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Table S 1 Michaelis-Menten reaction rate constants of *α*-amylase in aerobic soil mixed with different composite films.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Films** | ***V*max**  **(µg h-1 g-1 soil)**  **Mean ± SE** | ***Km* (µg)**  **Mean ± SE** | ***K*cat**  **(h-1 g-1 soil)** | ***R*2** | **Dunnett's test**  ***p*-values** |
| Control | 1082.13 ± 44.41 | 4296.64 ± 654.60 | 0.251 | 0.983 | - |
| UcS5%L | 628.40 ± 29.78 | 4577.00 ± 794.47 | 0.137 | 0.987 | 0.117 |
| UcS10%L | 597.32 ± 646.73 | 2891.29 ± 33.25 | 0.206 | 0.975 | 0.182 |
| UcS15%L | 497.04 ± 18.69 | 2294.62 ± 361.93 | 0.216 | 0.990 | 0.085 |
| UcS20%L | 530.55 ± 28.99 | 3276.12 ± 702.18 | 0.161 | 0.978 | 0.072 |
| Blank soil | 261.89 ± 11.40 | 5097.09 ± 970.57 | 0.051 | 0.982 | 0.001\*\* |

\*\* Highly significant difference (*p* < 0.001)

Table S 2 Michaelis-Menten reaction rate constants of the soil MnP in aerobic soil mixed with different composite film.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Films** | ***V*max**  **(µg h-1 g-1 soil)**  **Mean ± SE** | ***Km* (µg)**  **Mean ± SE** | ***K*cat**  **(h-1 g-1 soil)** | ***R*2** | **Dunnett's test**  ***p*-values** |
| Control | 281.67 ± 4.76 | 11.10 ± 1.07 | 25.37 | 0.996 | - |
| UcS5%L | 301.52 ± 10.25 | 13.37 ± 2.46 | 22.55 | 0.986 | 1.000 |
| UcS10%L | 382.07 ± 12.49 | 12.63 ± 2.27 | 30.25 | 0.985 | 0.580 |
| UcS15%L | 397.78 ± 13.29 | 11.76 ± 2.21 | 33.77 | 0.982 | 0.402 |
| UcS20%L | 402.08 ± 13.78 | 10.55 ± 2.10 | 38.11 | 0.982 | 0.317 |
| Blank soil | 203.38 ± 8.27 | 12.30 ± 2.78 | 16.53 | 0.978 | 0.743 |

Table S 3: The *Ea* of soil *α*-amylase enzyme under aerobic soil condition after mixing with different composite films.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Films** | ***Ea***  **(KJ mol-1)**  **Mean ± SE** | **Linear Fit Eq.** | ***R*2** | **Dunnett's test**  ***p*-values** |
| Control | 37.32 ± 8.62 | y = 4459x - 13.41 | 0.982 | - |
| UcS5%L | 55.45 ± 7.70 | y = 6643x - 20.00 | 0.993 | 0.043\* |
| UcS10%L | 52.99 ± 9.29 | y = 6342x - 19.43 | 0.989 | 0.087 |
| UcS15%L | 52.74 ± 4.79 | y = 6361x - 19.42 | 0.997 | 0.094 |
| UcS20%L | 41.39 ± 8.86 | y = 4948x - 14.58 | 0.984 | 0.938 |
| Blank soil | 25.08 ± 3.21 | y = 3006x - 6.981 | 0.994 | 0.220 |

\* Significant difference (*p* < 0.05)

Table S 4: The *Ea* of the soil MnP enzyme under aerobic soil condition after mixing with different composites.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Films** | ***Ea***  **(KJ mol-1)**  **Mean ± SE** | **Linear Fit Eq.** | ***R*2** | **Dunnett's test**  **p-values** |
| Control | 28.35 ± 3.11 | y = 3411x - 14.41 | 0.968 | - |
| UcS5%L | 27.77 ± 3.05 | y = 3341x - 14.09 | 0.985 | 1.000 |
| UcS10%L | 25.86 ± 2.84 | y = 3111x - 13.50 | 0.838 | 0.802 |
| UcS15%L | 25.40 ± 2.79 | y = 3056x - 13.46 | 0.876 | 0.692 |
| UcS20%L | 28.45 ± 3.13 | y = 3423x - 14.77 | 0.869 | 1.000 |
| Blank soil | 37.07 ± 4.07 | y = 4459x - 17.65 | 0.944 | 0.023\* |

\* Significant difference (*p* < 0.05)

Table S 5: Effect of lignin on starch biodegradability rates (*ks)* and its half-life (*t*1/2) in the composite films under aerobic soil.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Films** | **First-order Eq.**  ***Cs,t e-kst***  ***Cs,t e-kst*** | **MSE** | ***R*2** | ***t*1/2 (days)** |
| Control | 22.76e-0.254t | 0.525 | 0.983 | 2.728 |
| UcS5%L | 22.86e-0.168t | 0.664 | 0.984 | 4.125 |
| UcS10%L | 18.94e-0.165t | 0.535 | 0.942 | 4.200 |
| UcS15%L | 19.16e-0.161t | 0.577 | 0.972 | 4.305 |
| UcS20%L | 18.77e-0.122t | 0.977 | 0.970 | 5.681 |

Table S 6: Rates of saccharides formation (***kf***) and depletion (***kd*** ) in composite films under aerobic soil.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Saccharides** | **Films** | ***kf* (µg day-1)**  **(1-4 days)** | |  | ***kd*  (day-1)**  **(4-28 days)** | |
|  |  | **Zero-order kinetic rate equation** | ***R*2** |  | **First-order kinetic rate**  **equation** | ***R*2** |
| Glucose | Control | y = 215.59t-115.03 | 0.999 |  | y = 64.29 + 2300.36e-0.301t | 0.999 |
| UcS5%L | y = 197.87t-109.03 | 0.994 |  | y = 46.76 + 2275.51e-0.351t | 0.999 |
| UcS10%L | y =193.40t-128.10 | 0.998 |  | y = 48.41 + 1815.68e-0.282t | 0.991 |
| UcS15%L | y = 152.36t-79.38 | 0.999 |  | y = 22.83 + 1423.35e-0.256t | 0.999 |
| UcS20%L | y = 150.99t-118.51 | 0.998 |  | y = 22.30 + 1302.73e-0.252t | 0.998 |
| Maltose | Control | y = 213.75t-17.27 | 0.994 |  | y = 105.83 + 2561.50e-0.318t | 0.999 |
| UcS5%L | y = 208.42t-36.69 | 0.998 |  | y = 79.17 + 2463.18e-0.312t | 0.998 |
| UcS10%L | y = 200.09t-71.66 | 0.999 |  | y = 57.15 + 2279.42e-0.309t | 0.997 |
| UcS15%L | y = 193.93t-90.83 | 0.997 |  | y = 70.62 + 2000.46e-0.300t | 0.986 |
| UcS20%L | y = 187.50t-115.27 | 0.997 |  | y = 29.43 + 1977.38e-0.298t | 0.994 |
| Maltotriose | Control | y = 426.11t-201.74 | 0.998 |  | y = 115.66 + 9502.68e-0.480t | 0.996 |
| UcS5%L | y = 422.01t-233.33 | 0.998 |  | y = 68.53+9391.16e-0.477t | 0.998 |
| UcS10%L | y = 378.05t-230.09 | 0.999 |  | y = 31.67 +8004.52e-0.462t | 0.999 |
| UcS15%L | y = 375.65t-290.89 | 0.998 |  | y = 14.62 + 7316.46e-0.451t | 0.999 |
| UcS20%L | y = 359.04t-320.70 | 0.997 |  | y = 11.69 + 6873.08e-0.454t | 0.998 |