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PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

The inventor of this invention in the sense of being the actual deviser thereof within the meaning of Section 16 of the Patents Act 1949 is ALFRED CHAMPAGNAT of 21 rue de la Bienfaisance, Paris VIIIe, France and of French nationality.

Process for the Removal of Straight Chain Hydrocarbons from Petroleum Fractions

We, THE BRITISH PETROLEUM COMPANY LIMITED, of Britannic House, Finsbury Circus, London, E.C.2., a British joint-stock Corporation, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:

This invention relates to a process for the removal of straight chain hydrocarbons, wholly or in part, from petroleum fractions in which they are contained and, more particularly, to a combined process for effecting said removal of hydrocarbons from petroleum fractions with the production of yeasts.

It is well-known that certain petroleum fractions, particularly gas oils, contain straight chain hydrocarbons, mainly paraffins, which are waxes and which have an adverse effect upon the pour point of the fraction; that is to say, when these hydrocarbons are removed, wholly or in part, the pour point of the fraction is lowered. Usually the wax is removed by precipitation by means of solvents, the wax originally present in the fraction being recovered as such, that is, without conversion to more valuable products.

The petroleum fractions boiling below the gas oils, for example, heavy naphthas and kerosines also contain straight chain hydrocarbons which are potentially valuable for conversion to other products but hitherto, in general, utilisation of these hydrocarbons has been rendered difficult by the necessity of recovering these hydrocarbons from the petroleum fractions, in which they are contained, before they can be converted to other products.

In British Patent 914568, to The British Petroleum Company, published after the

priority date of the present application, there is described and claimed a process which comprises maintaining a yeast in a nutrient medium in the presence of a paraffinic feedstock of petroleum origin and a free oxygen-containing gas under conditions favouring growth of the yeast, said feedstock having an average molecular weight corresponding to at least 10 carbon atoms per molecule, and separating the yeast from the aqueous medium.

In British Patent 914567, to The British Petroleum Company, published after the priority date of the present application, there is described and claimed a process which comprises adding to a mixture of yeast, aqueous mineral medium and hydrocarbon, so obtained, at least 50 parts per million by weight of a surface active agent and thereafter centrifuging, whereby there is obtained a paste comprising yeast and aqueous mineral medium.

In British Patent Application 28092/65 (Serial 1017585) (The British Petroleum Company Ltd.), a divisional application based on the priority of the present application, there is claimed a process for the removal, wholly or in part, of straight chain hydrocarbons from a petroleum fraction, with production of a material rich in yeast, which comprises cultivating a strain of yeast, which is adapted to grow on straight chain paraffinic hydrocarbons, in the presence of a petroleum fraction consisting in part of straight chain hydrocarbons and having a mean molecular weight corresponding to at least 10 carbon atoms per molecule; and in the presence of an aqueous nutrient medium; and in the presence of a gas containing free oxygen; and separating from the mixture, on the one hand, a material containing yeast together with a minor proportion of hydrocarbons and, on the other

hand, a petroleum fraction having a reduced proportion of straight chain hydrocarbons or which is free of said straight chain hydrocarbons. In accordance with the process of that invention a yeast-containing product, obtained in the cultivation stage, may be subjected to a centrifuging stage in the presence of a surfactant and thereafter a pasty phase, containing yeast and a minor proportion of hydrocarbon, is washed with water, centrifuged and dried to recover a product consisting of yeast with a minor proportion, of the order of 1% by wt. of the yeast, of hydrocarbon.

It is an object of the present invention to provide a process for the removal wholly or in part of straight chain hydrocarbons from petroleum fractions with the recovery of a valuable product based on the original straight chain hydrocarbon content of the petroleum fractions. It is a further object to provide a process for the de-waxing of a petroleum gas oil fraction with the production of yeast.

According to the present invention there is provided a process which comprises cultivating a strain of yeast which is adapted to grow on straight chain paraffinic hydrocarbons, in the presence of a petroleum fraction consisting in part of straight chain hydrocarbons and having a mean molecular weight corresponding to at least 10 carbon atoms per molecule, and in the presence of an aqueous nutrient medium; and in the presence of a gas containing free oxygen and separating from the mixture, on the one hand, yeast and, on the other hand, a petroleum fraction having a reduced proportion of straight chain hydrocarbons or which is free of said straight chain hydrocarbons.

The process of the invention is of particular value for the treatment of petroleum gas oil fractions which contain straight chain hydrocarbons in the form of waxes, since by the process of the invention a gas oil of improved pour point is obtained while the waxes are converted to a valuable product.

Usually the straight-chain hydrocarbons will be present in the feedstocks according to the invention as paraffins; however, olefins may also be present.

Suitable feedstocks to the process of the invention include kerosine, gas oils and lubricating oils; these feedstocks may be unrefined or may have undergone some refinery treatment, but must contain a proportion of straight chain hydrocarbons in order to fulfil the purpose of this invention. Suitably the petroleum fraction will contain 3-45% by weight of straight chain hydrocarbons.

The process of the invention is of particular value for the treatment of petroleum gas oil fractions which contain straight chain hydrocarbons in the form of waxes, since by the process of the invention a gas oil of improved pour point is obtained while the waxes are converted to a valuable product.

It is an important feature of this invention

that when cultivating yeasts in the presence of the feedstocks hereinbefore described under conditions favouring the growth of the yeasts at the expense of the straight chain hydrocarbons, the other hydrocarbons, for example isoparaffins, naphthenes and aromatics, are not metabolised or, at most, the proportion which is metabolised is very small. Furthermore, unlike conventional chemical processes governed by the law of mass action, the rate of removal of straight chain hydrocarbons is not substantially reduced as the proportion of these hydrocarbons in the overall mixture of hydrocarbons decreases (except, of course, in the very final stages of removal). Thus, when desired, the percentage conversion of straight chain hydrocarbons which is achieved can be maintained at a value approaching 100% without necessitating a very disproportionate expenditure of contact time to achieve small improvement. Furthermore, in a continuous process, this high percentage conversion can be achieved without resorting to the use of a long reaction path.

By the application of this process under conditions which limit the assimilation of the straight chain hydrocarbons it is possible to operate with the removal of only a desired proportion of these hydrocarbons.

Preferably the yeast which is grown on the feedstock is of the family Cryptococcaceae and particularly of the sub-family Cryptococcoidae; however if desired there may be used, for example ascosporeogeneous yeasts of the sub-family Saccharomyceloidae. Preferred genera of the Cryptococcoidae sub-family are *Torulopsis* (also known as *Torula*) and *Candida*. Preferred strains of *Candida* are *Candida tropicalis*, *Candida utilis* and *Candida pulcherina* and, in particular, *Candida lipolytica* (also known as *Mycotorula lipolytica*). Other suitable strains include *Torulopsis colliculosa*, *Hansenula anomala* and *Oidium lactis*.

When starting with a fresh stock of the yeast it will usually be necessary to adapt the yeast to assimilate carbon from hydrocarbons and to use an inoculum of the adapted yeast for the process of growth according to the invention. However these yeasts, when cultivated on an aqueous mineral medium containing the appropriate nutrient elements, grow with difficulty because the petroleum fractions do not contain the growth factors which exist in molasses and wood hydrolysis sugars, for example.

The growth of the yeasts used is favoured by the addition to the culture medium of a very small proportion of extract of yeast (an industrial product rich in vitamins of group B obtained by the hydrolysis of a yeast) or more generally of vitamins of group B and/or biotin. This quantity is preferably of the order of 25 per part per million with reference to the aqueous fermentation medium. It can be

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higher or lower according to the conditions chosen for the growth.

The growth of the yeast takes place at the expense of the petroleum fraction with the intermediate production of bodies having an acid function, principally fatty acids, in such manner that the pH of the aqueous mineral medium progressively diminishes. If one does not correct it the growth is fairly rapidly arrested and the concentration of the yeast in the medium, or cellular density, no longer increases so that there is reached a so-called stationary phase.

Preferably therefore the aqueous nutrient medium is maintained at a desired pH by the step-wise or continuous addition of an aqueous medium of high pH value. Usually, and in particular when using *Candida lipolytica*, the pH of the nutrient medium will be maintained in the range 3—6 and preferably in the range 4—5. Suitable alkaline materials for addition to the growth mixture include sodium hydroxide, potassium hydroxide, disodium hydrogen phosphate and ammonia, either free or in aqueous solution.

The optimum temperature of the growth mixture will vary according to the type of yeast employed and will usually lie in the range 25—35°C. When using *Candida lipolytica* the preferred temperature range is 28—32°C.

The take-up of oxygen is essential for the growth of the yeast. The oxygen will usually be provided as air. In order to maintain a rapid rate of growth the air, used to provide oxygen, should be present in the form of fine bubbles under the action of stirring. The air may be introduced through a sintered surface. Preferably however there is used the system of intimate aeration known as "vortex aeration".

It has been found that by the use of yeast of the strain *Candida lipolytica* in a process according to the invention in which aeration is effected by "vortex aeration", a high growth rate is achieved whereby the generation time

lies in the range 2—5 hours and the cell concentration is increased by a factor of up to 12 in two days.

At the end of the growth there is obtained an emulsion which contains yeast and non-metabolised hydrocarbons in a continuous aqueous phase. This emulsion can be broken down by a first centrifuging in the presence of a surfactant. Thus there is obtained:—

(a) On the one hand a pasty phase of yeast cells impregnated with hydrocarbons and aqueous medium;

(b) on the other hand an aqueous phase and the greater part of the phase of hydrocarbons.

The pasty yeast phase can be subjected to successive alternate washing and centrifuging stages in the presence of a surfactant until the yeast is free from hydrocarbons, the last washing being carried out with pure water. The yeast can then be dried.

The hydrocarbon phase and the aqueous phase (together with wet hydrocarbon phases recycled from subsequent centrifuging of the yeast) can be treated by decantation or centrifuging to separate the hydrocarbons and the aqueous medium.

The process may be carried out batchwise. However if desired, any one or more of the stages herein described may be carried out in continuous manner.

The treated petroleum fractions will be very suited to a number of different uses, depending on boiling range and other characteristics. Thus the kerosine may be employed as aviation jet engine or gas turbine engine fuels; the heavy gas oils are suitable as heavy diesel fuels. Also there may be obtained oils suitable for use as refrigerator oils or as transmission fluids.

The invention is illustrated but not limited by the following Examples:—

EXAMPLE 1

The feedstock was a heavy gas oil having the following characteristics:—

Methods	
Density at 15°C/4°C	0.866 NF T 60 101
Distillation, initial point	204°C NF M 07 009
% at 250°C	2
% at 270°C	6
% at 357°C	82
Final point	370°C
Pour point	+9°C NF T 60 105
Content of normal paraffins by wt.	18%

The yeast employed was a strain of *Candida lipolytica* previously cultivated on a malt sugar medium and adapted to withdraw its carbon from hydrocarbons. This adaptation was carried out by preparing an inoculum by the method now described:—

Preparation of the inoculum:

A culture of *Candida lipolytica* is made in sterile 250-ml conical flasks. These are open to the air and contain 50 mls of a mineral medium together with 5/10 mls of the heavy gas oil described above. The mineral medium has the following composition:

monopotassium phosphate	7 gm
magnesium sulphate	0.2 gm
sodium chloride	0.1 gm
ammonium chloride	2.5 gm
tap water (trace elements)	100 mls
"Difco" yeast extract	1 ml

made up to 1000 mls with distilled water.

"Difco" is a Registered Trade Mark.

This culture is incubated for 3 days at 30°C with mechanical agitation.

5 mls of this culture are then taken and added to a flask containing the same quantities of the same mineral medium and hydrocarbons. The incubation is continued for 3 days with agitation. These same operations are repeated 4 or 5 times.

Two sterile 2-litre toxin flasks, each containing 1 litre of the above mineral medium to which 10 mls of heavy gas oil have been added, are seeded by means of 20 ml/litre of an inoculum coming from the preceding culture. This culture is incubated for 36 hours at 30°C with mechanical agitation. The 2 litres of culture are centrifuged at 30°C and the yeasts recovered in the centrifuge cups constitute the inoculum necessary for one experiment.

Subsequent stages were carried out by the method now described:—

Culture of Candida lipolytica on heavy gas oil:

There is introduced into a fermenter, equipped with an aeration system of a type which forms a vortex in the mixture, 1 litre of the same mineral nutritive medium as described above (containing 1 ml/litre of yeast extract). The pH is regulated to 4.5 at the beginning of the experiment and is maintained at this figure during the culture by the addition of monopotassium phosphate.

The air injection is started up at the rate of 50 litres/hour/litre of the medium and the temperature is maintained at 30°C, and periodically distilled water is added to compensate for evaporation losses.

The fermenter is then seeded with 800 mg of the inoculum whose preparation is described

above, and the gas oil is introduced in four stages in quantities in an exponentially increasing series, so as to reach in all 25 mls/litre of medium.

The incubation is stopped when the cellular density (concentration of cells) remains constant, that is to say when the stationary phase has been reached. The cellular density measured by taking periodical 25 ml samples of the culture, the cells of which are filtered, washed until the NH_4 ions disappear and dried. Their content of nitrogen is estimated by the Kjeldahl method. Measurements carried out previously on pure dry *Candida lipolytica* gave a nitrogen content of 7.25%. From the nitrogen content of the test sample taken it is possible to deduce the cellular density of the culture at the moment the sample was taken.

Recovery of the yeasts:

To the emulsion formed is added 0.25 per mil by weight, reckoned on the aqueous phase, of the cationic surfactant, ammonium stearyltrimethyl chloride and the pH is adjusted to 8 by the addition of caustic soda. The discontinuous centrifuging of this mixture gives:

- A pasty phase of yeast cells impregnated with hydrocarbons and aqueous medium,
- A phase of aqueous mineral medium,
- A wet hydrocarbon phase.

The pasty phase containing the yeast cells is then washed with water containing 0.25 parts per mil of the same surfactant and centrifuged. The washing and centrifuging is repeated and finally the yeast is washed with pure water at 60°C to eliminate the surfactant left in the yeast and once more centrifuged. The product thus obtained is dried at 80 to 90°C in a rapid current of air.

Recovery of the de-waxed heavy gas oil:

To the wet hydrocarbon phase from the first centrifuging, is added the wet hydrocarbon phases from the two subsequent centrifugings and the mixture is allowed to settle at 30°C,

until the water which it contains separates out. (More satisfactorily this step is carried out by centrifuging).

The table below gives the numerical results obtained in this experiment:

Initial cellular density	0.800 gm/litre
Final cellular density	4.76 gm/litre
Growth time	11 hours
Production of yeast per litre of culture medium and per hour:	
$\frac{4.76 - 0.80}{11}$	0.360 gm/litre/hour
Yield of yeast in relation to the gas oil:	
$\frac{4.76 - 0.80}{25 \times 0.866}$	18% by wt.
Yield of de-waxed gas oil	82% by wt.
Pour point de-waxed gas oil	-40°C

EXAMPLE 2

An inoculum was prepared by the method described in Example 1. In place of the feed-stock used in Example 1 there was employed the gas oils described in the following Table.

The method of culture and product separation was as described in Example 1 except

in respect of the scale of the operation. Thus 30 litre fermenters were employed containing 20 litres of the nutritive medium and in each case starting with 40—50 grams of inoculum.

Also, in place of monopotassium phosphate, N/1 ammonium hydroxide aqueous solution was employed to regulate the pH.

TABLE 1

Table 1 shows the results of the experiments carried out in respect of the scale of the operation. The table shows that the yield of yeast is high and that the yield of de-waxed gas oil is high.

TABLE

Feedstock Reference	A	B	C	D	E	F	G
Nature of gas-oil	Straight run Zarzaitine	Irak	Kuwait	Irak	Heavy Zarzaitine	Feed-stock after ferrofining	Feed-stock after desulphurisation by hydrofining
<i>Characteristics of Gas-oil before treatment Distillation Data</i>							
(Initial BP °C)	305	224	198	223	178	305	223
(50% °C)	327	348	361	366	380	327	366
(Final BP °C)	351	390	400	400	400	351	400
Pour point °C	+8	+11	+17	+22	+26	+6	+21
Content of normal Paraffins % by weight	13.3	13.2	8.8	14	11.6	13.3	12
<i>Characteristics of gas-oil after treatment</i>							
Pour point (°C)	-25	-24	-20	-16	+3	-25	-9.3
Percentage of normal paraffins but metabolised (by weight)	0.18	0.5	0.87	1.4	3.4	0.1	1.5
Yield of yeast, based on feedstock (by weight)	12.5	13.2	8.1	7.8	8	16	11.5

EXAMPLES 3 TO 8

An inoculum was prepared by the method described in Example 1. The method of culture and product separation was as described in Example 1 except in respect of the scale

of the operation which was the same as described in Example 2.

The results obtained with different strains of yeast and the characteristics of the feedstock used are recorded in the following table:



Example No.	3	4	5	6	7	8
Origin of gas-oil	Irak	Irak	Irak	Irak	Hassi Messaoud	Kuwait
Strain of yeast used	Torula utilis*	Candida tropicalis	Torulopsis colliculosa	Hansenula anomala	Candida pulcherina	Oidium lactis
<i>Characteristics of gas-oil before treatment</i>						
<i>Distillation Data</i>						
Initial BP °C	224	224	223	217	235	198
50% °C	348	348	366	290	294	361
Final BP °C	390	390	400	392	381	400
Pour point °C	+11	+11	+22	-4	-1	+17
Content of normal paraffins, % by weight	13,2	13,2	14,2	9	3,2	8,8
<i>Characteristics of gas-oil after treatment</i>						
Pour point °C	-24	-20	-15	-26	-30	-20
Content of normal Paraffins, % by weight	0,8	0,6	1	0,6	0,7	1,2
<i>Yield of dried yeast, based on feedstock, by weight</i>	14	13	8,2	8,5	9	8,2

*Also known as Candido utilis

Satisfactory de-waxing of the gas oil and production of yeast was obtained in each of the experiments described in Examples 3—8.

- 5 The yeasts as herein described are well suited for the metabolisation of the straight chain hydrocarbon components of petroleum fractions having a mean molecular weight corresponding to at least 10 carbon atoms per molecule despite the presence in the fractions of non-hydrocarbon components such as sulphur compounds and it has not been found necessary to remove such components prior to treatment in accordance with the invention. Nevertheless it will be necessary to ensure the absence of extraneous materials used in refining which are injurious to yeasts, at least up to and including the growth period. Thus it should be noted that furfural must be excluded from the feedstock, also bacteriostatic agents such as phenols and quaternary nitrogen compounds. Certain metals are also injurious and should be kept from contact with the yeast; typical of such metals are lead and mercury.

WHAT WE CLAIM IS:

1. A process for the removal, wholly or in part, of straight chain hydrocarbons from a petroleum fraction, with production of yeast, which comprises cultivating a strain of yeast, which is adapted to grow on straight chain paraffinic hydrocarbons, in the presence of a petroleum fraction consisting in part of straight chain hydrocarbons and having a mean molecular weight corresponding to at least 10 carbon atoms per molecule; and in the presence of an aqueous nutrient medium; and in the presence of a gas containing free oxygen; and separating from the mixture, on the one hand, yeast and, on the other hand, a petroleum fraction having a reduced proportion of straight chain hydrocarbons or which is free of said straight chain hydrocarbons.

2. A process according to claim 1 in which the feedstock is a kerosine, gas oil or a lubricating oil.

3. A process for the removal, wholly or in part, of waxes from a wax-containing petroleum gas oil, with production of yeast, which comprises cultivating a strain of yeast, which is adapted

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Example No.	3	4	5	6	7	8
Origin of gas-oil	Irak	Irak	Irak	Irak	Hassi Messaoud	Kuwait
Strain of yeast used	<i>Torula utilis</i> *	<i>Candida tropicalis</i>	<i>Torulopsis colliculosa</i>	<i>Hansenula anomala</i>	<i>Candida pulcherina</i>	<i>Oidium lactis</i>
<i>Characteristics of gas-oil before treatment</i>						
<i>Distillation Data</i>						
Initial BP °C	224	224	223	217	235	198
50% °C	348	348	366	290	294	361
Final BP °C	390	390	400	392	381	400
Pour point °C	+11	+11	+22	-4	-1	+17
Content of normal paraffins, % by weight	13,2	13,2	14,2	9	3,2	8,8
<i>Characteristics of gas-oil after treatment</i>						
Pour point °C	-24	-20	-15	-26	-30	-20
Content of normal Paraffins, % by weight	0,8	0,6	1	0,6	0,7	1,2
<i>Yield of dried yeast, based on feedstock, by weight</i>	14	13	8,2	8,5	9	8,2

*Also known as *Candido utilis*

Satisfactory de-waxing of the gas oil and production of yeast was obtained in each of the experiments described in Examples 3—8.

5 The yeasts as herein described are well suited for the metabolism of the straight chain hydrocarbon components of petroleum fractions having a mean molecular weight corresponding to at least 10 carbon atoms per molecule despite the presence in the fractions of non-hydrocarbon components such as sulphur compounds and it has not been found
10 necessary to remove such components prior to treatment in accordance with the invention. Nevertheless it will be necessary to ensure the
15 absence of extraneous materials used in refining which are injurious to yeasts, at least up to and including the growth period. Thus it should be noted that furfural must be
20 excluded from the feedstock, also bacteriostatic agents such as phenols and quaternary nitrogen compounds. Certain metals are also injurious and should be kept from contact with the yeast; typical of such metals are lead and mercury.

WHAT WE CLAIM IS:

1. A process for the removal, wholly or in part, of straight chain hydrocarbons from a petroleum fraction, with production of yeast, which comprises cultivating a strain of yeast, which is adapted to grow on straight chain paraffinic hydrocarbons, in the presence of a petroleum fraction consisting in part of straight chain hydrocarbons and having a mean molecular weight corresponding to at least 10 carbon atoms per molecule; and in the presence of an aqueous nutrient medium; and in the presence of a gas containing free oxygen; and separating from the mixture, on the one hand, yeast and, on the other hand, a petroleum fraction having a reduced proportion of straight chain hydrocarbons or which is free of said straight chain hydrocarbons.

2. A process according to claim 1 in which the feedstock is a kerosine, gas oil or a lubricating oil.

3. A process for the removal, wholly or in part, of waxes from a wax-containing petroleum gas oil, with production of yeast, which comprises cultivating a strain of yeast, which is adapted

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to grow on straight chain paraffinic hydrocarbons, in the presence of a wax-containing petroleum gas oil; and in the presence of an aqueous nutrient medium; and in the presence of a gas containing free oxygen and separating from the mixture, on the one hand, yeast and, on the other hand, a gas oil of reduced content of wax.

4. A process according to any one of claims 1—3 in which the petroleum fraction which is treated contains 3—45% by wt. of straight chain paraffinic hydrocarbons.

5. A process according to any one of claims 1—4 in which the yeast is of the family Cryptococcaceae.

6. A process according to claim 5 in which the yeast is of the sub-family Cryptococcoidae.

7. A process according to claim 6 in which the yeast is of the genus *Torulopsis*.

8. A process according to claim 6 in which the yeast is of the genus *Candida*.

9. A process according to claim 6 in which the yeast is *Candida Lipolytica*.

10. A process according to any one of the preceding claims in which the yeast is grown in the presence of a nutrient medium containing vitamins of group B.

11. A process according to any of the preceding claims in which the yeast is grown in the presence of a nutrient medium containing extract of yeast.

12. A process according to any one of the preceding claims in which the pH of the nutrient medium lies in the range 4—5.

13. A process according to any one of the preceding claims in which the pH of the nutrient medium is maintained during growth of the yeast at a desired value by the stepwise or continuous addition of an aqueous material

of high pH.

14. A process according to any one of the preceding claims in which aeration of the yeast is effected by vortex aeration.

15. A process according to any one of the preceding claims in which the product is treated with an aqueous solution of a surfactant and is centrifuged to yield a pasty phase comprising yeast cells impregnated with hydrocarbons and aqueous medium.

16. A process according to claim 15 in which there is also recovered a mixture of an aqueous phase and a hydrocarbon phase and in which said mixture is subsequently separated into an aqueous phase and a hydrocarbon phase.

17. A process according to claim 15 or 16 in which the pasty phase comprising yeast cells is subjected to successive alternate washing and centrifuging stages, wherein washing is carried out by means of an aqueous solution of a surfactant, and thereafter the pasty phase is washed with water and centrifuged.

18. A process according to any one of the preceding claims in which the free-oxygen-containing gas is air.

19. A process for the treatment of a petroleum fraction with production of a yeast substantially as hereinbefore described in any one of Examples 1—8.

20. A yeast whenever produced by a process as claimed in any one of the preceding claims.

21. Treated petroleum fractions whenever produced by a process as claimed in any one of claims 1—19.

J. WOOLARD,
Agent for the Applicants,
Chartered Patent Agent.

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Retained