A process to obtain low molecular weight polyphenols, medium molecular weight polyphenols, and a standardized solid fuel from tree bark or wood that includes the stages of: bark grinding; solid-liquid extraction from the bark using a low molecular weight aliphatic; concentration of the extract, to recover the aliphatic alcohol used in the extraction; decantation, filtration and/or centrifugation, in order to separate the solid and liquid phases of the extract; drying of the soluble fraction in water of the hydroalcoholic extract; drying of the insoluble fraction in water; separation of the fine fraction of the bark extracted in a sieve and/or air fractionation system. Also revealed are the use of the soluble fraction in water of the hydroalcoholic fraction as a raw material to prepare thermohardening resins, using aldehydes and/or isocyanates as crosslinking agents, the use of the insoluble fraction in water of the hydroalcoholic extracts as a raw material for processes of extrusion, injection or another process of transformation, characteristic of the plastics industry, and the use of bark free of extracts, directly as a solid fuel in industrial and/or residential combustion equipment or subjected to a densification process, to produce pellets, briquettes or another solid densified fuel.
PROCESS FOR OBTAINING LOW AND MEDIUM MOLECULAR WEIGHT POLYPHENOLS AND STANDARDIZED SOLID FUEL FROM TREE WOOD OR BARK


THE FIELD OF THIS INVENTION

[0002] This invention is related to chemical process engineering, specifically to a method of obtaining low and medium molecular weight polyphenols from natural solid fuel materials such as tree bark, especially from conifers, as well as the use of such products.

BACKGROUND OF THE INVENTION

[0003] Tree bark is composed of cellulose, lignin and hemicelluloses; that is, it has the same principal components as wood. However, unlike wood, bark also has significant quantities of additional compounds, among which are notable—in many species, especially conifers—polyphenols of the catechine type (also called tannins) with a high inorganic compound content. These additional compounds are crucial in the development of new commercial uses.

[0004] Bark is plentiful, as it represents between 10% and 20% of the wood mass in the case of adult trees. Nevertheless, only a small proportion is used, since both the tannins and inorganic compounds make it difficult to incorporate it into normal forestry processes such as pulping and particle board production. It is usually burnt, which, however, generates a large quantity of ashes.

[0005] Although polyphenols or tannins are a problem in the development of alternative uses, it is important to stress that they also have great potential, since these types of compounds have properties that can be used in a series of applications. The most interesting of these are their tanning characteristics and the possibility of using them to replace the fossil compound phenol in the production of phenol-formaldehyde resins, for example. In the case of a few species such as the quebracho tree in Argentina and acacias in Brazil and South Africa, industries have been established specifically to exploit these properties. It has not been possible, however, to develop the commercial use of pine species in the same way, despite repeated attempts, principally in New Zealand, Australia and Chile. In these cases the main obstacles to industrial processing have been the changing and unsuitable properties of the tannins obtained, as well as very low yields.

[0006] In the state of the art, there are various patent applications and patented inventions related to the exploitation technology for subproducts of bark and wood that are seeking protection. A discussion of the most relevant of these follows.

[0007] U.S. Pat. No. 5,238,680 proposes a bark extraction process with hot water in different countercurrent stages, in which the liquid and solid phases are separated after each stage by using a press filter.

[0008] U.S. Pat. No. 6,280,778, awarded to Gaudet et al. (2000), describes a process to obtain Botulin sp. from silver birch bark by using a lipophilic solvent and an oxidizing agent that reacts with the compounds of interest in situ. Another process with the same objective is proposed by Draeger et al. (2001) in U.S. Pat. No. 6,175,035, based on bark extraction with an intermediate polarity solvent and subsequent betulinic acid crystallization from a methanol liquid phase.

[0009] Pandey et al. (1997), in U.S. Pat. No. 5,654,448, present a process to obtain compounds called taxans from bark, needles and branches of trees belonging to the genus Taxus sp., which includes extraction, chromatographic, and selective halogenation of the compounds of interest operations.

[0010] Two U.S. patents have been awarded to Shimizu et al., U.S. Pat. No. 4,537,774 and U.S. Pat. No. 4,515,785, both involving the obtention of active components with biological activity from the bark of the neem species. One of the patents describes bark extraction using first a lipophilic organic solvent and later a hydrophilic solvent; in the other, bark extraction is carried out in two phases with hot and cold water and then the extracts are purified through precipitation from an alcoholic phase or dialysis treatment.

[0011] In New Zealand Patent Number 505716, awarded to Ferries et al. (2002) with PCT priority, a method is revealed for obtaining tannins from grapes or grape seeds. This method is based principally on a solid-liquid extraction process in which the aqueous solvent is purified with sodium sulphite and the tannins are recovered after a second selective purification of polyphenols in resin, filtering the tannins.

[0012] Canadian Patent Number 2307628 awarded to Danesi P. et al. (1999) claims a process and a plant to extract as well as to concentrate tannins from wood and other solid natural products, characterized in that the solid products are subjected to extraction through water and/or steam filtration. The solution obtained in this way from the tannin is then subjected to nanofiltration.

[0013] UK Patent Number GB 156583, applied for by Apolline A. (1921), describes a process in which the extraction of cellulose materials is carried out with a sulphite solution and then the alkaline extract is treated with an acid, which stops the tannins reduction.

[0014] UK Patent Number GB 217247, applied for by Chem. Faw Vormals Sandoz (1924), protects a process for producing a glucose from Bulbus scilae. In one of the stages of this process the inventors obtain a solution rich in tannins from this herbaceous plant. The tannins in this solution are precipitated using lead or zinc acetate. Two similar processes are protected under UK Patents GB199400 (1924) and GB300726 (1928). The raw material in the case of GB199400 is in a dehydrated state, and in the case of GB300726 small differences are presented in the extraction and isolation procedures of the glucosides, which are the compounds of interest in the three patent claims mentioned above.

[0015] UK Patent Number GB 777662, applied for by Sandoz Ltd. (1957) reveals a method of extracting glucosides from Podophyllum peltatum, based on the solubility of the drug in water. Within the extraction method there is a stage in which a solution rich in glucans and tannins must be separated from the other components: this is done by first extracting the tannins with lead acetate and subsequently the glucosides with a water-immiscible solvent. This patent shows, in a similar way to GB 1028232 (1966), that a parallel route can exist for extracting tannins by adding hydrocarbures treated with lead and other substances. In this case, Podophyllum sp. rhizomes are used and, as in the previous patents, glucans are the principal objective of this extraction, although other components are also isolated and obtained.
[0016] UK Patent GB 459708, applied for by Freiherr Von Horst (1937), claims an extract referred to as "II", which is a solution rich in tannins and pectone. The extraction process for these tannins is conducted with a water-organic solvent mixture, such as ether alcohol or dichloroethylene, at high temperature.

[0017] Improvements in an apparatus and the method of treating vegetable fibers used in paper manufacturing were protected under UK Patent GB 386305, applied for by Mead Paperboard Corp. (1935). The British patent also protects the manufacturing process that includes tannin extraction stages in a water medium under temperature and alkaline pH conditions, which are achieved adding sodium sulphite. The tannins are recovered later by acidifying the medium.

[0018] A process to purify enzymes using lichen and fungus preparations was protected under UK Patent GB 969936, invented by Ziegler et al. (1964). The recovery process for these proteolytic enzymes is carried out after isolating them from the crude extracts, the enzymes being associated with tannins. They are isolated by being extracted with a water-miscible solvent and the enzymes are separated from the tannins through a reaction with water-miscible cetonens.


[0020] A process to extract proantocyanidines from plant material invented by Duncan et al. (1999) is protected under U.S. Pat. No. 5,968,517. Extraction is conducted with hot water without any other solvent and the separation of the stages is carried out using pulverized deoxogenated water. Then the liquid stage is concentrated, purifying the tannins.

[0021] French Improvement Patent Number 2773150 in the public domain, invented by Feries et al., presents a method of obtaining components from grape pulp and/or tannin from the seeds, involving a solid-liquid extraction of the crude tannin fraction in a water solvent. The method is characterized by using water for the first extraction. Later, the tannins are purified selectively, fixing the polyphenolic compounds by adsorption in a resin.

[0022] A method of producing a tannin extract from bark and/or wood with a relatively low viscosity is protected by U.S. Pat. No. 5,417,888. The products of this invention can be used as glues when they react with formaldehyde. The tannins are recovered, separating the high molecular weight material through a treatment using one or more sulphite compounds to reduce the molecular weight of the tannin. The tannin extract is recovered from the bark and/or wood after subjecting the mixture to a hot water bath in a first stage, thus obtaining a more concentrated extract. In a second stage, the pH of the mixture is raised to a higher value than in the first stage, obtaining a tannin extract that can be recombined optionally with the extracts obtained in the first stage.

[0023] U.S. Pat. No. 4,490,405 protects a single-stage process to extract plant tannins, using water and ethanol as solvents. The solvent concentration can be controlled through a system similar to distillation, and the quantity of tannin extracted can also be controlled. The tannin component is separated from the extract using water vapor and all the alcohol can be expelled and recovered simultaneously. It is important to stress that, unlike the present invention, the patent is based on the ethanol extraction of hops to obtain a "bitter principle" and tannins, in order to replace toxic organic solvents such as dichloromethane. Both the "bitter principle" and the tannin are used as raw materials or ingredients in the brewing of beer, which is radically different from the use and therefore characteristics contemplated in the present invention, that is, the manufacture of thermocondensable resins and thermoplastic materials.

[0024] Australian Patent 8166387, invented by Collins J. et al. (1988) protects a procedure to obtain tannins from wood or bark in two stages. In the first stage the bark or wood is subjected to an extraction process using water at high temperatures, the separation of the solid material being effected in the presence of sulphites. In the second stage, the tannins are extracted in a water system, but with the addition of ethanol under the same conditions as in the first stage.

[0025] European Union Patent 1245613, invented by Yuso et al., presents a method of producing tannins for use in adhesives from a hydro-alcoholic extract obtained from tree bark, including that of radiata pine.

[0026] A state of the art analysis clearly shows that there is the need for a process that overcomes the following difficulties:

[0027] Tannin extraction from bark is carried out in an aqueous medium at a temperature that normally varies between 80° and 110° C. However, because of the low yields (less than 10% in mass), it is usual to increase the solubility of the tannins present in the bark through sulphatation, that is, by adding a sulphite salt to the solution. The extraction pH level is generally basic (pH 8-11, as these conditions produce the highest yields and the best quality extracts. Unfortunately the addition of sulphite salts and alkali to the extraction also has negative consequences such as the following:

[0028] A.—More tannins are extracted but with a greater molecular weight, so that the viscosity of the concentrated tannin solutions is very high (which makes it difficult to use them as wood adhesives, for example) and the resins manufactured from them are brittle, as three-dimensional reticulation with a cross-linking agent (an aldehyde, for example) is hindered.

[0029] B.—Only one part of the sulphite reacts with the polyphenols extracted; the rest combines physically and chemically with the high molecular weight polyphenols that can not be extracted from the bark. This not only signifies a high cost in reactives, but also makes it difficult to find a suitable use for the remaining bark, as the initial high concentration of inorganic compounds in the bark is increased even further.

[0030] These difficulties have been taken into consideration during the conception of this invention for the extraction of tannins.

**SUMMARY OF THE INVENTION**

[0031] This invention is a process to obtain low and medium molecular weight polyphenols, as well as a standardized solid fuel from tree bark or wood, which includes the following stages:

a) bark grinding,

b) solid-liquid extraction from bark using a low molecular weight aliphatic alcohol, 

c) concentration of the extract to recover the aliphatic alcohol used in the extraction,

d) decantation, filtration and/or centrifugation to separate the solid and liquid phases of the extract,

e) drying of the soluble fraction in water of the hydroalcoholic extract,

f) drying of the insoluble fraction in water,
[0032] In one of the preferred embodiments of this invention, the solid-liquid extraction can be discontinuous in two or more stages. Alternatively, extraction can be continuous.

[0033] In certain embodiments of the invention, the alcohol may be methanol or ethanol in water solution concentrations varying between 20% and 99% in mass, preferably between 50% and 95% in mass. In other embodiments, an acid or a base is added optionally to the alcohol solution in a concentration that can vary between 0.1 and 5% in mass in relation to the total mass of the solution.

[0034] This invention also includes hydroalcoholic extracts from bark from the water-soluble fraction of the hydroalcoholic extract, generated in any of the stages of the process in the invention, and the use of such extracts to prepare thermo-hardening resins, treating the extracts with aldehydes and/or isocyanates as cross-linking agents.

[0035] This invention also includes hydroalcoholic extracts from bark from the water-insoluble fraction of the hydroalcoholic extract, generated in any of the stages of the process in the invention, and the use of such extracts in extrusion, injection or any other transformation process characteristic of the plastics industry.

[0036] In addition, this invention includes bark subjected to hydroalcoholic extraction in any of the stages of the process in the invention, and the use of such treated bark as solid fuel in industrial and/or residential combustion equipment and/or densification processes to produce pellets, briquettes or other densified solid fuel.

BRIEF DESCRIPTION OF THE FIGURES

[0037] FIG. 1 presents a graph (tan delta), the loss module and the storage module as a function of the temperature, which shows the operating window in which it is possible to reduce viscosity, and the optimum temperature for Example 3.

DESCRIPTION OF THE INVENTION

[0038] The present invention is a process to obtain low and medium molecular weight polyphenols, in addition to a standardized solid fuel from tree bark. This process includes the following stages:

a) bark grinding,
b) solid-liquid extraction from bark using a low molecular weight aliphatic alcohol, such as methanol or ethanol,
c) concentration of the extract to recover the aliphatic alcohol used in the extraction,
d) dilution in water of the extract concentrate,
e) decantation, filtration and/or centrifugation of the extract in order to separate the solid phase (insoluble fraction in water of the hydroalcoholic extract) from the liquid phase (soluble fraction in water of the hydroalcoholic extract),
f) drying of water-soluble fraction of the hydroalcoholic extract in equipment suitable for this objective, preferably a spray, or tray or belt dryer at atmospheric pressure or in a vacuum,
g) washing with water of the insoluble phase in water in various stages,
h) drying of the insoluble fraction in water,
i) separation of the extract-free bark in a sieve and/or an air fractionation system,
j) heating of the extracted bark with live steam through an indirect heating system,
k) grinding, cutting, or trituration of the extracted bark,
l) separation of the extracted bark by size using a sieve,
m) air separation of the extracted bark using cyclones,
n) densification of the extracted bark.

[0039] The solid-liquid extraction can be discontinuous in two or more stages, or continuous.

[0040] The aliphatic alcohol concentration varies between approximately 20% and approximately 99% in mass, preferably between 50% and 95% in mass.

[0041] The extraction temperature is between approximately 40° and approximately 160°C, preferably between approximately 600 and approximately 140°C.

[0042] Each discontinuous extraction stage lasts from approximately 20 minutes to approximately 600 minutes, preferably between approximately 40 minutes and approximately 200 minutes.

[0043] To the alcoholic solution it is optional to add an acid or a base, the concentration of which can vary between approximately 0.1% and approximately 5% in mass of the total mass of the solution.

[0044] The concentration of the extract is carried out in an evaporator.

[0045] The product obtained from the extractable fraction in water of the hydroalcoholic extract can be used as raw material to prepare thermosetting resins using aldehydes and/or isocyanates as cross-linking agents.

[0046] The product obtained from the insoluble fraction in water of the hydroalcoholic extracts is used as raw material for extrusion and injection processes, or another transformation process, typical of the plastics industry.

[0047] The product obtained from the extracted bark can be used directly as a solid fuel in industrial and/or residential combustion equipment, or it can be subjected to a densification process to produce pellets, briquettes or other densified solid fuel.

[0048] The process for which protection is being requested makes it possible to obtain the following products from the bark and wood of trees belonging to different families and genera of conifers and other tree species (Pinaceae family), acacias (Acaciaceae family) and quebracho (Schinopsis sp.), principally:

[0049] Fraction of low molecular weight polyphenols, of which the low viscosity (to a given percentage of solids) and high capacity for three-dimensional reticulation make them ideal raw material for the production of thermosetting resins to be used as a wood adhesive among other applications.

[0050] Fraction of medium molecular weight polyphenols, which under certain conditions can be processed through extrusion to produce profiles or pellets, which can then be transformed using other processes characteristic of the plastics industry (injection, blown extrusion, thermoforming etc.).

[0051] A standardized solid fuel, characterized by the fact that the inorganic compound content is significantly lower than that present in the original bark.

[0052] The present invention refers to the obtention of three products of high commercial interest from bark for three different areas of application. The basis for the invention is the fact that a material that is highly heterogeneous with regard to the nature of its principal constituents, such as bark, can be fractioned using a cheap and simple process. This
process involves the use of a low molecular weight aliphatic alcohol solution to dissolve a significant part of the catequin type polyphenols (also known as tannins) that are present in the bark.

[0053] This extraction medium is much more selective with regard to tannins in comparison with aqueous solutions, as the proportion of carbohydrates that become soluble is significantly reduced. This fact is highly pertinent because, in particular, complex sugars of a hydrocolloid nature affect to a great extent the properties of the extracts obtained, especially viscosity (viscosity increases when the complex sugar content is increased) and reactivity to cross-linking agents, for example, aldehydes (carbohydrates do not react).

[0054] In addition, in an aqueous medium it is necessary to make the higher molecular weight tannins hydrophilic so that they are soluble in water. This is done by adding sulphite or hydrolysulphite groups of monovalent and bivalent cations to the extraction solution, generally at an alkaline pH, to cause sulphitation of the polyphenols. This has a negative impact on the characteristics of the extracts if they are going to be used to produce thermocondensable resins (principally a lower resistance to humidity). On the contrary, if a hydroalcoholic solution is used, the low and medium molecular weight tannins are extracted without it being necessary to modify them chemically. Thus the use of a hydroalcoholic solution as an extracting medium makes it possible to raise both yields as well as the quality with respect to the presence of impurities (carbohydrates) and the chemical characteristics (they are not modified by the incorporation of hydrophilic functional groups) of the extracts.

[0055] However, if the hydroalcoholic extraction is concentrated and the original medium is changed to an aqueous medium, part of the extracts precipitates. The solution that was proposed before the present invention was to add sulphite to the extract to allow its complete dissolution in water. Although this method solves the problem, it has negative consequences, since, just as in the case of a water-medium extraction, chemically modified polyphenols are obtained, and not only low molecular weight polyphenols but also larger polyphenolic molecules are incorporated (leading to two problems, high viscosity and brittle resins).

[0056] This invention therefore proposes obtaining two distinct extracts: on one hand, hydroalcoholic extracts that are soluble in water; and on the other hand, hydroalcoholic extracts that are insoluble in water.

[0057] Surprisingly and unexpectedly, it was possible to establish that the water-soluble fraction presents extraordinary characteristics for the production of thermocondensable resins. It is important to stress the following:

[0058] The viscosity of concentrated solutions is much lower than that of other types of extracts;

[0059] The polyphenol concentration is unusually high with respect to impurities present (mainly carbohydrates);

[0060] The average molecular weight of the polyphenols is low in relation to polyphenols obtained through alternative processes.

[0061] The practical consequence of the above-mentioned facts is that the water-soluble fraction of the hydroalcoholic extracts from bark constitutes an ideal raw material for the production of thermocondensable resins because it is of a significantly higher quality than any of the commercial tannins known to date.

[0062] If the conditions are right, the water-insoluble fraction of the hydroalcoholic extracts can be processed through extrusion and other transformation processes, characteristic of the plastics industry. For this purpose it is necessary to dry the product, add determined quantities of plasticizers, organic and/or inorganic loads, and/or specific functional agents (compatibilizers, lubricants, UV and fire protectors, etc.). In certain operating windows (those that depend on the characteristics of the transformation equipment and on the specific composition of the mixture to extrude), it is possible to process the insoluble fraction of hydroalcoholic extracts from bark quite easily. In addition, however, it is possible to incorporate cross-linking agents into the extrusion mixture in order to obtain profiles with extraordinary physical and mechanical characteristics. In this case, the extrusion is reactive, which means that during or after the extrusion process the cross-linking agent or agents react with the polyphenols and harden the material when it comes out of the extrusion mold or at a later stage.

[0063] After extraction, the bark is sieved in order to separate a minority mass fraction of fine particles whose inorganic compound content is high, thus lowering even more the inorganic content of the remaining bark. In this way it is possible to obtain a biomass fraction from bark whose ash content is equal to or less than 2%, which allows it to be used to produce densified solid fuels, or alternatively, this material can be mixed with sawdust or another type of forest or agricultural biomass.

APPLICATION EXAMPLES

Example 1

Bark Extraction

Stage I: Preparation of the Raw Material

[0064] The raw material for extraction consists of Pinus radiata D. Don bark of which the humidity content has been previously determined and which has been homogenized with respect to particle size.

Stage II: Extraction.

[0065] A 4 m³ reactor is loaded with pinus radiata bark. The solvent is added, which consists of a methanolic solution up to 75%, in a bark/methanol relation of 1/7 w/w.

[0066] The liquor is heated by recirculation through a heat exchanger until it reaches a temperature of 120°C. After 1 hour at the maximum temperature, the reactor contents are cooled and the liquid and solid phases separated. The process is repeated a second and a third time under similar conditions, each time with a fresh methanolic solution.

Stage III: Concentration and drying

[0067] The diluted liquor from the three extraction stages is concentrated in a falling film evaporator to approximately 30-40% of solid content. In this condition, one fraction of the extracts precipitates and the other remains in solution. Stage IV: Quantification and characterization.

[0068] The fraction that precipitates and the one that remains in solution are separated and quantified. The soluble phase is also characterized in terms of its Stiasny Number.

[0069] The results obtained are shown in Table 1.

<table>
<thead>
<tr>
<th>Water-Insoluble Phase Yield (%)</th>
<th>Water-Soluble Phase Yield (%)</th>
<th>Total Extraction Yield (%)</th>
<th>Soluble Phase Stiasny No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.5</td>
<td>5.2</td>
<td>16.7</td>
<td>93.5</td>
</tr>
</tbody>
</table>
Example 2

Bark Extract Application to the Manufacture of a Thermocondensable Adhesive

[0070] The soluble phase of the bark extract concentrated to a solid content of 20%, obtained using the methodology described in Application Example 1, is dried in a spray dryer. This extract is used to prepare an adhesive resin, which also contains paraffin and methanol in a proportion of 40, 7, and 40 in mass, respectively. The mixture is characterized with respect to its viscosity, pH, useful life and gel time. The adhesive mixture is then used in the manufacture of particle board, with a resin ratio of 10%. The pressing is carried out under the following operating conditions: a) temperature: 190 °C; b) press factor: 20 (s/mm); c) specific pressure: 24 (bar); and d) pressing cycle: 4 (min). Finally, the physical and mechanical properties of the board are determined in accordance with international norms.

[0071] The results are shown in Tables 2 and 3.

<table>
<thead>
<tr>
<th>Characterization of the Adhesive Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity (cp)</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>160</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical-mechanical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (kg/m3)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>663</td>
</tr>
</tbody>
</table>

Example 3

Application of Bark Extracts to Profile Extrusion

[0072] The insoluble phase of the bark extract, obtained using the methodology described in Application Example 1, is steamed at 50 °C. This extract is used to prepare a resin with thermoplastic characteristics, which also contains wood powder, glycine and water. The proportions, beginning with the bark extract, are 32.2%, 35.7%, 3.7%, and 28.6%, respectively. All the ingredients are mixed at ambient temperature in a static mixer.

[0073] The homogenized mixture is put into a gravimetric feeder, which introduces it to a twin screw, contrarotary extruder 45 mm in diameter and with an UD ratio of 45 (manufacturer TSA Industriale S.r.l., model EMT45-40). The temperature profile is 75 °C from Zones 1 to 3; 85 °C from Zones 4 to 7; and 95 °C in the headstock. This allows the production of a rectangular profile 15 mmx66 mm. The extruder has a vacuum degasification system in Zone 6.

[0074] The resulting profile is compact, hard after cooling, and has a uniform surface. Dynamic Mechanical Analysis (DMA) (see FIG. 1) establishes that the material possesses an operating window between 60 °C and 110 °C, in which its viscosity can be reduced; the optimum temperature is 90 °C. This operating window is the appropriate one for processing material by extrusion, injection, and other transformation processes characteristic of the plastics industry.

Example 4

Extracted Bark Application as a Fuel

[0075] Different samples of bark from Pinus radiata D.Don are subjected to extraction following the methodology described in Application Example 1. The extracted bark is fractioned according to size, the fine material being separated using a mesh 14 sieve. The remaining bark is characterized with respect to calorific power and ash content, and these values are compared with those of the original bark, before it was extracted.

[0076] Table 4 shows the highest calorific power and the ash content in unprocessed bark samples and after extrusion and fractioning by size:

<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest calorific power and ash content in bark samples before and after processing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unprocessed bark</th>
<th>Processed bark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bark sample</td>
<td>Highest calorific power (kcal/kg)</td>
</tr>
<tr>
<td>A</td>
<td>4721</td>
</tr>
<tr>
<td>B</td>
<td>4747</td>
</tr>
<tr>
<td>C</td>
<td>4650</td>
</tr>
<tr>
<td>D</td>
<td>4846</td>
</tr>
<tr>
<td>E</td>
<td>4825</td>
</tr>
</tbody>
</table>

[0077] Thus bark processing using a sequence of three extraction operations and subsequently the separation of the fraction less than 14 mesh makes it possible to obtain a material whose ash content is reduced by more than 60% on average and whose highest calorific power is only reduced by 4% on average.

[0078] The preceding examples describe and demonstrate in greater detail some illustrative embodiments within the reach of the present invention. The examples are offered only as illustrations and should not be interpreted as limits of this invention, since many variants are possible within the spirit and reach of the same. Diverse modifications of the invention in addition to the ones described and demonstrated in this document should be obvious to experts in the technology, and the intention is that these modifications should be interpreted within the scope of the adjoining claims.

1. A process for obtaining low and medium molecular weight polyphenols and a solid standardized fuel from tree wood or bark, characterized because it comprises the following stages:
   a) bark grinding;
   b) solid-liquid extraction from wood or bark using a low molecular weight aliphatic alcohol, which can be discontinuous in a plurality of stages or continuous;
   c) concentration of the extract to recover the aliphatic alcohol used in the extraction in an evaporation system to between approximately 5% and approximately 60%;
   d) separation of the solid and liquid phases of the extract through a process chosen from the group consisting of decantation, filtration, centrifugation and combinations of these;
e) drying of the soluble fraction in water of the hydroalcoholic extract;
f) drying of the insoluble fraction in water of the hydroalcoholic extract; and
g) separation of the fine fraction of the extracted bark in a sieve and/or air fractionation system.

2. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because the alcohol can be methanol or ethanol in a water solution in concentrations varying between approximately 50% and approximately 95% in mass.

3. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because the concentrated hydroalcoholic solution precipitates partially.

4. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because the extraction temperature is between 60°C and approximately 140°C.

5. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because the extraction temperature is between approximately 60°C and approximately 140°C.

6. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because each discontinuous extraction stage is carried out in a period of time varying between approximately 20 minutes and approximately 600 minutes.

7. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because each discontinuous extraction stage is carried out in a period of time varying between approximately 40 minutes and approximately 200 minutes.

8. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because an acid or a base is added to the alcoholic solution in a concentration that can vary between approximately 0.1% and approximately 5% in mass with respect to the total mass of the solution.

9. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because the hydroalcoholic solution resulting from the extraction is concentrated in an evaporator to a solid content of between approximately 10% and approximately 30%.

10. The process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because the precipitated phase of the hydroalcoholic solution is optionally washed with water.

11. A process for obtaining low molecular weight polyphenols, medium weight polyphenols and a standardized solid fuel from tree bark or wood according to claim 1, characterized because it includes the following stages:

a) bark grinding;
b) solid-liquid extraction of the bark using a low molecular weight aliphatic alcohol, selected from the group consisting of methanol and ethanol in a water solution in concentrations varying between approximately 50% and approximately 95% in mass, to which an acid or a base is optionally added in a concentration that can vary between approximately 0.1% and approximately 5%;
c) concentration by evaporation of the extract to recover the aliphatic alcohol used in the extraction to obtain a solid content of between approximately 10% and approximately 30%;
d) separation of the solid and liquid phases of the extract through a process chosen from the group consisting of decantation, filtration, centrifugation and combinations of these;
e) drying of the soluble fraction in water of the hydroalcoholic extract; and
f) drying of the insoluble fraction in water of the hydroalcoholic extract; and
separation of the fine fraction of the extracted bark in a sieve and/or air fractionation system.

12. The process of claim 1, further comprising the step of producing a plastic resin by treating the hydroalcoholic extracts with aldehydes and/or isocyanates as cross-linking agents.

13. The process of claim 1, further comprising the step of producing a plastic resin by treating the hydroalcoholic extracts with aldehydes and/or isocyanates as cross-linking agents.

14. The process of claim 1, further comprising the step of producing a plastic resin by treating the hydroalcoholic extracts with aldehydes and/or isocyanates as cross-linking agents.

15. Hydroalcoholic bark extracts from the soluble fraction in water of the hydroalcoholic extracts, obtained from any of the processes of claims 1 to 12.

16. Hydroalcoholic bark extracts from the insoluble fraction in water of the hydroalcoholic extracts, obtained from any of the processes of claims 1 to 12.

17. A bark or wood product obtained according to claims 1 or 14, densified to produce pellets, briquettes or another solid densified fuel.

* * * * *