

CLAIMS

1. A composition comprising functionalized lignin wherein hydroxyl groups of the lignin is functionalized with fatty acids via an ester linkage, wherein 5-70 weight% of the fatty acids are saturated, 20-90 weight% of the fatty acids are monounsaturated and 0-40 weight% of the fatty acids are polyunsaturated with proviso that the lignin is functionalized with more monounsaturated fatty acids than polyunsaturated fatty acids; and wherein the total degree of functionalization of the hydroxyl groups is 40 to 100%.
2. The composition according to claim 1 wherein 5-20 weight % of the fatty acids are saturated, 50-80 weight % of the fatty acids are monounsaturated and 1-35 weight % of the fatty acids are polyunsaturated.
3. The composition according to claim 1 wherein 5-10 weight % of the fatty acids are saturated, 55-75 weight % of the fatty acids are monounsaturated and 5-35 weight % of the fatty acids are polyunsaturated.
4. The composition according to claim 1 wherein 15-25 weight % of the fatty acids are saturated, 70-85 weight % of the fatty acids are monounsaturated and 2-10 weight % of the fatty acids are polyunsaturated.
5. The composition according to any one of claims 1 to 4 wherein the fatty acids are naturally derived and preferably derived from vegetable oils, used cooking oil or fats or a mixture thereof.
6. The composition according to claim 5 wherein the fatty acids are derived from one or more of rapeseed oil, olive oil, peanut oil, safflower oil, sunflower oil, canola oil, avocado oil or used cooking oil preferably derived from rapeseed oil, olive oil, used cooking oil or animal or fish fat such as tallow, schmaltz or lard or fish oil.
7. The composition according to claim 5 wherein the fatty acids are derived from two or more, or three or more of rapeseed oil, palm oil, palm kernel oil, coconut oil, carinata oil, cotton seed oil, olive oil, butter, peanut oil, safflower oil, soybean oil, corn oil, tall oil, sunflower oil, canola oil, avocado oil, used cooking oil, animal or fish fat such as tallow, schmaltz or lard or fish oil, or soap stock, acidulated soap stock, where in at least one is preferably derived from rapeseed oil, olive oil or used cooking oil.
8. The composition according to any of the preceding claims wherein the total degree of functionalization is at least 50%, preferably at least 70%, more

preferably at least 80%, more preferably at least 90%, preferably 100% or 95% or lower.

9. The composition according to any of the preceding claims wherein the lignin that is functionalized is Kraft lignin, preferably acid precipitated Kraft lignin.
10. The composition according to any of the preceding claims wherein the composition further comprises a carrier liquid wherein the carrier liquid is preferably selected from free fatty acids, esterified free fatty acids, triglyceride, hydrocarbon oil or recirculated stream or a mixture thereof; and wherein the functionalized lignin is preferably dissolved in the carrier liquid.
11. The composition according to claim 10 wherein the carrier liquid is selected from triglyceride, free fatty acids or a mixture thereof and wherein said triglycerides or free fatty acids are derived from one or more, or two or more, or three or more of rapeseed oil, palm oil, palm kernel oil, coconut oil, carinata oil, cotton seed oil, olive oil, butter, peanut oil, safflower oil, soybean oil, corn oil, tall oil, sunflower oil, canola oil, avocado oil, used cooking oil, tall oil, animal or fish fat such as tallow, schmaltz or lard or fish oil, or soap stock, acidulated soap stock, where in at least a part of the triglycerides or free fatty acids are preferably derived from rapeseed oil, olive oil or used cooking oil.
12. The composition according to claim 10 wherein the lignin is functionalized with fatty acids derived from rapeseed oil, olive oil or used cooking oil or a mixture thereof, and wherein the carrier liquid is selected from triglycerides or free fatty acids or a mixture thereof derived from rapeseed oil, olive oil or used cooking oil or a mixture thereof.
13. The composition according to claim 10 wherein the carrier liquid is a mixture of triglycerides or free fatty acids and a gas oil.
14. The composition according to any of the preceding claims wherein the content of the functionalized lignin in the composition is 40 weight% or more, or 50 weight% or more, or 65 weight% or more, or 75 weight% or more, or essentially 100 weight%, or 98 weight% or less, or 95weight% or less, or 90 weight% or less, or 85 weight% or less.
15. The composition according to any one of claim 10 to 14 wherein the content of carrier liquid is at least 20 weight%, or at least 30 weight%, or at least 40 weight%, or at least 50 weight%, or at least 60 weight%, but preferably 80 weight% or less, or 70 weight% or less of the total composition.

16. The composition according to any one of claim 10 to 15 wherein the combined content of the functionalized lignin and the carrier liquid in the composition constitute at least 90weight% of the total composition, preferably at least 95weight%, more preferably at least 98weight%.
17. The composition according to claim 10 wherein the functionalized lignin is dissolved in the carrier liquid, wherein the carrier liquid is a hydrocarbon oil; wherein the content of the functionalized lignin in the composition is 40 weight% or more and wherein the content of carrier liquid is at least 20 weight%.
18. The composition according to any of the preceding claims wherein the composition has a stability of not more than 2 weight% of insoluble particles is formed when stored at 150°C for 2 days or at 100°C for 64 days, preferably not more than 1 weight%.
19. The composition according to any one of claim 1 to 18 wherein the composition is suitable for refinery processes for production of fuel.
20. A method of preparing the composition according to any one of claim 1 to 19 comprising functionalized lignin wherein the method comprises
 - a. Providing a blend of free fatty acids wherein the blend comprises 5-70 weight% of saturated free fatty acids, 20-90 weight % of monounsaturated free fatty acids and 0-40 weight% of polyunsaturated free fatty acids, or alternatively providing a blend of free fatty acids and analysing or estimating the content of the blend to determine the amount of saturated, monounsaturated and polyunsaturated free fatty acids in said blend and optionally adjusting said content to obtain a blend comprising 5-70 weight % of saturated free fatty acids, 20-90 weight % of monounsaturated free fatty acids and 0-40 weight% of polyunsaturated free fatty acids;
 - b. Providing lignin, an esterification agent and a catalyst;
 - c. Allowing the free fatty acids and the esterification agent to esterify the lignin in the presence of the catalyst at an elevated temperature;
 - d. Optionally removing the catalyst and/or any other by-product; and
 - e. Optionally adding a carrier liquid.
21. The method according to claim 20 wherein the free fatty acids are derived from one or more of rapeseed oil, olive oil, peanut oil, safflower oil, sunflower oil, canola oil, avocado oil, soap stock, acidulated soap stock, or used

cooking oil preferably derived from rapeseed oil, olive oil, used cooking oil or animal or fish fat such as tallow, schmaltz or lard or fish oil.

22. The method according to claim 20 wherein the free fatty acids are derived from two or more, or three or more of rapeseed oil, palm oil, palm kernel oil, coconut oil, carinata oil, cotton seed oil, olive oil, butter, peanut oil, safflower oil, soybean oil, corn oil, tall oil, sunflower oil, canola oil, avocado oil, used cooking oil, animal or fish fat such as tallow, schmaltz or lard or fish oil or soap stock, acidulated soap stock, where in at least a part of the free fatty acids are preferably derived from rapeseed oil, olive oil or used cooking oil.
23. The method according to any one of claims 20 to 22 wherein the elevated temperature is at least 150°C, preferably at least 180°C, more preferably at least 200°C but preferably not more than 250°C, preferably not more than 220°C.
24. The method according to any one of claims 20 to 23 wherein the esterification agent is an anhydride, preferably acetic anhydride.
25. The method according to any one of claims 20 to 24 wherein the amount of free fatty acids to hydroxyl groups is preferably 0.8 weight equivalents or higher, more preferably 1.0 weight equivalents or higher, more preferably 1.15 weight equivalents or higher, more preferably 1.2 weight equivalents or higher, more preferably 1.5 weight equivalents or higher, but preferably not more than 2.5 weight equivalents, preferably 2.0 weight equivalents or less, more preferably 1.7 weight equivalents or less.
26. The method according to any one of claims 20 to 25 wherein the esterification agent is in molar excess of the free fatty acid.
27. The method according to any one of claim 20 to 26 wherein the carrier liquid is preferably selected from free fatty acids, esterified free fatty acids, triglyceride, hydrocarbon oil or recirculated stream, or a mixture thereof.
28. Use of the composition according to any one of claim 1 to 19 for preparing fuel, biofuel or fuel type compounds through hydroprocessing such as hydrocracking and/or hydrotreatment.
29. A method of preparing fuel, biofuel or fuel type compounds comprising:
 - a. Providing a composition according to any one of claims 1 to 19;
 - b. Optionally diluting the composition with a carrier liquid;
 - c. Hydroprocessing the composition; and
 - d. Isolating the fuel.

30. A method for producing the composition according to any one of claims 1 to 19 wherein the method comprises the steps of:
- Providing two or more fatty acid sources, lignin, optionally catalyst, optionally additives and optionally carrier liquid; wherein the weight ratio of saturated, monounsaturated and polyunsaturated fatty acids in each of the two or more fatty acid sources is known or determined;
 - Providing a blend of fatty acids from the two or more fatty acid sources wherein the blend has a predetermined weight ratio between the saturated, monounsaturated and polyunsaturated fatty acids;
 - Mixing the lignin, optionally the catalyst and the blend of fatty acids in a mixing ratio in order to obtain a predetermined degree of lignin functionalization;
 - Esterifying the lignin with the blend of fatty acids during heating in a reactor; and
 - Optionally adding a carrier liquid to the esterified lignin.
31. The method according to claim 30 wherein the two or more fatty acid sources are naturally derived and preferably derived from vegetable oils, used cooking oil or animal or fish fats, or a mixture thereof.
32. The method of claim 31 wherein the two or more fatty acid sources are or are derived from rapeseed oil, palm oil, palm kernel oil, coconut oil, carinata oil, cotton seed oil, olive oil, butter, peanut oil, safflower oil, soybean oil, corn oil, tall oil, sunflower oil, canola oil, avocado oil, used cooking oil, animal or fish fat such as tallow, schmaltz or lard or fish oil, soap stock, acidulated soap stock or fat from microorganisms such as bacteria and algae, wherein at least one of the fatty acid sources preferably is or is derived from rapeseed oil, olive oil or used cooking oil.
33. The method according to any one of claim 30 to 32 wherein the method further comprises a step of transforming the fatty acids into fatty acid halides or fatty acid anhydrides and wherein said step is performed prior to the step of esterifying the lignin with the blend of fatty acids.
34. A system (10) for producing the composition according to any one of claim 1 to 19;
- wherein the system (10) comprises a reactor (12) with a lignin inlet (13) having a lignin valve (15) for receiving lignin, two or more fatty acid containers (14₁-14_n) provided in fluid connection with the reactor (12) via at

least one fatty acid pump (17) and at least one fatty acid valve (19), a heating device (16) provided to the reactor (12) configured to heat the content of the reactor (12), and a control system (18) provided in communication contact with the at least one fatty acid pump, the at least one fatty acid valve and the heating device (16);

wherein the control system (18) is provided with weight ratio information about the weight ratio between the saturated, monounsaturated and polyunsaturated fatty acids in each of the two or more fatty acid containers (14₁-14_n) and with lignin amount information about an amount of lignin in the reactor (12);

wherein the control system (18) is configured to control the at least one fatty acid pump (17) and the at least one fatty acid valve (19) in dependence of said weight ratio information and said lignin amount information in order to provide a fatty acid blend from the fatty acids of the two or more fatty acid containers (14₁-14_n) wherein said blend has a predetermined weight ratio between the saturated, monounsaturated and polyunsaturated fatty acids, and to provide an amount of said blend to the reactor (12) to obtain the degree of lignin functionalization.

35. The system according to claim 34 wherein the system further comprises a mixing tank (20) provided in fluid connection with the reactor (12) via at least one fatty acid blend pump (26) wherein the mixing tank (22) is arranged between the two or more fatty acid containers (14₁-14_n) and the reactor (12) wherein the mixing tank (20) is configured to receive fatty acids from the fatty acid containers and configured to provide a blend of fatty acids to the reactor (12).

36. The system according to claim 34 or 35 wherein the system comprises a temperature sensor (21) arranged in the reactor (12) and preferably a pressure sensor (23) arranged in the reactor (12) and wherein the control system (18) is in communication contact with said sensors in order to control and adapt the temperature and the pressure in the reactor (12) in dependence of the output of the said sensors.

37. The system according to any one of claim 34 to 36 wherein the system further comprises a carrier liquid container (22) in fluid connection with the reactor (12) via a carrier liquid pump (24); wherein the carrier liquid preferably is a hydrocarbon oil, more preferably a gas oil or recirculated stream.

38. The system according to claim 37 wherein the system further comprises a viscosity sensor (25) arranged in the reactor (12), wherein the control system (18) is in communication contact with said sensor (25) and wherein the control system is configured to control the carrier liquid pump in order to deliver carrier liquid from the carrier liquid container (22) to the reactor (12) in dependence of output from the viscosity sensor.
39. The system according to claim 38 wherein the control system (18) is adapted to determine based on a predetermined viscosity a suitable amount of carrier liquid to be delivered to the reactor (12) in dependence of output from the viscosity sensor.
40. The system according to any one of claim 34 to 39 wherein the system (10) further comprises a mixing device (28) arranged in the reactor (12) configured to mix the content of the reactor.
41. The system according to any one of claims 34 to 40 wherein the control system (18) is in communication with the lignin valve (15).
42. A computer program product comprising instructions which, when executed in a processor in a control system (18) in a system (10) for producing a composition according to any one of the claims 1 to 19 cause the control system (18) to perform the method according to any one of the claims 30-33.