operations similar to those employed in the field of refining petroleum oils. The numerous methods proposed for rerefining used lubricating compositions include for example the method described in document EP 0 708 174, which comprises dewatering, vacuum distillation, extraction with the aid of a solvent, and hydrotreating steps.
A process for preparing a regenerated lubricating oil advantageously having a reduced content of the undesirable polycyclic aromatic hydrocarbons (PAHs) that are present in used lubricating compositions, is likewise described in document WO 2018/109208 and comprises passing the used lubricating composition through activated carbon.

But even though such processes make it possible to obtain rerefined lubricating oils having good performance, these rerefined or regenerated oils usually have silicon contents that are still significantly higher than those of conventional base oils resulting directly from petroleum refining.
However, the presence of silicon in base oils intended for the formulation of lubricants, especially for the lubrication of mobile or stationary drive systems, in particular engine lubricants, is undesirable given the wear problems that it can cause.
This means that the amount of rerefined lubricating oils, or the nature of the rerefined lubricating oils, that can be incorporated for the formulation of lubricating compositions is limited in order to meet the specifications required for the lubricant in terms of silicon content. Consequently, the amount of rerefined lubricating oils introduced is usually kept within limits in favor of new base oils.

There therefore remains a need to optimize the composition of rerefined oils, in particular to reduce their silicon content, in order to be able to fully exploit these regenerated oils for use as base oils in the formulation of lubricating compositions.

Statement of the disclosure

The present disclosure aims specifically to overcome the constraint associated with the presence of undesirable elements such as silicon in regenerated oils.
More particularly, it proposes a novel method for purifying at least partially rerefined lubricating oils, advantageously making it possible to reduce the content of undesirable

elements, in particular silicon, in order to obtain regenerated and purified oils that can be used as base oils for the formulation of lubricating compositions.

Thus, according to a first of its examples, the disclosure relates to a process or method for purifying an at least partially rerefined lubricating oil, said process comprising at least the following steps:

(a) contacting said at least partially rerefined lubricating oil, referred to as "regenerated lubricating oil", with from 0.1% to 50% by weight of at least one strong base containing an alkali metal or alkaline earth metal cation; and

(b) recovering said purified lubricating oil by separating the strong base containing the alkali metal or alkaline earth metal cation from the product obtained at the end of step (a).

Preferably, as detailed hereinbelow, step (a) of contacting the regenerated lubricating oil with said strong base is carried out in the presence of water and, preferably, step (b) of separating said strong base is carried out via one or more steps of filtration, distillation, separation by settling and/or liquid/liquid extraction, preferably liquid/liquid extraction, in particular with water.

In one aspect, the present disclosure refers to a process for purifying an at least partially rerefined lubricating oil comprising at least the following steps:

(a) contacting said at least partially rerefined lubricating oil with from 0.1% to 50% by weight of at least one strong base containing an alkali metal or alkaline earth metal cation; and

(b) recovering said purified lubricating oil by separating the strong base containing the alkali metal or alkaline earth metal cation from the product obtained at the end of step (a).

In another aspect, there is provided the use of a purification process as defined above for reducing the silicon content of an at least partially rerefined lubricating oil.

In another aspect, the present disclosure refers to a process for preparing a lubricating composition comprising at least the steps of:

(i) purifying an at least partially rerefined lubricating oil by a purification process as defined above;

(ii) optionally mixing said purified lubricating oil from step (i) with one or more further lubricating oils selected in particular from virgin base oils, lubricating oils regenerated and purified by a purification process as defined above; and at least partially rerefined lubricating oils; and

(iii) supplementing said purified lubricating oil resulting from step (i) or the mixture of lubricating oils from step (ii) with at least one additive, preferably selected from friction-modifying additives, extreme pressure additives, anti-wear additives, detergents, antioxidants, viscosity index (VI) improvers, pour point depressants (PPDs), dispersants, antifoaming agents, thickeners, and mixtures thereof.

Such a process has already been proposed for the purposes of purifying feedstocks containing oils from the pyrolysis of plastic wastes with a view to the use thereof in a steam cracking process, in applications filed under the numbers FR2104616, FR2104617, and FR2109395.

On the other hand, as far as the inventors are aware, nobody has yet proposed exploiting this means of purifying oils from the pyrolysis of plastics for the purposes of purifying partially rerefined lubricating oils, and especially with a view to lowering the silicon content.

In the context of the disclosure, “used lubricating composition” (or more simply “used lubricant” or “used oil”) is understood as meaning any lubricating composition that has been used for lubricating moving parts, in particular metal parts, of a mechanical system, such as bearings, gears or motors.

A used lubricating composition can come from a variety of sources. In particular, as detailed hereinbelow, it may be a lubricant that has been used for the lubrication of a drive system, in particular a “mobile” drive system, or else for the lubrication of a so-called industrial system, in particular a “stationary” industrial system.

It is understood that a used lubricating composition may be a mixture of more than one used lubricating composition from the same source or from more than one different source.

On account of their origin, used lubricants, in particular engine lubricants, comprise a number of degradation products derived from the oil itself or from additives present therein, as well as metal particles, metal oxide particles, and particles of other elements originating for example from the engine. A used oil may in particular contain a high content of undesirable elements, for example of calcium (Ca), iron (Fe), magnesium (Mg), sodium (Na), nickel (Ni), phosphorus (P), silicon (Si), chlorine (Cl), zinc (Zn), etc.

By contrast with a “used lubricating composition”, the expression “new lubricating composition” refers for the purposes of the disclosure to a lubricating composition that has not yet been used for lubricating moving parts of a mechanical system and that is ready for such use.

In the context of the present disclosure, the expression “at least partially rerefined lubricating oil”, also referred to more simply hereinbelow as “regenerated oil” or “recycled oil”, means an oil resulting at least in part from a used lubricating composition that has been subjected to one or more steps of treatment known as rerefining treatment.

In other words, an at least partially rerefined lubricating oil is obtained from one or more steps of treatment of a used lubricant intended to at least partially remove a number of contaminants present therein, such as dust, water, fuel fractions, metallic elements, and other residues resulting from the degradation of additives present in the lubricant.

As detailed hereinbelow, these pretreatment steps to which the lubricating oils have been subjected prior to use in a purification process according to the disclosure may be selected in particular from steps of dewatering, distillation, filtration, hydrogenation, liquid/liquid extraction, separation by settling and/or of passing the used lubricant through an adsorbent material, in particular through activated carbon.

This distinguishes an at least partially rerefined composition of the disclosure from a used lubricating composition or oil. Compared to a used lubricant, the at least partially rerefined lubricating oil has in particular a reduced content of certain undesirable contaminants, for example of water or fuel, and advantageously a reduced content of PAHs, and preferably satisfies a number of quality standards required for a lubricating base oil.

An at least partially rerefined lubricating oil according to the disclosure likewise differs from a virgin or new base oil (i.e. a refined base oil), especially with regard to the silicon content present in the regenerated oil.

In particular, an at least partially rerefined oil used in the treatment process according to the disclosure may have a silicon content that is particularly high and in any event undesirable for the use of said regenerated oil for the formulation of a lubricating composition.
The silicon content of a regenerated lubricating oil used in the purification process according to the disclosure may in particular be strictly greater than 2 ppm, preferably greater than or equal to 5 ppm, in particular greater than or equal to 10 ppm, more particularly greater than or equal to 15 ppm, for example greater than or equal to 20 ppm, or even greater than or equal to 30 ppm.
In some cases, the silicon content of a regenerated lubricating oil may be up to 285 ppm, even up to 290 ppm, or even up to 300 ppm.
The silicon content can be evaluated by any method known to those skilled in the art, for example by X-ray fluorescence (XRF), by inductively-coupled plasma atomic emission spectrometry (ICP-AES) or else by inductively-coupled plasma mass spectrometry (ICP-MS).

Advantageously, as illustrated in the examples that follow, the purification process according to the disclosure for a regenerated lubricating oil makes it possible to significantly reduce the silicon content present in the regenerated oil.
It is advantageous when the silicon content initially present in the regenerated lubricating oil can be reduced by at least 50% by weight of its initial value, in particular by at least 60%, advantageously by at least 70%, preferably by at least 80%, of its initial value.
Advantageously, in particular irrespective of the silicon content of the regenerated lubricating oil initially provided, the process according to the disclosure makes it possible to reduce the amount of silicon to a content of strictly less than 10 ppm, in particular less than or equal to 7 ppm, in particular less than or equal to 5 ppm.

Thus, the purification process of the disclosure is found to be particularly advantageous for treating regenerated lubricating oils that, despite the rerefining treatments to which they have

been subjected, have a high residual silicon content that is undesirable for the use thereof as base oils for the formulation of new lubricants.

According to another of its examples, the disclosure thus relates to a process or method for reducing the silicon content in an at least partially rerefined lubricating oil, said process employing at least the steps (a) and (b) defined above.

It also relates to the use of at least one purification process according to the disclosure employing at least the above steps (a) and (b) to reduce the silicon content of an at least partially rerefined lubricating oil.

It also relates to a process for preparing an at least partially rerefined lubricating oil that contains less than 10 ppm, in particular less than 7 ppm, preferably less than 5 ppm, of silicon from at least partially rerefined lubricating oil, said process employing at least the steps (a) and (b) defined above.

A further advantage, as illustrated in the examples that follow, is that, in addition to significantly reducing the silicon content of the regenerated oil, the process of the disclosure advantageously makes it possible to reduce the content of other elements that may be considered undesirable, especially chlorine, nitrogen and/or oxygen. These elements can be undesirable in the lubricant, especially with regard to the corrosion effects (in the case of chlorine), changes in interfacial properties (in the case of nitrogen), and tendency to oxidation (in the case of oxygen) that they can cause.

In particular, the process of the disclosure, especially when the regenerated oil has a high chlorine content, advantageously makes it possible to significantly reduce this content. Such a reduction in the chlorine content is advantageous given the undesirable corrosion effects that can be caused by the hydrogen chloride potentially generated by residual chlorine present in the lubricating oil.

It is advantageous when the chlorine content of a regenerated oil treated according to the disclosure is less than or equal to 30 ppm, in particular less than or equal to 25 ppm, and more particularly less than or equal to 10 ppm, or even less than or equal to 5 ppm.

The disclosure thus relates to the use of a purification process according to the disclosure employing at least the above steps (a) and (b) to reduce the silicon,

chlorine, oxygen and/or nitrogen content, in particular silicon and/or chlorine content, more particularly silicon content, of an at least partially rerefined lubricating oil.

Advantageously, as illustrated in the examples that follow, the process of the disclosure also makes it possible to reduce the boron and phosphorus contents present in the regenerated oils.

The disclosure thus relates to the use of a purification process according to the disclosure employing at least the above steps (a) and (b) to reduce the silicon, chlorine, oxygen, nitrogen, boron and/or phosphorus contents of an at least partially rerefined lubricating oil.

The regenerated and purified lubricating oil obtained at the end of the treatment process according to the disclosure is found to be particularly suitable, and without requiring additional purification treatment, for use as a base oil, for example for the purposes of being sold as is, further treated in fractions of different viscosities or else formulated with additives to produce a new lubricating composition.

In particular, the process of the disclosure advantageously makes it possible to overcome the constraint associated with their silicon content when using regenerated lubricating oils for the formulation of new lubricants.

Thus, lubricating oils regenerated and purified according to the process of the disclosure may be incorporated on their own or as a mixture with one or more virgin base oils for the formulation of a lubricant, without a limit on the amount, since they do not contribute to an increase in the silicon content of the lubricant.

Thus, the present disclosure also relates, according to another of its examples, to the use of a lubricating oil regenerated and purified according to the process according to the invention for the formulation of a new lubricating composition, in particular by additizing it with one or more additives conventionally used in the field of lubricants.

The disclosure relates in particular to a process or method for preparing a lubricating composition comprising at least the following steps:

(i) purifying an at least partially rerefined lubricating oil by a purification process according to the disclosure as defined above, said process preferably including no distillation step subsequent to step (b);

(ii) optionally mixing said purified lubricating oil from step (i) with one or more further lubricating oils selected in particular from virgin base oils, lubricating oils regenerated and

purified according to the process of the disclosure, and at least partially rerefined lubricating oils;

(iii) supplementing said purified lubricating oil resulting from step (i) or the mixture of lubricating oils from step (ii) with at least one additive, preferably selected from friction-modifying additives, extreme pressure additives, anti-wear additives, detergents, antioxidants, viscosity index improvers, pour point depressants, dispersants, antifoaming agents, thickeners, and mixtures thereof.

Other features, alternative forms, and advantages of the process for purifying at least partially rerefined lubricating oils according to the disclosure will emerge more clearly on reading the description and the examples that follow, which are given as non-limiting illustrations of the disclosure.

The expressions “between... and...”, “ranging from… to…”, “formed from… to…”, and “varying from... to...” should be understood as being meaning inclusive of limits, unless otherwise stated.

In the description and the examples, percentages are percentages by weight unless otherwise stated. Percentages are thus expressed as weights relative to the total weight of the composition.

Detailed description

Regenerated lubricating oil

The process of the invention makes it possible to purify any at least partially rerefined lubricating oil, referred to as “regenerated oil”, in other words any lubricating oil resulting from a used lubricating composition that has been subjected to one or more refining treatment steps.

The used lubricating compositions and consequently the regenerated lubricating oils comprise as the majority component one or more base oils conventionally used in the field of lubricants, such as synthetic or natural mineral oils, animal oils or vegetable oils or mixtures thereof.