further size reduction. Reduction
5 of the raw coal can be carried out in the absence of added
liquid but for convenience is preferably carried out in
the presence of water. If size reduction in the presence
of water is contemplated, it may be advantageous to add
a small quantity of a water treating agent to enhance
10 the wettability of the coal and facilitate pulverization.
Such water treating agents include dispersants, surfac-
tants, wetting agents and the like. Preferred water con-
ditioning additives are sodium carbonate, sodium pyro-
phosphate and the like. It may also be further advan-
15 tageous to employ water which has previously been treated
in an ion exchange technique.

The quantity of water in admixture with the coal
can vary over wide limits provided a sufficient amount is
ultimately present to result in an apparent aqueous phase
20 and an apparent flocculent phase containing surface-treated
coal particles as more fully described hereinafter. It
is generally preferred to employ only as much water as
is necessary to provide the aforesaid phases in order to
minimize the overall amount of water which must be
25 processed. In contrast to prior art beneficiation processes
which typically are carried out upon coal slurries contain-
ing from about 90% to about 95% water by weight, the
present process works very well with slurries containing
from about 65% to about 95% water by weight.

30 Any polymerizable monomer can be employed in the
polymerization reaction medium herein. While it is more
convenient to utilize monomers which are liquid at ambient
temperature and pressure, gaseous monomers which contain
olefinic unsaturation permitting polymerization with the

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1 same or different molecules can also be used. Thus,
monomers intended to be employed herein may be characterized
by the formula $\text{XHC} = \text{CHX}'$ wherein X and X' each may be
hydrogen or any of a wide variety of organic radicals or
5 inorganic substituents. Illustratively, such monomers
include ethylene, propylene, butylene, tetrapropylene,
isoprene, 1,3-butadiene, pentadiene, dicyclopentadiene,
octadiene, olefinic petroleum fractions, styrene, vinyl-
toluene, vinylchloride, vinylbromide, acrylonitrile, meth-
10 acrylonitrile, acrylamide, methacrylamide, N-methylol-
acrylamide, acrolein, maleic acid, maleic anhydride,
fumaric acid, abietic acid, and the like.

A preferred class of monomers for the purposes
of the present invention are unsaturated carboxylic acids,
15 esters, or salts thereof, particularly those included
within the formula $\text{RC} \begin{smallmatrix} \text{O} \\ \parallel \end{smallmatrix} - \text{OR}'$ wherein R is an olefinically
unsaturated organic radical, preferably containing from
about 2 to about 30 carbon atoms, and R' is hydrogen, a
20 salt-forming cation such as an alkali metal, alkaline earth
metal or ammonium cation, or a saturated or ethylenically
unsaturated hydrocarbyl radical, preferably containing from
1 to about 30 carbon atoms, either unsubstituted or substi-
tuted with one or more halogen atoms, carboxylic acid groups,
25 hydroxyl groups and/or hydroxyl groups in which the hydroxyl
hydrogens may be replaced with saturated and/or unsaturated
acyl groups, the latter preferably containing from about
8 to about 30 carbon atoms. Specific monomers conforming
to the foregoing structural formula include unsaturated
30 fatty acids such as oleic acid, linoleic acid, linolenic
acid, rincinoic acid, mono-, di- and tri-glycerides of
one or more unsaturated fatty acids, and other esters of
unsaturated fatty acids, acrylic acid, methacrylic acid,
methylacrylate, ethylacrylate, ethylhexylacrylate,

1 tertiary-butylacrylate, oleylacrylate, methylmethacrylate,
oleylmethacrylate, stearylacrylate, stearylmethacrylate,
laurylmethacrylate, vinylstearate, vinylmyristate, vinyl-
laurate, soybean oil, cottonseed oil, palm oil, dehydrated
5 castor oils, tall oil, corn oil, and the like. For the
purpose of this invention tall oil and corn oil have been
found to provide particularly advantageous results. Corn
oil is especially preferred.

While the cause and effect relationship between
10 polymerization (or possibly dimerization or oligomerization
as the case may be) of monomer and the development of
hydrophobic, hydrophilic characteristics on the surface
of the coal particles is not known with certainty, there
does appear to be a connection between the two. In practice,
15 an amount of monomer will be employed which will provide
these hydrophobic, hydrophilic characteristics to an
appreciable extent. It is a particular feature of the
present invention to minimize the combined use of monomer
and fluid organic medium consistent with the need to
20 obtain coal having a suitable degree of hydrophobic,
hydrophilic surface properties. In general, the monomer
can be used at a level of from about .005% to about .10%, and
preferably, 0.1% to about .05%, by weight of dry coal.

The catalyst employed in the polymerization
25 reaction medium can be selected from among any such
materials commonly used to effect polymerization of
ethylenically unsaturated monomers. Typically, for the
purposes of this invention, a catalytic amount of those
catalysts of the so-called free radical type are preferred.
30 Their amounts include from about 10-1000 ppm of catalyst,
preferably 10-200 ppm (parts per million) based on the
amount of dry coal. Thus, illustratively, catalysts con-
templated herein include benzoyl peroxide, methylethyl
ketone peroxide, tertbutylhydroperoxide, hydrogen peroxide,
35 ammonium persulfate, di-tert-butylperoxide, tert-butyl-

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1 perbenzoate, peracetic acid, and including such non-
peroxy free radical initiators as the diazo compounds,
such as 1-1-bis-azo-isobutyro nitrile and the like.
Hydrogen peroxide is especially preferred for use here-
5 in.

Moreover, free radical polymerization systems
commonly employ free radical initiators which function
to initiate the formation of free radicals. For the
purposes herein, any of the initiators disclosed in the
10 prior art can be used. Specifically, some of these ini-
tiators include, for example, sodium perchlorate and per-
borate, sodium persulfate, potassium persulfate, ammonium
persulfate, silver nitrate, water soluble salts of noble
metals such as platinum and gold, water soluble salts of
15 iron, zinc, arsenic, antimony, tin and cadmium. Particu-
larly preferred initiators herein are the water soluble
copper salts, i.e., cuprous and cupric salts, such as
copper acetate, copper sulfate and copper nitrate. Most
advantageous results have been obtained herein with cupric ni-
20 trate, $\text{Cu}(\text{NO}_3)_2$. Further initiators contemplated herein are
also disclosed in U.S. Patent Application Serial No. 230,063
filed January 29, 1981. These initiators include metal
salts of naphthenates, tallates, octanoates, etc., said
metals including copper, cobalt, chromium, mercury, manga-
25 nese, nickel, tin, lead, zinc, iron, rare earth metals and
mixed rare earths. Amounts of initiator contemplated for
use herein are generally in the range from about 10-1000 ppm
(parts per million) of the metal portion and preferably
10-200 ppm, based on the amount of dry coal.

30 It is, of course, understood that the catalyst
shall be present in any catalytically effective amount.
Optimum quantities employed will depend upon such factors
as the nature and concentration of the monomer, the pres-
sure and temperature under which polymerization occurs, the
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1 reaction rate desired, and so forth, and can be determined
for a particular beneficiation process employing simple
procedures as is evident to those skilled in the art.
Ambient pressure will ordinarily be used for reasons of
5 process economy and simplicity and for the same reasons,
ambient temperatures or slightly higher will also be favored
although it is, of course, recognized that polymerization
will readily occur within a broad temperature range, e.g.
from about 0°C to about 200°C. For example, at ambient
10 pressure and within the preferred temperature range of
from about 20° to about 50°C, employing corn oil (a mixture
of triglycerides typically averaging an unsaturated fatty
acid content, based on the free acids, of about 86%) as
the polymerizable monomer, hydrogen peroxide can be used
15 as catalyst at a level of from about 0.01% to about 0.1%
by weight of dry coal with good results.

The process of this invention further requires
the use of a fluid organic medium to facilitate contact
of the surface of the coal particles with the polymeriza-
20 tion reaction medium. Fluid organic media included within
the scope of this invention, are for example, fuel oil,
such as No. 2 or No. 6 fuel oils, other hydrocarbons including
benzene, toluene, xylene, hydrocarbon fractions such as
naphtha and medium boiling petroleum fractions (boiling
25 point 100°-180°C), dimethylformamide, tetrahydrofuran,
tetrahydrofurfuryl alcohol, dimethylsulfoxide, methanol,
ethanol, isopropyl alcohol, acetone, methylethylketone,
ethylacetate, and the like, and mixtures thereof. For the
purpose of this invention, fuel oil is a preferred fluid
30 organic medium. The maximum amount of fluid organic medium
which can be used herein represents a critical aspect of the
present invention and, in combination with polymerizable
monomer, must not exceed 2.0% by weight of the coal being
processed. By itself, it is preferred to use from about

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1 0.10% to about 1.0%, and more preferred, from about 0.20%
to about 0.50% fluid organic medium by weight of coal.

It is further within the scope of the present
invention to employ a frothing agent herein in order to
5 effect greater recovery of surface-treated coal from pro-
cess water as described and claimed in aforesaid U.S. patent
application Serial No. 230,061 filed January 29, 1981.

The frothing agents which are optionally intended
for use herein can be selected from among any of the known
10 and conventional materials used to effect frothing in coal
which are suitable for use herein include aliphatic alcohols
such as methylisobutyl carbinol (MIBC) which is a preferred
frothing agent herein, the cresylic acids, eucalyptus oils,
camphor oils and pine oils, all of which are slightly
15 soluble in water. Water soluble frothers which can be
used herein include alkyl ethers and phenyl ethers of
propylene and polypropylene glycols.

The amount of optional frothing agent employed
will depend in large measure upon the volume of slurry
20 undergoing treatment and the coal content thereof and is
related to other process parameters as will be readily
understood by those skilled in the art. Amounts of frothing
agent ranging from about 0.005% to about 0.5% or higher, and
preferably from about 0.01% to about 0.1%, by weight of dry
25 coal being treated generally provide good results. The point
of addition is not critical; however, to avoid the possibility
that frothing might interfere with the surface treating
phase of the coal cleaning process, it is preferred to
add the frothing agent to the slurry only after significant
30 polymerization has taken place, i.e., from about 1 minute
to about 2 hours following contact of the coal with the
polymerization reaction medium.

1 The process herein contemplates conventional
flotation recovery techniques, intermittent or continuous
skimming of the surface-treated coal from the surface of
the slurry being an entirely suitable technique. The
5 recovered coal flocculate can, if desired, be subjected
to one or more further cycles of chemical surface treat-
ment and/or washing to effect still greater separation of
impurities and/or recovery of treated pulverized coal.

A particularly effective technique for separating
10 the treated coal particles from unwanted ash and sulfur in
the water phase is an aeration spray technique wherein a
coal froth phase is formed by spraying or injecting the
treated coal-water slurry into the surface of cleaning
water as is described and claimed in U.S. Patent Nos.
15 4,347,126 and 4,347,127 incorporated herein by reference.
Briefly, according to the method and apparatus there
described the coal slurry is injected through at least
one spray nozzle at pressures for example at from about 15-
20 psi to a spaced-apart distance above the water surface
20 into the water surface producing aeration and a frothing
or foaming of the coal particles, causing these particles
to float to the water surface for skimming off.

Referring to the drawing, raw coal entering through
line 16 is cleaned of unwanted rock, heavy ash and the like
25 and is crushed in the presence of water, added through line
18, in pulverization zone 10 to provide an aqueous coal slurry.
The rock and ash leave pulverization zone 10 through line
20. In pulverization zone 10 the particulate coal in the
slurry is ground to particle sizes of about 48 to 300 mesh,
30 preferably about 80% of the particles being of about a 200
mesh size. A water conditioning agent such as described
hereinbefore may also be added through line 22 to assist
in the separation of impurities.

1 The aqueous coal slurry is fed to a chemical
and separation zone 12 through line 24 where it is ad-
mixed with fuel oil and polymerizable monomer such as
corn oil introduced through line 26. The fuel oil can
5 act as a diluent for the monomer. Polymerization cata-
lyst such as hydrogen peroxide and free radical initiator
such as cupric nitrate are also added to zone 12 via line
28 and admixed therein. Preferably, the reactants, coal-
aqueous slurry and carrier oil are sprayed into at least
10 one froth flotation vessel (not shown) in zone 12 wherein
a coal froth phase and an aqueous impurity containing phase
ensue. Optionally, frothing agent is also added to the slurry
in zone 12 through line 30 to induce frothing.

 The aqueous impurity containing phase containing
15 ash and sulfur is removed through line 32 and may be sent
to, e.g., waste disposal treatment.

 The coal froth phase, containing cleaned coal
particles, is removed such as by skimming or otherwise
and recovered through line 34. The recovered coal which
20 may be dried can be used as is, such as for example in
the formation of coal-oil or coal-aqueous mixtures or
may be used as a particulate coal for burning.

 The following examples in which all percentages
are by weight are further illustrative of the process
25 herein for beneficiating coal.

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EXAMPLES 1 - 7

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A series of coal beneficiating runs were carried out upon Pittsburgh Seam coal at varying levels of polymerizable monomer (i.e., corn oil) and fluid organic medium (i.e., No. 2 fuel oil) to demonstrate the improved levels of ash reduction and moisture reduction obtained at relatively low levels of combined monomer and fluid organic medium.

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Individual portions of an aqueous slurry of course ground coal having a maximum particle size of about 570 microns containing 200 grams coal and 500 grams water were subjected to further size reduction employing grinding times of 5, 10, 15, 30 and 60 minutes, respectively. The individual slurries were thereafter combined with varying quantities of No. 2 fuel oil and corn oil as indicated in Table I below as well as 1.0 ml. of a 5% aqueous solution of hydrogen peroxide catalyst and 5 ml. of a 50 mg./ml. solution of sodium pyrophosphate and 2 ml. of a 50 mg./ml. aqueous solution of cupric nitrate. The results of each coal beneficiation run are set forth in Table I as follows:

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TABLE I

1 EFFECT OF THE AMOUNT OF MONOMER AND FLUID ORGANIC
MEDIUM ON BENEFICIATION OF PITTSBURGH SEAM COAL

Example		Coal	Product	% Ash	% Coal	Filter
		Grinding Time (Min.)	Ash %	Elimination	Recovery	Cake Moisture %
5	1	5% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil				
		5	3.79	37.2	98.9	24.9
		10	3.64	42.1	95.8	26.2
		15	3.73	41.9	99.8	22.0
		30	3.99	33.8	95.7	28.0
		60	3.70	43.0	99.6	33.4
10	2	2 1/2% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil				
		5	3.84	39.2	89.6	21.0
		10	3.77	40.5	92.8	25.8
		15	3.67	43.8	92.0	21.7
		30	3.60	44.7	85.6	26.8
		60	3.51	43.8	93.6	29.6
15	3	1% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil				
		5	3.75	41.4	92.5	19.4
		10	3.66	42.4	85.4	22.3
		15	3.45	46.3	84.3	28.7
		30	3.35	46.7	86.1	34.4
		60	3.15	48.5	80.7	34.7
20	4	0.5% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil				
		5	3.60	44.2	79.8	20.9
		10	3.43	43.2	81.1	28.7
		15	3.16	50.2	71.8	27.0
		30	3.05	51.9	72.6	30.2
		60	2.64	58.4	56.5	39.3
25	5	0.5% No. 2 Fuel Oil; 0.30 lb/ton Corn Oil				
		5	3.29	48.4	78.0	18.0
		10	3.27	48.3	74.7	23.7
		15	3.24	48.6	76.8	23.2
		30	2.67	58.0	41.0	28.7
		60	2.49	60.7	45.3	35.4
30	6	0.5% No. 2 Fuel Oil; 0.10 lb/ton Corn Oil				
		5	3.21	48.1	69.8	24.7
		10	2.97	52.5	60.2	19.0
		15	2.97	52.9	51.7	22.4
		30	2.62	58.2	49.3	28.7
		60	2.16	64.7	13.2	34.8

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TABLE I

1 EFFECT OF THE AMOUNT OF MONOMER AND FLUID ORGANIC
MEDIUM ON BENEFICIATION OF PITTSBURGH SEAM COAL

<u>Example</u>	<u>Coal Grinding Time (Min.)</u>	<u>Product Ash %</u>	<u>% Ash Elimination</u>	<u>% Coal Recovery</u>	<u>Filter Cake Moisture %</u>
5	0.5% No. 2 Fuel Oil; 0.10 lb/ton Corn Oil				
7	5	3.10	50.6	50.9	24.4
	10	2.73	56.2	46.0	24.4
	15	2.49	60.0	29.4	28.7
	30	1.77	71.5	1.0	53.1
	60	1.96	68.7	3.0	42.7

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1 As these data show, the amount of ash retained
in the coal (for a given grinding time) begins to decline
noticeably with the reduction in combined quantities of
fuel oil and corn oil to 2.0% by weight of the dry coal
5 and below. At the same time, the degree of ash elimina-
tion from the recovered beneficiated coal increases signi-
ficantly at the lower fuel oil/corn oil levels. While the
actual percentages of beneficiated coal recovery falls off
sharply as very low levels of fuel oil and corn oil are used,
10 this result is readily offset by recycling the non-surface
treated coal to the surface treatment step herein until
substantially complete recovery of the coal is effected.
The filter cake moisture levels are actual moisture levels
of product. Filtrations were standardized to show the com-
15 parative data. The actual amounts of retained moisture
in the recovered coal were far smaller and in the case of
Examples 3 to 7 which are illustrative of the process of-
this invention, were substantially less than the amounts
of retained moisture in the beneficiated coals resulting
20 from the processes of Examples 1 and 2.

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EXAMPLES 8 - 11

The general beneficiating procedure employed with Examples 1 to 7 was employed herein except that the coal was Freeport Seam and all of the runs were carried out in accordance with the process of this invention. The results are set forth in Table II as follows:

TABLE II

EFFECT OF THE REAGENT AMOUNT OF MONOMER AND FLUID ORGANIC MEDIUM ON BENEFICIATION OF LOWER FREEPORT SEAM COAL

Example	Coal Grinding Time, min.	Product Ash %	% Ash Elimination	% Coal Recovery	Filter Cake Moisture %
<u>1% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil</u>					
8	5	3.54	3.5	77.7	21.8
	10	3.25	66.4	63.3	26.0
	15	3.54	64.4	83.5	28.7
	30	2.78	71.6	51.2	36.0
	60	2.83	71.0	58.1	38.6
<u>0.5% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil</u>					
9	5	3.23	66.6	66.9	28.2
	10	3.55	63.1	71.15	26.3
	15	2.69	72.2	45.9	34.1
	30	2.57	73.3	38.7	38.7
	60	2.48	74.3	41.2	40.1
<u>0.5% No. 2 Fuel Oil; 0.30 lb/ton Corn Oil</u>					
10	5	2.86	70.0	53.9	20.5
	10	3.79	59.4	56.6	28.8
	15	2.74	71.2	44.0	31.3
	30	3.09	67.1	64.5	43.0
	60	2.28	76.8	33.1	43.0
<u>0.5% No. 2 Fuel Oil; 0.10 lb/ton Corn Oil</u>					
11	5	3.12	68.1	51.6	28.9
	10	2.83	67.4	54.9	29.2
	15	2.69	71.3	44.0	33.0
	30	2.66	71.7	43.0	41.9
	60	2.42	73.8	38.3	43.2

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1 These data further demonstrate the advantageous
effect of reducing the combined level of monomer and
fluid organic medium in the coal beneficiating process
of this invention.

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EXAMPLES 12 - 15

1 The beneficiating procedure of Examples 8 to
11 was substantially repeated but with Pocohontas
Seam coal. The results which further demonstrate
the improvements provided by the instant invention are
5 set forth in Table III as follows:

TABLE III

EFFECT OF THE AMOUNT OF MONOMER AND FLUID REACTION
MEDIUM ON BENEFICIATION OF POCOHONTAS SEAM COAL

10	Example	Coal Grinding Time, min.	Product Ash %	& Ash Elimination	% Coal Recovery	Filter Cake Moisture %
		<u>5% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil</u>				
	12	5	2.08	46.8	86.7	21.1
		10	1.77	55.2	76.9	31.5
15		15	1.83	52.5	71.6	29.1
		30	1.77	55.8	83.8	31.7
		60	1.71	57.5	91.6	26.2
		<u>0.5% No. 2 Fuel Oil; 0.50 lb/ton Corn Oil</u>				
	13	5	1.95	52.6	83.5	24.2
		10	1.75	52.4	73.6	28.8
20		15	2.08	47.3	69.8	23.6
		30	2.02	51.3	77.6	30.9
		60	1.74	61.1	51.1	40.0
		<u>0.5% No. 2 Fuel Oil; 0.30 lb/ton Corn Oil</u>				
	14	5	1.86	57.5	82.0	21.5
		10	1.75	56.9	65.6	32.5
25		15	1.67	57.0	40.5	36.5
		30	1.77	58.1	54.8	31.0
		60	1.67	61.3	51.7	40.6
		<u>0.5% No. 2 Fuel Oil; 0.10 lb/ton Corn Oil</u>				
	15	5	1.78	52.7	77.5	19.3
		10	1.87	56.3	62.7	23.7
30		15	1.78	57.7	64.7	29.6
		30	1.63	62.1	54.6	32.1
		60	1.60	60.8	43.5	35.2

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1 While it is not completely understood at this
time and without intending to be limited by any theory,
it is believed that the above-described advantageous re-
sults are achieved by employing selectively low amounts
5 of polymerizable monomer and fluid organic medium not
exceeding about 2.0% by weight of the dry coal, by a
unique combination wherein sufficient additives are pre-
sent to achieve the desired chemical treatment, but which
are of sufficiently low level so as to avoid undue agglomera-
10 tion of the coal particles which might hinder or impair coal
recovery by avoiding agglomerated coal from being lost in
the wash stream.

 Obviously, other modifications and variations
of the present invention are possible in light of the
15 above teachings. It is therefore to be understood that
changes may be made in the particular embodiments of
this invention which are within the full intended scope
of the invention as defined by the appended claims.

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CLAIMS:

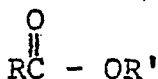
1. A process for beneficiating coal which comprises:

5 a) contacting pulverized coal with water, a polymerization reaction medium comprising a polymerizable monomer and polymerization catalyst therefor under polymerization reaction conditions, and a fluid organic medium facilitating contact of the surface of the coal particles with the polymerization reaction medium, to
 10 provide surface-treated coal particles, the total combined quantity of polymerizable monomer and fluid organic medium not exceeding about 2.0% by weight of the dry coal; and
 b) separating surface-treated coal particles from the water.

15 2. The process of Claim 1 wherein the coal has an average particle size of from about 48 to about 200 mesh.

20 3. The process of Claim 1 wherein the polymerizable monomer is represented by the general formula $XHC = CHX'$ wherein X and X' each may be hydrogen, an organic radical or an inorganic substituent.

4. The process of Claim 3 wherein the polymerizable monomer is represented by the general formula



25 wherein R is an olefinically unsaturated radical or a saturated or ethylenically unsaturated hydrocarbyl radical, unsubstituted or substituted with one or more halogen atoms, carboxylic acid groups, hydroxyl groups and/or
 30 hydroxyl groups in which the hydroxyl hydrogen may be replaced with saturated and/or unsaturated acyl groups.

- 1 5. The process of Claim 4 wherein R contains
from 2 to about 30 carbon atoms.
6. The process of Claim 1 wherein the
polymerizable monomer is a mono-, di- or tri-glyceride of
5 one or more unsaturated fatty acids.
7. The process of Claim 6 wherein the
polymerizable monomer is corn oil.
8. The process of Claim 7 wherein from about
.005% to about .10% polymerizable monomer by weight of dry
10 coal is used.
9. The process of Claim 8 wherein from about
0.01% to about 0.05% polymerizable monomer by weight of dry
coal is used.
10. The process of Claim 1 wherein the
15 polymerization catalyst is an inorganic or organic
peroxide.
11. The process of Claim 10 wherein the polymeri-
zation catalyst is hydrogen peroxide.
12. The process of Claim 11 wherein the hydrogen
20 peroxide is present at a level of from about 0.01% to about
0.1% by weight of monomer.
13. The process of Claim 1 wherein a frothing
agent is employed.
14. The process of Claim 13 wherein the frothing
25 agent is selected from the group consisting of
methyisobutyl carbinol, cresylic acid, eucalyptus oil,
camphor oil, pine oil, alkyl ether or phenyl ether of
propylene, and polypropylene glycols.
15. The process of Claim 13 wherein the frothing
30 agent is employed at a level of from about 0.005% to about
0.5% by weight of the mixture of coal, water, polymeriza-
tion reaction medium and fluid organic medium.

1 16. The process of Claim 15 wherein the frothing
agent is employed at a level of from about 0.01% to about
0.1% by weight of the mixture of coal, water,
polymerization reaction medium and fluid organic medium.

5 17. The process of Claim 1 wherein the fluid
organic medium is a fuel oil.

 18. The process of Claim 1 wherein the fluid
organic medium is used at a level of from about 0.10% to
about 1.0% by weight of coal.

10 19. The process of Claim 18 wherein the fluid
organic medium is used at a level of from about 0.20% to
about 0.50% by weight of coal.

 20. The process of Claim 1 wherein the poly-
merization reaction medium further comprises a free radical
15 initiator.

 21. The process of Claim 20 wherein the free
radical initiator is a water soluble copper salt.

 22. The beneficiated coal produced by the process
of Claim 1.

20 23. The process of Claim 1 wherein said poly-
merizable monomer is corn oil, said polymerization catalyst
comprises hydrogen peroxide and cupric nitrate and said
fluid organic medium is fuel oil.

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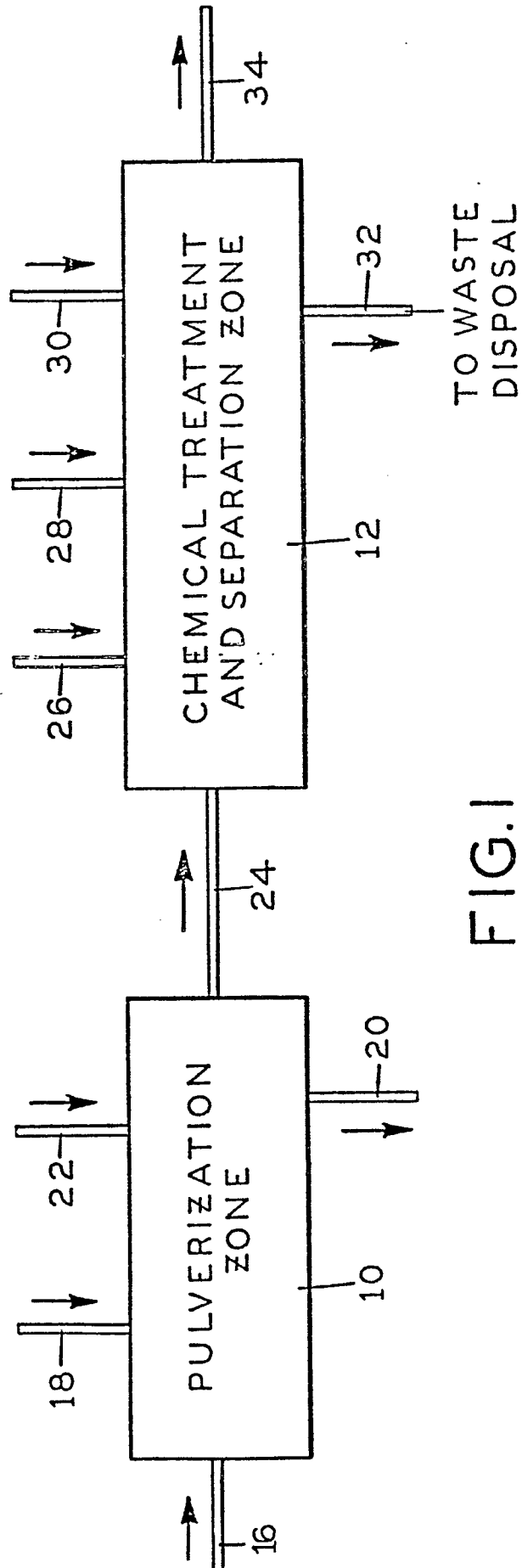


FIG.1



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
X	EP-A-0 057 577 (GULF & WESTERN) * Page 17, line 8 - page 20, line 23 *	1-23	B 03 D 1/02 C 10 L 9/10
X	EP-A-0 066 066 (GULF & WESTERN) * Page 6, line 16 - page 12, line 10; page 15, lines 1-16; page 30, lines 1-15 *	1-12, 17-23	
A	US-A-4 450 070 (DOW CHEMICAL) * Column 6, lines 7-21 *	14	
			TECHNICAL FIELDS SEARCHED (Int Cl 4)
			B 03 D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-12-1985	Examiner LAVAL J.C.A
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			