**Supplementary materials**

# Development of Hybrid Biorefinery for Jet Biofuel Production

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**Table A1:** Fischer-Tropsch reactions (at ASF-ά =0.85).

|  |  |  |  |
| --- | --- | --- | --- |
| **Products category** | **Reaction** | **Key product name** | **CO conversion factor** |
| Paraffins | CO + 3 H2 🡪 CH4 + H2O | Methane | 0.0216 |
| 2 CO + 5 H2 🡪 C2H6 + 2 H2O | Ethane | 0.0368 |
| 3 CO + 7 H2 🡪 C3H8 + 3 H2O | Propane | 0.0468 |
| 4 CO + 9 H2 🡪 C4H10 + 4 H2O | Butane | 0.0531 |
| 5 CO + 11 H2 🡪 C5H12 + 5 H2O | Pentane | 0.0564 |
| 6 CO + 13 H2 🡪 C6H14 + 6 H2O | Hexane | 0.0575 |
| 7 CO + 15 H2 🡪 C7H16 + 7 H2O | Heptane | 0.0570 |
| 8 CO + 17 H2 🡪 C8H18 + 8 H2O | Octane | 0.0554 |
| 9 CO + 19 H2 🡪 C9H20 + 9 H2O | Nonane | 0.0530 |
| 10 CO + 21 H2 🡪 C10H22 + 10 H2O | Decane | 0.0500 |
| 11 CO + 23 H2 🡪 C11H24 + 11 H2O | Undecane | 0.0468 |
| 12 CO + 25 H2 🡪 C12H26 + 12 H2O | Dodecane | 0.0434 |
| 13 CO + 27 H2 🡪 C13H28 + 13 H2O | Tridecane | 0.0399 |
| 14 CO + 29 H2 🡪 C14H30 + 14 H2O | Tetradecane | 0.0366 |
| 15 CO + 31 H2 🡪 C15H32 + 15 H2O | Pentadecane | 0.0333 |
| 16 CO + 33 H2 🡪 C16H34 + 16 H2O | Hexadecane | 0.0301 |
| 17 CO + 35 H2 🡪 C17H36 + 17 H2O | Heptadecane | 0.0273 |
| 18 CO + 37 H2 🡪 C18H38 + 18 H2O | Octadecane | 0.0246 |
| 19 CO + 39 H2 🡪 C19H40 + 19 H2O | Nonadecane | 0.0220 |
| 20 CO + 41 H2 🡪 C20H42 + 20 H2O | Eicosane | 0.1684 |
| Olefins | 2 CO + 4 H2 🡪 C2H4 + 2 H2O | Ethene | 0.0012 |
| 3 CO + 6 H2 🡪 C3H6 + 3 H2O | Propene | 0.0015 |
| 4 CO + 8 H2 🡪 C4H8 + 4 H2O | Butene | 0.0017 |
| 5 CO + 10 H2 🡪 C5H10 + 5 H2O | Pentene | 0.0018 |
| 6 CO + 12 H2 🡪 C6H12 + 6 H2O | Hexene | 0.0018 |
| 7 CO + 14 H2 🡪 C7H14 + 7 H2O | Heptene | 0.0018 |
| 8 CO + 16 H2 🡪 C8H16 + 8 H2O | Octene | 0.0018 |
| 9 CO + 18 H2 🡪 C9H18 + 9 H2O | Nonene | 0.0017 |
| 10 CO + 20 H2 🡪 C10H20 + 10 H2O | Decene | 0.0016 |
| 11 CO + 22 H2 🡪 C11H22 + 11 H2O | Undecene | 0.0015 |
| 12 CO + 24 H2 🡪 C12H24 + 12 H2O | Dodecene | 0.0014 |
| 13 CO + 26 H2 🡪 C13H26 + 13 H2O | Tridecene | 0.0013 |
| 14 CO + 28 H2 🡪 C14H28 + 14 H2O | Tetradecene | 0.0012 |
| 15 CO + 30 H2 🡪 C15H30 + 15 H2O | Pentadecene | 0.0011 |
| 16 CO + 32 H2 🡪 C16H32 + 16 H2O | Hexadecene | 0.0010 |
| 17 CO + 34 H2 🡪 C17H34 + 17 H2O | Heptadecene | 0.0009 |
| 18 CO + 36 H2 🡪 C18H36 + 18 H2O | Octadecene | 0.0008 |
| 19 CO + 38 H2 🡪 C19H38 + 19 H2O | Nonadecene | 0.0007 |
| 20 CO + 40 H2 🡪 C20H40 + 20 H2O | Eicosene | 0.0054 |
| Alcohol | CO + 2 H2 🡪 CH3OH | Methanol | 0.0005 |
| 2 CO + 4 H2 🡪 C2H5OH + H2O | Ethanol | 0.0008 |
| 3 CO + 6 H2 🡪 C3H7OH + 2 H2O | Propanol | 0.0011 |
| 4 CO + 8 H2 🡪 C4H9OH + 3 H2O | Butanol | 0.0012 |
| 5 CO + 10 H2 🡪 C5H11OH + 4 H2O | Pentanol | 0.0013 |
| 6 CO + 12 H2 🡪 C6H13OH + 5 H2O | Hexanol | 0.0013 |
| 7 CO + 14 H2 🡪 C7H15OH + 6 H2O | Heptanol | 0.0013 |
| 8 CO + 16 H2 🡪 C8H17OH + 7 H2O | Octanol | 0.0013 |
| 9 CO + 18 H2 🡪 C9H19OH + 8 H2O | Nonanol | 0.0012 |

**Table A2:** Biocrude components and their resultant refined compounds.

|  |  |  |
| --- | --- | --- |
| **Biocrude components** | **Formula** | **Possible refined components** [1] |
| Syringol | C8H10O3 | C6H14/ C6H6/ C6H12 |
| Benzaldehyde | C7H6O | C7H8/ C6H6/ C7H14/ C7H16 / C6H14 |
| Guaiacol | C7H8O | C6H6/ C6H12/ C6H14/ |
| Diacetone alcohol | C6H12O | C6H14 |
| Creosol | C8H10O3 | C7H8/ C7H14/ C7H16 |
| Vanillin | C8H8O3 | C7H8/ C7H14/ C7H16 / C6H6/ C6H14 |
| Phenol | C6H6O | C6H6/ C6H12/ C6H14 |
| 1,4-Dimethoxy-2-methylbenzene | C9H12O2 | C7H8/ C7H14/ C7H16 |
| Butylated hydroxytoluene | C15H24O | C14H30/ C15H32 |
| Diphenylamine | C12H11N | C6H6/ C6H12/ C6H14 |
| Furfural | C5H4O2 | C5H12/ C4H10 |
| Butyl isobutyl phthalate | C16H22O4 | C4H10 / C8H16/ C8H18/ C6H6/ C6H12/ C6H14 |
| 5-(Hydroxymethyl) furfural | C6H6O3 | C6H14 |
| Acetic acid | C2H4O2 | CH4/ C2H6 |
| Syringaldehyde | C9H10O4 | C7H8/ C6H6/ C7H14/ C6H14/ C7H16 |
| Isoeugenol | C10H12O2 | C10H14/ C10H20/ C10H22 |
| 3-Methoxycatechol | C7H8O3 | C6H6/ C6H12/ C6H14 |
| Propanoic acid | C3H6O2 | C2H6/ C3H8 |
| 1,2-Benzenediol | C6H6O2 | C6H6/ C6H12/ C6H14 |
| 2-Butanone | C4H8O | CH4/ C2H6/ C3H8/ C4H10 |
| 3-methyl-Phenol | C7H8O | C7H8/ C7H14/ C7H16 |
| Isovanillic acid | C8H8O4 | C7H8/ C6H6/ C7H14/ C6H14/ C7H16 |
| Toluene | C7H8 | C7H14/ C7H16 |
| 4-Methyl-3-penten-2-one | C6H10O | C6H14/ C5H12 |
| 2-butanol | C4H10O | C3H8 |
| Cyclopropane-carboxylic acid | C4H6O2 | C4H8/ C3H6/ C3H8/ C4H10 |
| Diethyl Phthalate | C12H14O4 | C4H10/ C8H10/ C8H16/ C8H18/ C6H6/ C6H12/ C6H14 |
| 3-Hydroxy-benzaldehyde | C7H6O2 | C7H8/ C7H14/ C7H16/ C6H6/ C6H14 |
| Elaidic acid | C18H34O2 | C18H38/ C17H36 |

**Table A3:** Starting paraffines and isomerised products [2].

|  |  |  |  |
| --- | --- | --- | --- |
| **Starting n-paraffin** | **Isomers produced** | **Structure** | **(%)** |
| C6H14 | 3-methylpentane |  | 38.2 |
| 2-methylpentane |  | 40.7 |
| 2-hexene |  | 0.93 |
| Unconverted n-hexane |  | 20.17 |
| C7H16 | 2,2-dimethylpentane |  | 19.8 |
| 2,3-dimethylpentane |  | 14.9 |
| 3-ethylpentane |  | 9.2 |
| 3-methyl-1-hexene |  | 0.19 |
| Unconverted n-heptane |  | 55.91 |
| C8H18 | 3-methylheptane |  | 9.5 |
| 3-ethylhexane |  | 10.3 |
| 3,3-dimethylhexane |  | 3.2 |
| 2,3-dimethylhexane |  | 10.2 |
| 2,3-dimethyl-2-hexene |  | 0.58 |
| Unconverted n-heptane |  | 66.22 |

**Table A4:** Labour requirement and costs for *Jatropha* cultivation project [3,4].

|  |  |  |
| --- | --- | --- |
| **Position** | **No.** | **Annual salary ($)** |
| Managers | 1 | 120,000 |
| Admin officers | 3 | 36,000 |
| Agronomists | 1 per section | 48,000 |
| Shift workers | 15 per section | 6,000 |
| Supervisors | 2 per section | 7,200 |

**Table A5:** Biorefinery’s labour requirement and costs [4,5].

|  |  |  |
| --- | --- | --- |
| **Position** | **No.** | **Annual salary ($)** |
| Plant manager | 1 | 150,000 |
| Admin officers | 7 | 36,000 |
| Plant engineers | 8 | 75,000 |
| Maintenance supervisors | 6 | 60,000 |
| Shift supervisors | 12 | 50,000 |
| Maintenance technicians | 50 | 40,000 |
| Shift operators | 100 | 40,000 |

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