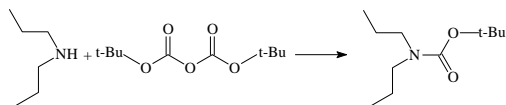


Reaction

STT® Conditions

Amine Protection



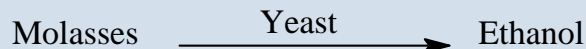
Conditions:

- Ambient Pressure
- 100°C
- RT (Residence Time) 7 Sec

Results:

- Quantitative Conversion

Fermentation



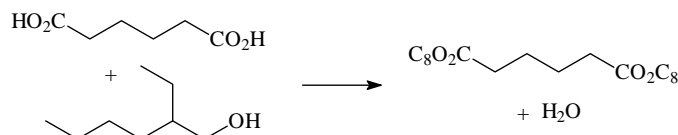
Conditions:

- Ambient Pressure
- 25-30°C
- Low Shear, reactor attached to fermentation tank

Results:

- 40% decrease in fermentation time

Esterification



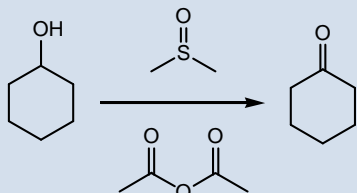
Conditions:

- 1 atmosphere
- ~180°C
- RT 90 sec

Results:

- >60x rate increase over batch with H₂O removed
- ~260x rate increase over batch with H₂O retained

Mild Selective Oxidation - Swern Reaction



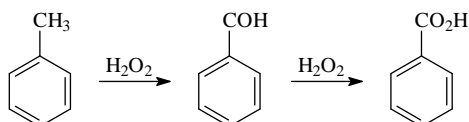
Conditions:

- Ambient Pressure
- 30°C
- RT 300 sec

Results:

- 6X rate increase
- Typical batch reaction times are 18-24 hours

Selective Oxidation – Toluene



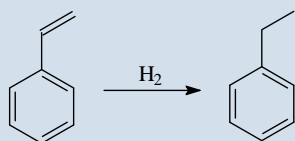
Conditions:

- Ambient Pressure
- 80-130°C
- RT varied

Results:

- Goal was improved selectivity to benzaldehyde

Hydrogenation



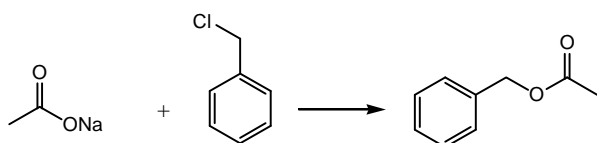
Conditions:

- ~18 PSIG H₂
- ~60°C
- RT 129 Seconds
- Run catalyst (Pd) deficient

Results:

- 13.6% Yield in 2 min

Coupling - Benzyl Acetate Synthesis



Conditions:

- Ambient Pressure
- 90-100°C
- RT 300 sec
- No Phase Transfer Catalyst Used

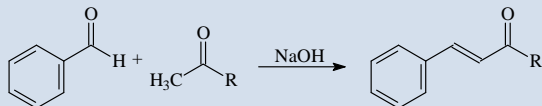
Results:

- 6X rate increase & comparable yield

Reaction

STT[®] Conditions

Claisen-Schmidt Reaction



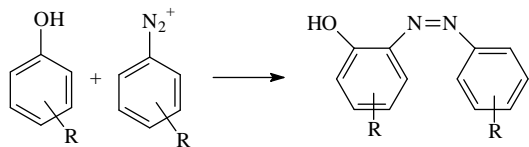
Conditions:

- Ambient Pressure
- 65°C
- RT 30 sec

Results:

- ~7X higher yield, 60X rate increase.
- Typical batch reaction times are 18 to 24 hours

Diazonium Coupling



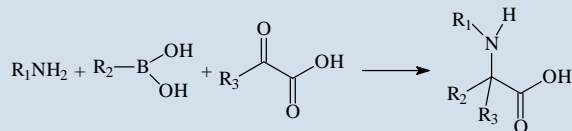
Conditions:

- Ambient Pressure
- 35-65°C
- RT <20 sec

Results:

- 12x faster with same conversion as batch

Coupling - Amino Acid Synthesis similar to Suzuki



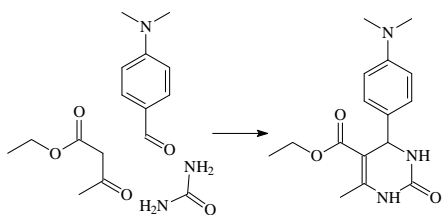
Conditions:

- Ambient pressure
- ~60°C
- RT 13 sec

Results:

- ~1,000x rate increase with higher conversion

Biginelli Reaction



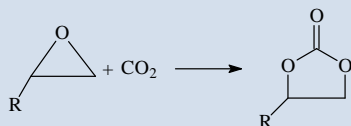
Conditions:

- Ambient Pressure
- 60°C
- RT 120 sec

Results:

- 25-50x rate increase to same conversion
- Typical batch reaction time is ~9 hours

Carbonylation



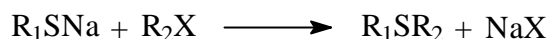
Conditions:

- 100 PSIG
- 63°C
- RT 30 sec

Results:

- 16x rate improvement

Sulfidation



Conditions:

- Ambient pressure
- 60-75 °C
- RT 2.5-5 min

Results:

- 100x rate improvement

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The STT[®] process and equipment are covered by 15 patents and several patents pending worldwide. STT, Magellan, and Innovator are trademarks of Four Rivers BioEnergy Company, Inc. and are registered with the USPTO.

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