

CLAIMS

1. A process for the hydrolysis of ligno-cellulosic biomass comprising the steps of
 - 5 A) Contacting a ligno-cellulosic feedstock, the feedstock comprised of biomass having a dry content and water with at least a portion of a solvent, the solvent comprised of water soluble hydrolyzed species, in the presence of a catalyst which converts at least one of the compounds in the biomass to a compound or compounds of lower molecular weight; wherein at least some of the water soluble hydrolyzed species are the same as the water soluble hydrolyzed species obtainable from the hydrolysis of the biomass in the feedstock;
 - 10 B) maintaining the contact between the feedstock of the feedstock stream and the solvent at a temperature in the range of 20°C to 200°C for a time in the range of 5 minutes to 72 hours to create a hydrolyzed product from the biomass in the feedstock.
2. The process according to claim 1, wherein the dry content comprises cellulose, hemicellulose, and the weight percent of the cellulose in the dry content is greater than 5 weight percent of the dry content; wherein at least some of the water soluble hydrolyzed species are the same as the water soluble hydrolyzed species obtainable from the hydrolysis of the cellulose in the feedstock and the contact between the feedstock and the solvent is in the presence of a catalyst for the hydrolysis of the cellulose.
- 25 3. The process of any of claims 1 and 2, wherein the ratio of the weight of the solvent contacted with the feedstock to the weight of the feedstock is in a range selected from the group consisting of 1:99 to 99:1, 10:90 to 90:10, 20:80 to 90:10, 30:70 to 90:10, 40:60 to 90:10, 50:50 to 90:10, and 60:40 to 90:10.
- 30 4. The process of claim 2, wherein the ratio of the weight of the solvent contacted with the feedstock to the weight of the feedstock is greater than 0.8:1.

5. The process of claim 2, wherein the ratio of the weight of the cellulose plus hydrolysis products of cellulose in the solvent to the weight of the cellulose in the ligno-cellulosic feedstock is selected from the group consisting of greater than 1:1, greater than 1.5:1, greater than 2:1, greater than 3:1, greater than 4:1, and greater than 5:1.
- 5 6. The process of any of claims 2 through 5, wherein at least a portion of the catalyst composition is contacted with the feedstock before, after or simultaneously with contacting the feedstock with at least a portion of the solvent.
- 10 7. The process of any of claims 1 through 16, wherein the ratio of the biomass to water of the feedstock is selected from the group consisting of greater than 1:4, greater than 1:3, greater than 1:2, greater than 1:1.5, greater than 1:1, and greater than 1:0.9.
- 15 8. The process of any of claims 2 through 7, where the catalyst composition comprises an enzyme.
9. The process of any of claims 1 through 8, wherein the temperature is in a range selected from the group consisting of 20 to 105°C, and 20 to 95°C.
- 20 10. The process of any claims 1 through 9, wherein the time is in a range selected from the group consisting of 5 minutes to 48 hours, 5 minutes to 36 hours, 5 minutes to 24 hours, 5 minutes to 12 hours, and 5 minutes to 8 hours.
- 25 11. The process of any of claims 1 through 10, where the process is a batch process comprising the steps of
- A) Introducing the feedstock into a vessel already containing at least a portion of the solvent,
 - B) Introducing the catalyst composition into the vessel before, simultaneously with, or after introduction of the feedstock into the vessel,
 - C) Maintaining the feedstock, the solvent, and the catalyst composition in the vessel in the said temperature range of 20°C to 200°C for a time in the
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range of 5 minutes to 72 hours,

D) removing the hydrolyzed product from the vessel.

5 12. The process of claim 11 wherein all of the hydrolyzed product is removed from the vessel prior to introducing more feedstock and solvent containing water soluble hydrolyzed species.

13. The process of claim 11, wherein a portion of the hydrolyzed product, namely a heel, is left in the vessel.

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14. The process of any of claims 1 through 10, where the process is a continuous process comprising the steps of

A) continuously introducing the feedstock into a vessel already containing at least a portion of the solvent,

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B) introducing the catalyst composition into the vessel,

C) continuously removing a weight of the hydrolyzed product from the vessel.

15. The process of claim 14, wherein the process is a plug flow process.

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16. The process of claim 14, wherein the process utilizes a continuously stirred reactor.

25 17. The process of any of claims 11 through 16, wherein a portion in the solvent stream is mixed with the feedstock prior to introduction into the vessel and the ratio of the solvent to the feedstock stream are based upon the amount of the solvent in the vessel plus the amount of the solvent with the feedstock stream.

30 18. The process according to any of claims 1 through 17, wherein prior to contacting the ligno-cellulosic feedstock with the solvent, an amount of the feedstock is apportioned into at least a first feedstock stream to create a first solvent stream by hydrolyzing the feedstock of the first feedstock stream with the addition of a catalyst to the first feedstock stream wherein the catalyst amount is in range of 0.1 to 150 FPU / g of dry content of all the feedstock and the hydrolysis is conducted at a temperature in the range of 20°C to 95°C for

a time in the range of 5 minutes to 72 hours and the ligno-cellulosic feedstock, the solvent, and the solvent of the first solvent stream are contacted with each other and the contact is maintained in the temperature range for a time in the time range.

- 5 19. The processes of claim 18, wherein a portion of the first solvent stream is mixed with the feedstock which is not the first feedstock stream prior to introduction to a vessel and all ratios of the solvent stream to the feedstock stream are based upon the total amount of solvent stream which is the amount of the first solvent stream and the solvent in the vessel.
- 10 20. The processes of any of claims 1 through 19, wherein at least a portion of the solids in the hydrolyzed product are separated from the hydrolyzed product.
21. The processes of any of claims 1 through 20 wherein at least a portion of the solids separated from the hydrolyzed product are recycled to the process.
- 15 22. The processes of any of claims 1 through 20, wherein the separation of at least a portion of the solids from the hydrolyzed product stream is done by a device selected from the group consisting of hydrocyclones and centrifuges.

CLAIMS

1. A process for the hydrolysis of ligno-cellulosic biomass comprising the steps of

- 5 A) Contacting a ligno-cellulosic feedstock, the feedstock comprised of biomass having a dry content and water with at least a portion of a solvent, the solvent comprised of water soluble hydrolyzed species; in the presence of a catalyst which converts at least one of the compounds in the biomass to a compound or compounds of lower molecular weight, wherein at least some of the water soluble hydrolyzed species are the same as the water soluble hydrolyzed species obtainable from the hydrolysis of the biomass in the feedstock
- 10 B) maintaining the contact between the feedstock of the feedstock stream and the solvent at a temperature in the range of 20°C to 200°C for a time to create a hydrolyzed product from the biomass in the feedstock, wherein the ratio of the weight of the solvent contacted with the feedstock to the weight of the feedstock
- 15 is greater than 0.8:1.

2. The process according to claim 1, wherein the dry content comprises cellulose, hemicellulose, and the weight percent of the cellulose in the dry content is greater than 5

20 weight percent of the dry content; wherein at least some of the water soluble hydrolyzed species are the same as the water soluble hydrolyzed species obtainable from the hydrolysis of the cellulose in the feedstock and the contact between the feedstock and the solvent is in the presence of a catalyst for the hydrolysis of the cellulose.

25 3. The process of any of claims 1 and 2, wherein the ratio of the weight of the solvent contacted with the feedstock to the weight of the feedstock is in a range selected from the group consisting of 1:99 to 99:1, 10:90 to 90:10, 20:80 to 90:10, 30:70 to 90:10, 40:60 to 90:10, 50:50 to 90:10, and 60:40 to 90:10.

30 4. The process of claim 2, wherein the ratio of the weight of the solvent contacted with the feedstock to the weight of the feedstock is greater than 0.8:1.

5. The process of claim 2, wherein the ratio of the weight of the cellulose plus hydrolysis products of cellulose in the solvent to the weight of the cellulose in the ligno-cellulosic feedstock is selected from the group consisting of greater than 1:1, greater than 1.5:1, greater than 2:1, greater than 3:1, greater than 4:1, and greater than 5:1.

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6. The process of any of claims 2 through 5, wherein at least a portion of the catalyst composition is contacted with the feedstock before, after or simultaneously with contacting the feedstock with at least a portion of the solvent.

10 7. The process of any of claims 1 through 16, wherein the ratio of the biomass to water of the feedstock is selected from the group consisting of greater than 1:4, greater than 1:3, greater than 1:2, greater than 1:1.5, greater than 1:1, and greater than 1:0.9.

15 8. The process of any of claims 2 through 7, where the catalyst composition comprises an enzyme.

9. The process of any of claims 1 through 8, wherein the temperature is in a range selected from the group consisting of 20 to 105°C, and 20 to 95°C.

20 10. The process of any claims 1 through 9, wherein the time is in a range selected from the group consisting of 5 minutes to 48 hours, 5 minutes to 36 hours, 5 minutes to 24 hours, 5 minutes to 12 hours, and 5 minutes to 8 hours.

25 11. The process of any of claims 1 through 10, where the process is a batch process comprising the steps of

A) Introducing the feedstock into a vessel already containing at least a portion of the solvent,

30 B) Introducing the catalyst composition into the vessel before, simultaneously with, or after introduction of the feedstock into the vessel,

C) Maintaining the feedstock, the solvent, and the catalyst composition in the vessel in the said temperature range of 20°C to 200°C for a time in the

range of 5 minutes to 72 hours,

D) removing the hydrolyzed product from the vessel.

5 12. The process of claim 11 wherein all of the hydrolyzed product is removed from the vessel prior to introducing more feedstock and solvent containing water soluble hydrolyzed species.

13. The process of claim 11, wherein a portion of the hydrolyzed product, namely a heel, is left in the vessel.

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14. The process of any of claims 1 through 10, where the process is a continuous process comprising the steps of

A) continuously introducing the feedstock into a vessel already containing at least a portion of the solvent,

15 B) introducing the catalyst composition into the vessel,

C) continuously removing a weight of the hydrolyzed product from the vessel.

15. The process of claim 14, wherein the process is a plug flow process.

20 16. The process of claim 14, wherein the process utilizes a continuously stirred reactor.

25 17. The process of any of claims 11 through 16, wherein a portion in the solvent stream is mixed with the feedstock prior to introduction into the vessel and the ratio of the solvent to the feedstock stream are based upon the amount of the solvent in the vessel plus the amount of the solvent with the feedstock stream.

30 18. The process according to any of claims 1 through 17, wherein prior to contacting the ligno-cellulosic feedstock with the solvent, an amount of the feedstock is apportioned into at least a first feedstock stream to create a first solvent stream by hydrolyzing the feedstock of the first feedstock stream with the addition of a catalyst to the first feedstock stream wherein the catalyst amount is in range of 0.1 to 150 FPU / g of dry content of all the feedstock and the hydrolysis is conducted at a temperature in the range of 20°C to 95°C for

a time in the range of 5 minutes to 72 hours and the ligno-cellulosic feedstock, the solvent, and the solvent of the first solvent stream are contacted with each other and the contact is maintained in the temperature range for a time in the time range.

- 5 19. The processes of claim 18, wherein a portion of the first solvent stream is mixed with the feedstock which is not the first feedstock stream prior to introduction to a vessel and all ratios of the solvent stream to the feedstock stream are based upon the total amount of solvent stream which is the amount of the first solvent stream and the solvent in the vessel.
- 10 20. The processes of any of claims 1 through 19, wherein at least a portion of the solids in the hydrolyzed product are separated from the hydrolyzed product.
21. The processes of any of claims 1 through 20 wherein at least a portion of the solids separated from the hydrolyzed product are recycled to the process.
- 15 22. The processes of any of claims 1 through 20, wherein the separation of at least a portion of the solids from the hydrolyzed product stream is done by a device selected from the group consisting of hydrocyclones and centrifuges.