**Enhancing Ternary Biomass Co-Pyrolysis Products: An Investigative Study of Natural and Commercial Catalysts**

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Table S1: Bio-oil composition of ternary catalytic and non-catalytic feeds.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Family classification** | **Compound name** | **Ternary** | **CaCO3** | **CaO** | **Ca(OH)2** | **Zeolite** |
| 550°C | | | | | | |
| Acid | Acetic acid | 8.09 | 7.29 | 6.19 | 2.93 | 3.39 |
| Acid | Butanoic acid | - | 1.07 | - | - | - |
| Acid | Butanoic acid, 4-hydroxy- | - | - | - | 1.42 | - |
| Acid | Propanoic acid | - | - | - | - | 0.750 |
| Acid | Tetradecanoic acid | 2.09 | - | - | - | - |
| Acid | 9-Eicosenoic acid, (Z)- | 2.08 | - | - | - | - |
| Acid | 9-Octadecenoic acid (Z)-, 2,3-bis(acetyloxy)p | 8.10 | 4.25 | 9.45 | 6.57 | 3.35 |
| Acid | 9-Octadecenoic acid (Z)-, methyl ester | - | - | 0.840 | 0.810 | - |
| Acid | Dodecanoic acid | 4.36 | 2.66 | 2.20 | - | 1.35 |
| Acid | Hexadecanoic acid, methyl ester | 1.48 | 1.05 | 1.39 | 1.01 | - |
| Acid | n-Hexadecanoic acid | 17.58 | 9.49 | 9.44 | 1.54 | 4.74 |
| Acid | Octadecanoic acid | 3.14 | 1.78 | 1.88 | - | - |
| Acid | Oleic Acid | 3.11 | 0.940 | 0.920 | - | - |
| Alcohol | 1,6-Heptadien-4-ol | 0.910 | - | - | - | - |
| Alcohol | 2-Furanmethanol | 3.03 | 3.89 | 2.71 | 3.68 | 1.25 |
| Alcohol | 2-Furanmethanol, tetrahydro- | - | 1.99 | - | - | 1.50 |
| Aldehyde | Hexanal | - | - | 1.21 | - | - |
| Aldehyde | Pentanal | 2.20 | - | - | - | - |
| Aliphatic | Furan-2-carbonyl chloride, tetrahydro- | 3.00 | - | - | - | - |
| Aliphatic | Heptane, 4-methyl- | - | 1.09 | - | - | - |
| Aliphatic | Hexadecane, 1-(ethenyloxy)- | 0.86 | - | - | - | - |
| Aliphatic | 1-Pentadecene | - | - | - | 0.870 | - |
| Aliphatic | Pentadecane | 1.27 | 1.01 | 1.39 | 0.930 | - |
| Aliphatic | Tridecane | 0.580 | - | 0.760 | 0.620 | - |
| Aliphatic | Heptadecanenitrile | - | - | - | - | 2.78 |
| Aliphatic | Hexadecanenitrile | - | - | - | - | 5.80 |
| Alkaloid | Caffeine | 3.85 | 5.86 | 4.75 | 6.20 | 7.77 |
| Amide | Benzenesulfonamide, N-butyl- | - | - | - | - | 1.03 |
| Aromatic | Furan-2-carbohydrazide, N2-(1-methylhexylideno) | - | - | - | 0.760 | - |
| Aromatic | 1,2-Benzenediol, 4-methyl- | 0.810 | 1.00 | 0.89 | - | 1.58 |
| Aromatic | 3,4'-Isopropylidenediphenol | 7.95 | 20.4 | 28.3 | 32.2 | 35.0 |
| Aromatic | Catechol | 4.75 | 5.14 | 3.38 | - | 5.39 |
| Aromatic | Hydroquinone | 0.740 | - | 0.720 | - | 0.870 |
| Aromatic | p-Cresol | 1.97 | 2.45 | 2.10 | 3.36 | 1.71 |
| Carbohydrate | .beta.-D-Glucopyranose, 1,6-anhydro- | - | - | 1.78 | - | - |
| Carbohydrate | 1,4:3,6-Dianhydro-.alpha.-d-glucopyranose | 0.610 | - | - | - | 0.900 |
| Carbohydrate | 1,6-Anhydro-2,3-O-isopropylidene-.beta.-D- | - | - | - | - | 0.820 |
| Carbohydrate | 2,3-Anhydro-d-mannosan | - | - | - | - | 0.730 |
| Ester | Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate | - | - | - | 1.33 | - |
| Ketone | Butyrolactone | 3.18 | 1.24 | 0.690 | - | 0.770 |
| Ketone | 1,2-Cyclopentanedione, 3-methyl- | 1.14 | 1.69 | 1.09 | 1.01 | 1.32 |
| Ketone | 2-Acetyl-2-methyl-succinonitrile | - | 1.08 | - | - | 0.8 |
| Ketone | 2-Cyclopenten-1-one, 2,3-dimethyl- | - | - | - | 0.760 | - |
| Ketone | 2-Cyclopenten-1-one, 2-methyl- | - | 1.18 | - | 1.01 | - |
| Ketone | 2-Cyclopenten-1-one, 3-methyl- | - | - | 0.64 | 1.20 | 0.630 |
| Ketone | 2-Heptadecanone | - | - | 4.17 | 10.22 | - |
| Ketone | 2-Nonadecanone | - | 4.63 | 1.95 | 4.38 | - |
| Ketone | 2-Pentadecanone | - | - | - | 1.01 | - |
| Ketone | 2-Pentadecanone, 6,10,14-trimethyl- | 2.07 | - | - | - | - |
| Ketone | 2-Pentanone, 4-hydroxy-4-methyl- | 5.85 | 7.33 | 5.02 | 5.06 | 7.34 |
| Ketone | 2-Propanone, 1-hydroxy- | - | 3.66 | - | - | 3.31 |
| Ketone | 2-Pyrrolidinone | - | 1.18 | - | - | 0.78 |
| Ketone | 2-Tridecanone | - | - | - | 2.62 | - |
| Ketone | Ethanone, 1-cyclododecyl- | - | - | - | 0.980 | - |
| Phenol | Phenol | 3.26 | 4.18 | 3.54 | 4.30 | 2.74 |
| Phenol | Phenol, 2,5-dimethyl- | - | - | - | 1.11 | - |
| Phenol | Phenol, 2-methyl- | 0.98 | 1.22 | 1.07 | 1.66 | 0.71 |
| Phenol | Phenol, 4-(1-methyl-1-phenylethyl)- | 0.96 | 1.22 | 0.960 | - | 0.890 |
| Phenol | Pyridine | - | - | 0.560 | 0.450 | - |
| **750°C** | | | | | | |
| Acid | 9,12-Octadecadienoic acid (Z,Z)- | - | - | 0.950 | - | - |
| Acid | 9-Eicosenoic acid, (Z)- | - | - | - | - | 1.38 |
| Acid | 9-Octadecenoic acid (Z)-, 2-(acetyloxy)-1-[(a | - | - | - | 2.26 | - |
| Acid | 9-Octadecenoic acid (Z)-, 2,3-bis(acetyloxy)p | 14.7 | - | 12.2 | 6.92 | 7.54 |
| Acid | 9-Octadecenoic acid (Z)-, methyl ester | - | 0.710 | 0.620 | 0.690 | - |
| Acid | Acetic acid | 4.36 | 4.29 | 4.50 | 0.810 | 2.79 |
| Acid | Butanoic acid | - | 0.560 | - | - | - |
| Acid | Octadecanoic acid | 1.47 | 1.84 | - | - | 2.20 |
| Acid | Octadecanoic acid, 2,3-bis(acetyloxy)propyl | - | - | 0.810 | 0.720 | - |
| Acid | Oleic Acid | 0.620 | 0.670 | - | - | - |
| Acid | Propanoic acid | - | 0.620 | - | - | - |
| Acid | Dodecanoic acid | 2.11 | 2.40 | 1.96 | - | 2.60 |
| Acid | n-Hexadecanoic acid | 9.55 | 8.54 | 5.01 | 1.24 | 8.92 |
| Acid | Tetradecanoic acid | 0.670 | 0.760 | - | - | 0.980 |
| Alcohol | 2-Furanmethanol | 0.680 | 1.32 | 0.920 | - | - |
| Alcohol | 2-Isopropyl-5-methyl-1-heptanol | - | - | - | 0.630 | - |
| Aliphatic | Decane, 1,1'-oxybis- | - | - | - | 0.600 | 0.630 |
| Aliphatic | Heneicosanoic acid, methyl ester | - | 0.770 | - | - | - |
| Aliphatic | Hexadecanoic acid, methyl ester | 0.860 | 1.02 | 0.980 | 0.770 | 0.970 |
| Aliphatic | Hexanedioic acid, bis(2-ethylhexyl) ester | - | 0.920 | - | - | - |
| Aliphatic | Pentadecane | - | - | 0.710 | - | - |
| Aliphatic | Heptadecanenitrile | - | - | - | - | 4.16 |
| Aliphatic | Hexadecanenitrile | 2.07 | - | - | - | 6.70 |
| Aliphatic | Nonadecanenitrile | - | - | - | - | 0.68 |
| Alkaloid | Caffeine | 3.60 | 4.78 | 4.30 | 3.81 | 3.68 |
| Amide | Octadecanamide | 1.37 | - | - | - | - |
| Amide | Acetamide | 3.00 | - | - | 1.07 | 0.770 |
| Amide | Dodecanamide | 2.28 | 0.700 | - | - | - |
| Amide | Palmitoleamide | 0.690 | - | - | - | - |
| Amide | Valeramide, N-(2-phenylethyl)-N-undecyl- | 0.800 | - | - | - | - |
| Amine | Benzenesulfonamide, N-butyl- | - | - | - | 0.910 | - |
| Aromatic | 1,2-Benzenediol, 4-methyl- | - | - | 0.680 | - | 0.770 |
| Aromatic | 3,4'-Isopropylidenediphenol | 22.1 | 36.8 | 34.4 | 45.4 | 26.0 |
| Aromatic | 4-Pyridinol | - | 1.22 | 0.950 | - | 0.790 |
| Aromatic | Catechol | 2.27 | 2.83 | 2.63 | 0.610 | 2.68 |
| Aromatic | Hydroquinone | - | 0.810 | 0.660 | - | - |
| Aromatic | Naphthalene | 2.03 | 2.67 | 1.48 | 2.05 | 1.50 |
| Aromatic | p-Cresol | 1.47 | 1.82 | 1.77 | 2.05 | 1.93 |
| Carbohydrate | .beta.-D-Glucopyranose, 1,6-anhydro- | 1.57 | 3.39 | 2.62 | - | 3.13 |
| Carbohydrate | 1,3-Di-O-acetyl-.alpha.-.beta.-d-ribopyranose | - | 0.630 | - | - | - |
| Carbohydrate | D-Allose | - | - | - | 1.19 | - |
| Ester | Methyl stearate | - | - | 0.800 | - | 0.860 |
| Ester | Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate | - | - | 0.920 | 1.31 | - |
| Ester | Z,Z-4,6-Nonadecadien-1-ol acetate | - | - | - | - | 1.14 |
| Ketone | 1,2-Cyclopentanedione, 3-methyl- | - | - | 0.67 | - | - |
| Ketone | 2-Heptadecanone | - | - | 5.56 | 6.24 | - |
| Ketone | 2-Nonadecanone | - | 4.21 | 2.80 | 3.27 | - |
| Ketone | 2-Pentadecanone | - | - | - | 0.70 | - |
| Ketone | 2-Pentanone, 4-amino-4-methyl- | 6.55 | - | - | 4.31 | 3.59 |
| Ketone | 2-Pentanone, 4-hydroxy-4-methyl- | 7.61 | 9.52 | 5.64 | 4.27 | 7.58 |
| Ketone | 2-Tridecanone | - | - | 0.770 | 1.04 | - |
| Ketone | 3-Penten-2-one, 4-methyl- | 0.760 | - | - | 0.620 | - |
| Ketone | 4-Piperidinone, 2,2,6,6-tetramethyl- | 3.30 | 1.37 | - | 1.86 | 2.44 |
| Ketone | Ethanone, 1-cyclododecyl- | - | - | - | 0.780 | - |
| Ketone | Furan, tetrahydro-2-methyl- | - | 0.670 | - | - | 0.870 |
| Phenol | Phenol | 1.89 | 2.79 | 3.00 | 2.33 | 2.03 |
| Phenol | Phenol, 2-methyl- | - | - | 0.740 | - | - |
| Phenol | Phenol, 4-(1-methyl-1-phenylethyl)- | 1.57 | 1.34 | 0.970 | 0.870 | - |
| Phenol | Phenol, 4-ethyl- | - | - | - | 0.630 | 0.660 |