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(54) Title: LIQUEFACTION OF PLASTIC MATERIALS (57) Abstract <p>A process for converting scrap plastic material into a high quality transportation fuel. The plastic material is granulated and mixed with granulated solid carbonaceous fuel e.g. coal and liquid hydrocarbonaceous solvent e.g. waste motor oil to produce a plastic-containing sludge. The plastic-containing sludge is liquefied in a closed autoclave while in contact with hydrogen gas. A pumpable slurry from the autoclave is heated and fractionated in a fractionation zone to produce a hydrocarbonaceous distillate which may be used for transportation fuel. A bottoms stream from the fractionation zone comprising liquid hydrocarbonaceous material and inorganic material is reacted by partial oxidation to produce nontoxic slag and raw synthesis gas, fuel gas or reducing gas which may be purified in a gas purification zone.</p>		

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LIQUEFACTION OF PLASTIC MATERIALS

FIELD OF THE INVENTION

This invention relates to an environmentally safe method for disposing of scrap plastic materials. More particularly, it pertains to a process for converting scrap plastic materials into a high quality transportation fuel.

Scrap plastics are solid organic polymers and are available in such forms as sheets, extruded shapes, moldings, reinforced plastics, laminates, and foamed plastics. About 60 billion pounds of plastics are sold in the United States each year. For example, automobiles are increasingly being manufactured containing more plastic parts. A large part of these plastic materials wind up as scrap plastics in landfills. Although plastics account for only a small portion of the waste dumped in landfills i.e. about 7 wt. % and about 20 percent by volume, burying them is getting increasingly difficult. The cost of landfilling this material in 1993 is between \$12 to \$100 per ton (excluding shipping costs); and this cost is rising. Landfills are not universally viewed as an acceptable, or even a tolerable option for the disposal of plastic materials. Due to the combined effects of the unpopularity of existing facilities and the need for land to allow normal growth of populations, new landfills have been all but banned in many parts of the world. Existing facilities are also facing finite limits as to how long they may continue to function. Also, toxic wastes from buried plastics seep into and pollute underground streams which are commonly the source of our fresh water. Further, on-site burning or incineration which are alternative disposal methods are in disfavor because they generate heavy air pollution from noxious gases and soot. With respect to recycling plastics, it has been economically feasible to recycle

only about 1 wt. % of the scrap plastics. It is obvious from the aforesaid that the disposal of scrap plastics is one of the nation's most pressing environmental problems.

Advantageously by the subject environmentally acceptable process, a wide range of waste plastic feedstocks are safely disposed. Useful synthesis gas, reducing gas or fuel gas is produced. Further, the relatively medium heating value of the plastic material e.g. greater than about 3,000 Btu/lb is made available for heating internal process streams or producing by-product hot water or steam.

SUMMARY OF THE INVENTION

This invention relates to an environmentally acceptable process for converting a wide range of solid carbonaceous plastic materials into a high quality transportation fuel and includes the partial oxidation of a fractionator bottoms stream comprising liquid hydrocarbonaceous material and separated inorganic material;

wherein synthesis gas, reducing gas, or fuel gas is produced by said process comprising the steps of:

- (1) granulating solid carbonaceous plastic material;
- (2) mixing about 25 to 48 parts by wt. of the granulated solid carbonaceous plastic material from (1) with about 4 to 50 parts by wt. of a pumpable liquid hydrocarbonaceous solvent, and about 5 to 48 parts by wt. of granulated solid carbonaceous fuel to produce a plastic-containing sludge having a solids content in the range of about 45 to 96 wt. %;
- (3) liquefying the plastic-containing sludge from (1) in a closed autoclave at a temperature in the range of about 500°F to 1500°F and a pressure in the range of 150 psig to 2700 psig while said plastic-containing sludge is in contact with hydrogen gas in the amount of about 0.1 to 1.0 parts by wt. of hydrogen gas per part by weight of plastic-containing sludge; wherein said reaction is

continued until a pumpable slurry is produced comprising the following materials in weight percent room temperature and pressure:

a. a slurry comprising solubilized plastic, 50 to 95
5 solubilized solid carbonaceous fuel, and
hydrocarbonaceous liquid solvent

b. unconverted organic and inorganic material 5 to 50
(4) separating a gas mixture comprising H_2 , CO , CO_2 , C_1-C_6
gases, H_2O , and a trace of H_2S from the autoclave in (3),
10 thereby leaving a pumpable slurry;

(5) fractionating the degassed pumpable slurry from (4)
in a distillation zone to produce:

a. a hydrocarbonaceous distillate comprising a mixture of
 C_5 to C_{30} compounds selected from the group consisting of
15 naphthenes, paraffins, aromatics, olefins, and mixtures
thereof, wherein said distillate has an initial
atmospheric boiling point in the range of about $130^\circ F$ to
 $500^\circ F$, a viscosity in the range of about 100 to 1500
centipoise at room temperature, and a specific gravity of
20 about 0.7 to 1.1;

b. a bottoms stream comprising aromatic and paraffinic
hydrocarbonaceous materials containing C_{20} or higher
compounds in admixture with inorganic material from said
plastic and solid carbonaceous fuel; wherein said bottoms
25 stream has an initial boiling point in the range of about
 $300^\circ F$ to $1500^\circ F$, a viscosity in the range of about 1500
to 15,000 cP at room temperature, a solids content in the
range of about 60 to 90 wt. %, a specific gravity of 0.9-
1.3; and

30 (6) reacting by partial oxidation in a free-flow partial
oxidation gasifier with a free-oxygen containing gas in
the presence of a temperature moderator said bottoms
stream (5)(b) to produce raw synthesis gas, fuel gas or
reducing gas, and slag.

DESCRIPTION OF THE INVENTION

Scrap plastics are disposed of by the process of the subject invention without polluting the nation's environment. Simultaneously, useful by-product nonpolluting synthesis gas, reducing gas, fuel gas and nonhazardous slag are produced.

The scrap plastic materials which are processed as described herein include at least one solid carbonaceous thermoplastic and/or thermosetting material that may or may not contain associated inorganic matter e.g. fillers and reinforcement material. Sulfur is also commonly found in scrap plastics. Scrap plastic materials may be derived from obsolete equipment, household containers, packaging, industrial sources and junked automobiles. The mixture of plastics is of varying age and composition. With the presence of varying amounts of incombustible inorganic matter compounded in the plastic as fillers, catalysts, pigments and reinforcing agents, recovery of the plastic material is generally impractical. Further, complete combustion can release toxic-noxious components including volatile metals and hydrogen halides. Associated inorganic matter in the scrap solid carbonaceous plastic may include fillers such as titania, talc, clays, alumina, barium sulfate and carbonates. Catalysts and accelerators for thermosetting plastics include tin compounds for polyurethanes, and cobalt and manganese compounds for polyesters. Dyes and pigments such as compounds of cadmium, chromium, cobalt, and copper; non-ferrous metals such as aluminum and copper in plastic coated wire cuttings; metal films; woven and nonwoven fiber glass, graphite, and boron reinforcing agents; steel, brass, and nickel metal inserts; and lead compounds from plastic automotive batteries. Other heavy metals e.g. cadmium, arsenic, barium, chromium, selenium, and mercury may be also present. The inorganic constituents may be present

in the solid carbonaceous plastic-containing material in the amount of about a trace amount to about 60 wt. % of said solid carbonaceous plastic-containing material, such as about 1 to 20 wt. %. The scrap plastic material may be in the form of sheets, extruded shapes, moldings, reinforced plastics, and foamed plastics.

Figure 1 gives a breakdown of 1991 sales in the United States of applicable solid carbonaceous plastics.

Figure 1

		Million lbs.
	<u>Material</u>	<u>1991</u>
	Acrylobutadienestyrene (ABS)	1,125
	Acrylic	672
	Alkyd	315
15	Cellulosic	840
	Epoxy	428
	Nylon	536
	Phenolic	2,556
	Polyacetal	140
20	Polycarbonate	601
	Polyester, thermoplastic	2,549
	Polyester, unsaturated	1,081
	Polyethylene, high density	9,193
	Polyethylene, low density	12,143
25	Polyphenylene-based alloys	195
	Polypropylene and copolymers	8,155
	Polystyrene	4,877
	Other styrenes	1,180
	Polyurethane	2,985
30	Polyvinylchloride and copolymers	9,130
	Other vinyls	120
	Styrene acrylonitrile (SAN)	117
	Thermoplastic elastomers	584
	Urea and melamine	1,467
35	Others	345
	Total	60,598

The solid carbonaceous plastic material that may contain associated inorganic matter e. g. filler or reinforcement material, has a higher heating value (HHV) in the range of about 3000 to 19,000 BTU per lb of solid carbonaceous plastic-containing material. The plastic material is granulated by conventional means to a maximum particle dimension of about 1/4", such as about 1/8".

Granulating is the preferred method for reducing the size of plastic. Any conventional plastic granulator and mill may be used. For example, a granulator will readily shred/grind solid plastic pieces to a particle size which passes through ASTM E 11 Alternative Sieve Designation 1/4" or less. A mill can take the product from the granulator (i.e., -1/4") and readily convert it to smaller sizes (-1/8" or less), such as ASTM E11 Alternative Sieve Designation No. 7 or less. For example, a suitable granulator and mill are made by Enteleter Inc., 251 Welton St., Hamden, CT 06517. The ash content for an as-received granulated sample of automotive crusher plastic residue (ACR) is 58.2 wt %.

About 25 to 48 parts by weight of the granulated solid carbonaceous plastic material is mixed together with about 4 to 50 parts by wt. of a liquid slurring medium comprising a liquid hydrocarbonaceous solvent and about 5 to 48 parts by wt. of granulated solid carbonaceous fuel to produce a sludge material having a solids content in the range of about 45 to 95 wt.% and having a minimum higher heating value (HHV) of about 10,000 BTU/lb. of slurry.

By definition, the term liquid hydrocarbonaceous solvent as used herein to describe suitable liquid solvents is a liquid hydrocarbonaceous fuel selected from the group consisting of liquefied petroleum gas, petroleum distillates and residues, gasoline, naphtha, kerosine, crude petroleum, asphalt, gas oil, residual oil, tar sand oil and shale oil, coal derived oil, aromatic hydrocarbons (such as benzene, toluene, xylene fractions), coal tar, cycle gas oil from fluid-catalytic-cracking operations, furfural extract of coker gas oil, and mixtures thereof. Waste hydrocarbon motor oil may also be used as a liquid solvent. Hydrocarbon oils having the following properties are suitable: initial atmospheric boiling point, greater than 500°F; Neutralization No., mg KOH/g 0.70 to 1.0; and Aniline point °F 100 to 110. Other suitable oils comply

with ASTM specification D2226, Types 101 and 102. The expression "A and/or B" is used herein in its usual manner and means A or B or A and B.

5 The term solid carbonaceous fuels, as used
herein to describe suitable solid carbonaceous
feedstocks, is intended to include various materials and
mixtures thereof from the group consisting of coal, coke
from coal, char from coal, coal liquefaction residues,
10 petroleum coke, particulate carbon soot, and solids
derived from oil shale, tar sands, and pitch. All types
of coal may be used including anthracite, bituminous,
sub-bituminous, and lignite. The particulate carbon soot
may be that which is obtained as a byproduct of the
subject partial oxidation process, or that which is
15 obtained by burning fossil fuels. The amount of
inorganic matter e.g. ash in solid carbonaceous fuels in
weight percent may be in the range of about 0.2 for
petroleum coke to 20 for coal. The ash particles in the
hot gas stream have not reached the melting temperature
20 of the mineral matter originally contained in the solid
fuel. These ash particles are typically less than 74
microns in size. Typical compositions of the ash
particles in the gas stream from a coal feed for example
in wt. % follow: SiO₂ 58.8-62.6; Al₂O₃ 15.8-20.0; Fe₂O₃
25 3.3-5.1; TiO₂ 0.8-1.4; CaO 5.3-7.6; MgO 0.5-1.6; Na₂O
0.2-0.4; K₂O 0.4-0.7; P₂O₃ 0.1-0.3; and SO₃ 0.9-3.2.

 The sludge material is introduced into a closed
autoclave where the granulated plastic material and solid
carbonaceous fuel are directly contacted by said pumpable
30 liquid hydrocarbonaceous solvent and hydrogen gas. About
4 to 50 parts by weight of liquid hydrocarbonaceous
solvent and about 0.1 to 1.0 parts by weight of hydrogen
gas contact each part by weight of plastic material and
each part by weight of solid carbonaceous fuel. In one
35 embodiment, the hydrogen gas is derived from a portion of
the synthesis gas produced subsequently in the process.
The temperature in the autoclave is in the range of about
500°F to 1500°F. The pressure in the autoclave is in the

range of about 270 psig to 2750 psig. Liquefaction of the organic portions of the plastic and solid carbonaceous fuel by contact with the hot hydrocarbonaceous liquid solvent and hydrogen gas takes place over a period of time in the range of about 5.0 min. to 5.0 hrs, such as about 60 minutes. The heating and liquefaction step is continued until a pumpable slurry is produced which when cooled to room temperature and pressure comprises the following ingredients in wt. %:

- a. a slurry comprising solubilized plastic, solubilized solid carbonaceous fuel, and 50 to 95
- b. unconverted organic and inorganic material 5 to 50

The solubilized plastic and solubilized solid carbonaceous fuel is that portion of the granulated plastic material and the solid carbonaceous fuel that is liquefied by contact with liquid hydrocarbonaceous solvent and hydrogen. The slurry in a. has an initial atmospheric boiling point in the range of about 180½F to 600½F and a specific gravity in the range of about 0.8 to 1.2. It comprises C₅ to C₃₅ compounds selected from the group consisting of naphthenes, aromatics, olefinics, and mixtures thereof. The unconverted organic and inorganic material is the material produced by the solvent liquefaction treatment of the granulated plastic material and solid carbonaceous fuel that is not liquefied and may be easily separated from the remainder of the slurry by settling, screening, filtering, or centrifuging. The density of these materials is greater than 1.2. Typical inorganic compounds are selected from the group consisting of silica, alumina, calcium carbonate, and mixtures thereof. Also included are the oxides and/or sulfides of Na, Ca, Mg, Fe, and mixtures thereof. The unconverted organic material represents that portion of the carbon-containing compounds in the feed that is not readily converted during the liquefaction step and is

composed of carbonaceous material containing carbon, hydrogen, nitrogen and sulfur.

The autoclave is vented and a gas mixture comprising the following is separated from the pumpable slurry: H_2 , CO , CO_2 , C_1 - C_6 gases, H_2O and H_2S . The vented gases may be sent to a partial oxidation gasifier (to be further described) as a supplemental fuel, or purified in a conventional gas purification zone prior to discharge.

The degassed pumpable slurry comprising solubilized plastic and solid carbonaceous fuel, hydrocarbonaceous liquid solvent, separated inorganic material, and unseparated inorganic material is heated in a conventional distillation zone and fractionated into a distillate having an initial atmospheric boiling point in the range of about $130^\circ F$ to $500^\circ F$, a viscosity in the range of about 100 cP to 1500 cP at room temperature, and a specific gravity in the range of about 0.7 to 1.1. The distillate comprises C_5 to C_{25} compounds selected from the group consisting of naphthenes, aromatics, olefinics, and mixtures thereof. The bottoms stream from the fractionator comprises liquid hydrocarbonaceous material and said unconverted organic and inorganic material. The bottoms stream has an initial boiling point in the range of about $300^\circ F$ to $1500^\circ F$, a viscosity in the range of about 1500 cP to 15,000 cP at room temperature, a specific gravity in the range of about 0.9 to 1.3, a solids content in the range of about 60 to 90 wt. %, and comprises compounds having greater than C_{30} carbon atoms. The distillate material was found to be a high quality transportation fuel.

The aforesaid bottoms stream, a temperature moderator e.g. H_2O , CO_2 , and a stream of free-oxygen containing gas are introduced into the reaction zone of a free-flow unobstructed downflowing vertical refractory lined steel wall pressure vessel where the partial oxidation reaction takes place for the production of synthesis gas, reducing gas, or fuel gas. A typical gas generator is shown and described in coassigned U.S. Pat.

No. 3,544,291, which is incorporated herein by reference.

A two, three or four stream annular type burner, such as shown and described in coassigned U.S. Pat. Nos. 3,847,564, and 4,525,175, which are
5 incorporated herein by reference, may be used to introduce the feedstreams into the partial oxidation gas generator. With respect to U.S. Pat. No. 3,847,564, free-oxygen containing gas, for example in admixture with steam, may be simultaneously passed through the central
10 conduit 18 and outer annular passage 14 of said burner. The free-oxygen containing gas is selected from the group consisting of substantially pure oxygen i.e. greater than 95 mole % O₂, oxygen-riched air i.e. greater than 21 mole % O₂, and air. The free-oxygen containing gas is
15 supplied at a temperature in the range of about 100°F. to 1000°F. The aforesaid bottoms stream (b) is passed into the reaction zone of the partial oxidation gas generator by way of the intermediate annular passage 16 at a temperature in the range of about ambient to 650°F. In
20 another embodiment, the aforesaid stream of vent gas may be simultaneously introduced into the free-flow gas generator by way of a separate passage in the burner and reacted by partial oxidation simultaneously with the partial oxidation reaction of said bottoms stream.

25 The burner assembly is inserted downward through a top inlet port of the noncatalytic synthesis gas generator. The burner extends along the central longitudinal axis of the gas generator with the downstream end discharging a multiphase mixture of fuel,
30 free-oxygen containing gas, and temperature moderator such as water, steam, or CO₂ directly into the reaction zone.

35 The relative proportions of fuels, free-oxygen containing gas and temperature moderator in the feedstreams to the gas generator are carefully regulated to convert a substantial portion of the carbon in the fuel feedstream, e.g., up to about 90% or more by weight, to carbon oxides; and to maintain an autogenous reaction

zone temperature in the range of about 1800°F. to 3500°F. Preferably the temperature in the gasifier is in the range of about 2400°F. to 2800°F., so that molten slag is produced. The pressure in the partial oxidation reaction zone is in the range of about 1 to 30 atmospheres. Further, the weight ratio of H₂O to carbon in the feed is in the range of about 0.2 - 3.0 to 1.0, such as about 0.5 - 2.0 to 1.0. The atomic ratio of free-oxygen to carbon in the feed is in the range of about 0.8 - 1.5 to 1.0, such as about 0.9 - 1.2 to 1.0. By the aforesaid operating conditions, a reducing atmosphere comprising H₂ + CO is produced in the reaction zone along with nontoxic slag.

The dwell time in the partial oxidation reaction zone is in the range of about 1 to 15 seconds, and preferably in the range of about 2 to 8 seconds. With substantially pure oxygen feed to the gas generator, the composition of the effluent gas from the gas generator in mole % dry basis may be as follows: H₂ 10 to 60, CO 20 to 60, CO₂ 5 to 60, CH₄ nil to 5, H₂S+COS nil to 5, N₂ nil to 5, and Ar nil to 1.5. With air feed to the gas generator, the composition of the generator effluent gas in mole % dry basis may be about as follows: H₂ 2 to 20, CO 5 to 35, CO₂ 5 to 25, CH₄ nil to 2, H₂S+COS nil to 3, N₂ 45 to 80, and Ar 0.5 to 1.5. Unconverted carbon, ash, or molten slag are contained in the effluent gas stream. Depending on the composition and use, the effluent gas stream is called synthesis gas, reducing gas, or fuel gas. For example, synthesis gas comprises mixtures of H₂ + CO that can be used for chemical synthesis; reducing gas is rich in H₂ + CO and is used in reducing reactions; and fuel gas comprises mixtures of H₂ + CO, and may also includes CH₄. Advantageously, in the extremely hot reducing atmosphere of the gasifier, the toxic elements in any inorganic matter from the solid carbonaceous plastic and fuel materials are captured by the noncombustible constituents present and converted into nontoxic nonleachable slag. This permits the

nontoxic slag to be sold as a useful by-product. For example, the cooled slag may be ground or crushed to a small particle size e.g. less than 1/8" and used in road beds or building blocks.

5 The hot gaseous effluent stream from the reaction zone of the synthesis gas generator is quickly cooled below the reaction temperature to a temperature in the range of about 250°F. to 700°F. by direct quenching in water, or by indirect heat exchange for example with
10 water to produce steam in a gas cooler. The cooled gas stream may be cleaned and purified by conventional methods. For example, reference is made to coassigned U.S. Pat. No. 4,052,176, which is included herein by reference for removal of H₂S, COS, and CO₂.
15 Advantageously, when gasifying plastics that contain halides such as polyvinylchloride, polytetrafluoroethylene, by partial oxidation, the halide is released as hydrogen halide (i.e. HCl, HF) and is scrubbed out of the synthesis gas with water containing
20 ammonia or other basic materials. Plastics that contain bromine-containing fire retardants may be similarly treated. Reference is made to coassigned U.S. 4,468,376 which is incorporated herein by reference.

25 The following examples illustrate the subject invention and should not be construed as limiting the scope of the invention.

EXAMPLESExample 1

4 tons per day of a mixture comprising several types of plastic that are found in post consumer plastics, from the following resins: polystyrene, polyamide, polyurethane, polyvinylchloride, polypropylene, and others are shredded to a particle dimension of less than about 1/8" and mixed with 0.5 tons per day of bituminous coal having a particle size of less than 1/8". The mixture of plastic and coal are mixed with 2 tons per day of waste hydrocarbon motor oil having an initial atmospheric boiling point in the range of about 250 °F to 500°F to produce a plastic-containing sludge. The ultimate chemical analysis of the shredded mixture of plastics is shown in Table I. The chemical analysis of the ash in the mixture of plastics is shown in Table II.

TABLE I

Dry Analysis
of Mixture of Plastics
In Example 1.

		<u>Weight Percent</u>
	C	84.0
25	H	13.0
	N	0.4
	S	0.5
	O	0.1
	Ash	2.0

TABLE II

Chemical Analysis of the Ash Present
In the Mixture of Plastics
In Example 1.

5		<u>Wt. %</u>
	SiO ₂	33.20
	Al ₂ O ₃	6.31
	Fe ₂ O ₃	22.00
	CaO	29.20
10	MgO	0.94
	Na ₂ O	1.27
	K ₂ O	0.43
	TiO ₂	0.89
	P ₂ O ₃	0.92
15	Cr ₂ O ₃	0.28
	ZnO	2.31
	PbO	0.09
	BaO	0.80
	CuO	0.89
20	NiO	0.47

The plastic-containing sludge is liquefied in a closed autoclave while in contact with hydrogen gas at a temperature of about 800°F and a pressure of about 1000 psig. About 1.0 parts by wt. of hydrogen gas is in contact with each part by wt. of plastic-containing sludge. The reaction is continued for 0.5 hrs. to produce a pumpable slurry comprising the following ingredients in wt. % when measured at room temperature and pressure: a. solubilized plastic, solubilized solid carbonaceous fuel, and hydrocarbonaceous liquid solvent 68, and b. unconverted organic and inorganic material 32. Gases from the autoclave are sent to a conventional gas purification zone. The degassed pumpable slurry at the temperature in the autoclave is heated and fractionated to produce a hydrocarbonaceous distillate having an initial atmospheric boiling point of 200°F, and a

viscosity of 200 cP, when measured at room temperature. The bottoms stream from the fractionation zone, comprising a pumpable slurry of liquid hydrocarbonaceous material and said unconverted organic and inorganic material is reacted by partial oxidation in a conventional free flow noncatalytic gas generator at a temperature of about 2400°F and a pressure of about 500 psig with about 6 tons per day of a free-oxygen containing gas in the presence of a temperature moderator e.g. H₂O to produce raw synthesis gas, fuel gas, or reducing gas, and slag. Objectionable gases e.g. H₂S, COS, CO₂ may be removed from the aforesaid raw gas streams in a conventional gas purification zone. Synthesis gas comprising H₂ + CO is produced along with about 0.05 tons of slag. Upon cooling, the slag is a coarse, glassy nonleachable material. If however, the same mixture of plastics were fully combusted in air, the slag may contain toxic elements, e.g. chromium in a leachable form.

Other modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed on the invention as are indicated in the appended claims.

WE CLAIM:

1. A partial oxidation process comprising:

(1) granulating solid carbonaceous plastic material;
(2) mixing about 25 to 48 parts by wt. of the granulated solid carbonaceous plastic material from (1) with about
5 4 to 50 parts by wt. of a pumpable liquid hydrocarbonaceous solvent, and about 5 to 48 parts by wt. of granulated solid carbonaceous fuel to produce a plastic-containing sludge having a solids content in the range of about 45 to 96 wt. %;

10 (3) liquefying the plastic-containing sludge from (1) in a closed autoclave at a temperature in the range of about 500°F to 1500°F and a pressure in the range of 150 psig to 2700 psig while said plastic-containing sludge is in contact with hydrogen gas in the amount of about 0.1 to
15 1.0 parts by wt. of hydrogen gas per part by weight of plastic-containing sludge; wherein said reaction is continued until a pumpable slurry is produced comprising the following materials in weight percent at room temperature and pressure:

20 a. a slurry comprising solubilized plastic, 50 to 95
solubilized solid carbonaceous fuel and
hydrocarbonaceous liquid solvent

b. unconverted organic and inorganic material 5 to 50
(4) separating a gas mixture comprising H_2 , CO , CO_2 , C_1 - C_6
25 gases, H_2O , and a trace of H_2S from the autoclave in (3),
thereby leaving a pumpable slurry;

(5) fractionating the degassed pumpable slurry from (4) in a distillation zone to produce:

30 a. a hydrocarbonaceous distillate comprising a mixture of C_5 to C_{30} compounds selected from the group consisting of naphthenes, paraffins, aromatics, olefins, and mixtures thereof, and wherein said distillate has an initial atmospheric boiling point in the range of about 130°F to 500°F, a viscosity in the range of about 100 to 1500
35 centipoise at room temperature, and a specific gravity of about 0.7 to 1.1;

b. a bottoms stream comprising aromatic and paraffinic hydrocarbonaceous materials containing C₂₀ or higher compounds in admixture with inorganic material from said plastic and solid carbonaceous fuel; wherein said bottoms stream has an initial boiling point in the range of about 300°F to 1500°F, a viscosity in the range of about 1500 to 15,000 cP at room temperature, a solids content in the range of about 60 to 90 wt. %, a specific gravity of about 0.9-1.3; and

(6) reacting by partial oxidation in a free-flow partial oxidation gasifier with a free-oxygen containing gas in the presence of a temperature moderator said bottoms stream (5)(b) to produce raw synthesis gas, fuel gas or reducing gas, and slag.

2. The process of Claim 1 wherein said pumpable liquid hydrocarbonaceous solvent is selected from the group consisting of liquefied petroleum gas, petroleum distillates and residues, gasoline, naphtha, kerosine, crude petroleum, asphalt, gas oil, residual oil, tar sand oil and shale oil, coal derived oil, aromatic hydrocarbons (such as benzene, toluene, xylene fractions), coal tar, cycle gas oil from fluid-catalytic-cracking operations, furfural extract of coker gas oil and mixtures thereof.

3. The process of Claim 1 wherein said pumpable liquid hydrocarbonaceous solvent meets ASTM Specification D2226, Types 101 and 102.

4. The process of Claim 1 wherein said liquid hydrocarbonaceous solvent is a hydrocarbon oil having the following properties: initial atmospheric boiling point greater than 500°F, Neutralization No., mg KOH/g 0.70 to 1.0, and aniline point °F 100 to 110.

5. The process of Claim 1 wherein said plastic material is selected from the group consisting of polyesters, polyurethane, polyamide, polystyrene, cellulose acetate, polypropylene, and mixtures thereof.

6. The process of Claim 1 where in (1) said plastic material is granulated to a particle size which passes through ASTM E11 Alternative Sieve Designation No. 7 or less.

7. The process of Claim 1 where in (3) said liquefaction reaction takes place for a period in the range of about 5.0 minutes to 5.0 hr.

8. The process of Claim 1 wherein the unconverted inorganic material (3)(c) has a density of greater than 1.2.

5 9. The process of Claim 1 where in (6) said bottoms stream from (5)(b) is reacted with a free oxygen containing gas by partial oxidation in a free-flow refractory lined vertical gas generator at a temperature in the range of about 1800°F to 3500°F, a pressure in the range of about 1 to 300 atmospheres, an atomic ratio O/C in the range of about 0.8 - 1.5 to 1.0, and a weight ratio of H₂O to carbon in the range of about 0.2 - 3.0 to 1.0, to produce a hot raw effluent gas stream comprising
10 H₂, CO, CO₂, H₂O, H₂S, COS, and optionally N₂.

10. The process of Claim 9 provided with the step of purifying said raw effluent gas stream in a gas purification zone.

11. The process of Claim 1 wherein said solid carbonaceous fuel is selected from the group consisting of coal, coke from coal, char from coal, coal liquefaction residues, petroleum coke, particulate carbon soot, solids derived from oil shale, tar sands, and pitch, and mixtures thereof.

12. The process of Claim 1 provided with the step of introducing said gas mixture separated in (4) into said free-flow partial oxidation gasifier and reacting same by partial oxidation simultaneously with the partial oxidation reaction of said bottoms stream (5) (b).

AMENDED CLAIMS

[received by the International Bureau on 18 March 1995 (18.03.95),
original claims 1 and 2 amended; new claim 13 added;
remaining claims unchanged (3 pages)]

1. A partial oxidation process consisting essentially of:

(1) granulating solid carbonaceous plastic material;

(2) mixing about 25 to 48 parts by wt. of the granulated solid carbonaceous plastic material from (1) with about 4 to 50 parts by wt. of a pumpable liquid hydrocarbonaceous solvent, and about 5 to 48 parts by wt. of granulated solid carbonaceous fuel to produce a plastic-containing sludge having a solids content in the range of about 45 to 96 wt. %;

(3) liquefying the plastic-containing sludge from (1) in a closed autoclave at a temperature in the range of about 500°F to 1500°F and a pressure in the range of 150 psig to 2700 psig while said plastic-containing sludge is in contact with hydrogen gas in the amount of about 0.1 to 1.0 parts by wt. of hydrogen gas per part by weight of plastic-containing sludge; wherein said reaction is continued until a pumpable slurry is produced comprising the following materials in weight percent at room temperature and pressure:

a. a slurry comprising solubilized plastic, 50 to 95
solubilized solid carbonaceous fuel and
hydrocarbonaceous liquid solvent

b. unconverted organic and inorganic material 5 to 50

(4) separating a gas mixture comprising H₂, CO, CO₂, C₁-C₆ gases, H₂O, and a trace of H₂S from the autoclave in (3), thereby leaving a pumpable slurry;

(5) fractionating the degassed pumpable slurry from (4) in a distillation zone to produce:

a. a hydrocarbonaceous distillate comprising a mixture of C₅ to C₃₀ compounds selected from the group consisting of naphthenes, paraffins, aromatics, olefins, and mixtures thereof, and wherein said distillate has an initial atmospheric boiling point in the range of about 130°F to 500°F, a viscosity in the range of about 100 to 1500 centipoise at room temperature, and a specific gravity of about 0.7 to 1.1;

40 b. a bottoms stream comprising aromatic and paraffinic
hydrocarbonaceous materials containing C₂₀ or higher
compounds in admixture with inorganic material from said
plastic and solid carbonaceous fuel; wherein said bottoms
stream has an initial boiling point in the range of about
300°F to 1500°F, a viscosity in the range of about 1500 to
15,000 cP at room temperature, a solids content in the
45 range of about 60 to 90 wt. %, a specific gravity of about
0.9-1.3; and

(6) reacting by partial oxidation in a free-flow partial
oxidation gasifier with a free-oxygen containing gas in the
presence of a temperature moderator said bottoms stream
50 (5) (b) to produce raw synthesis gas, fuel gas or reducing
gas, and nonhazardous slag.

2. The process of Claim 1 wherein said pumpable
liquid hydrocarbonaceous solvent is selected from the group
consisting of petroleum distillates and residues, crude
petroleum, asphalt, gas oil, residual oil, tar sand oil and
5 shale oil, coal derived oil, aromatic hydrocarbons, coal
tar, cycle gas oil from fluid-catalytic-cracking
operations, furfural extract of coker gas oil and mixtures
thereof.

3. The process of Claim 1 wherein said pumpable
liquid hydrocarbonaceous solvent meets ASTM Specification
D2226, Types 101 and 102.

4. The process of Claim 1 wherein said liquid
hydrocarbonaceous solvent is a hydrocarbon oil having the
following properties: initial atmospheric boiling point
greater than 500°F, Neutralization No., mg KOH/g 0.70 to
5 1.0, and aniline point °F 100 to 110.

11. The process of Claim 1 wherein said solid carbonaceous fuel is selected from the group consisting of coal, coke from coal, char from coal, coal liquefaction residues, petroleum coke, particulate carbon soot, solids
5 derived from oil shale, tar sands, and pitch, and mixtures thereof.

12. The process of Claim 1 provided with the step of introducing said gas mixture separated in (4) into said free-flow partial oxidation gasifier and reacting same
5 by partial oxidation simultaneously with the partial oxidation reaction of said bottoms stream (5) (b).

13. The process of Claim 2, wherein the aromatic hydrocarbons are selected from the group consisting of benzene, toluene, xylene fractions, and mixtures thereof.

STATEMENT UNDER ARTICLE 19

This statement accompanies the Amendment under Article 19.

Claims 1 and 2 have been amended to more precisely define the invention. Claim 13 has been added to recite the specific aromatic hydrocarbons deleted from Claim 2.

All of the amendments are identical to those made to the claims in the priority U.S. patent application Serial No. 08/130,922 upon which this PCT application is based. No new matter has been added.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US94/11172

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C10J 3/46

US CL : 48/197R, 206, 209; 585/240, 241; 252/373

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 48/197R, 206, 209, DIG. 7; 252/373; 585/240, 241; 208/400, 433, 434; 44/628

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONEElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,443,230 (STELLACCIO) 17 April 1984, see entire document.	1-12
Y	US, A, 4,468,376 (SUGGITT) 28 August 1984, see entire document.	1-12
Y	US, A, 4,982,027 (KORFF ET AL.) 01 January 1991, see entire document.	1-12
Y	US, A, 3,704,108 (ALPERT) 28 November 1972, see entire document.	1-12
Y	US, A, 3,856,658 (WOLK ET AL.) 24 December 1974, see entire document.	1-12
Y	US, A, 4,175,211 (CHEN ET AL.) 20 November 1979, see entire document.	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G*	document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means		
P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

05 DECEMBER 1994

Date of mailing of the international search report

18 JAN 1995

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/11172

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,E	US, A, 5,364,996 (CASTAGNOLI ET AL.) 15 November 1994, see entire document.	1-12