

# PILON'S TECHNOLOGY SCALE-UP ROADMAP

From Process Validation to Commercial Success

***BATCH TO CONTINUOUS...***



*A Phased Scale-Up Roadmap — From Lab Studies to Commercial Production*

WITNESS TRIAL

POC

PILOTING

DEMONSTRATION/  
COMMERCIAL

# TECHNOLOGY READINESS LEVEL, PROCESS DEVELOPMENT ROADMAP

*From first on-site trials to commercial deployment — a staged, evidence-led path for scaling your process.*



1

**Demo Trials**

**Prove Feasibility,  
seeing is believing**

2

**1-5 kg/day**

**Prove Feasibility**

3

**50–500 kg/day**

**Scale-Up Production**

4

**TPD Scale  
Production**

**Commercial Plant**

Each milestone builds on validated data from the previous stage — lab batch studies at the Pilon's R&D facility are backup for 5 kg/day prototype; prototype data drives the 100–150 kg/day scale-up; scale-up data underpins the final 200–500 TPD commercial plant, built at Pilon's continuous plant design facility.

1

**Trials at client premises**

**1-2 day**

2

**POC**

**2-3 weeks**

3

**Piloting**

**12-16 weeks**

4

**Demonstration/  
Commercial  
30-45 weeks**

# First Trials Witness at Client Site

*Before committing to a formal proof-of-concept program, Pilon runs short, low-risk trials directly at client facility — on your feedstock, with your raw materials — to confirm the chemistry is worth pursuing further.*

## A

### OBJECTIVES

1. Witness complete batch reaction
2. Study catalyst type, particle size/loading and performance
3. Review raw materials, charging sequence and mixing
4. Record temperature, pressure, dosing, agitation, residence time
5. Observe sampling points, yield, selectivity and impurities

## B

### ACTIVITIES

1. Witness plant trials
2. Record process conditions
3. Discuss technical challenges
4. Define project objectives
5. Trial observation report

**Results will give an unambiguous signal to invest in a full POC program**

**OUTCOME:** Trials will confirm that the reaction proceeds cleanly on the client's real feedstock — the project can be taken up to formal POC planning.

# POC \_Proof of Concepts

*After successful Trials at client side, PILON performs a Proof of Concept (POC) on its systems to validate the technical feasibility of converting the client's batch process into a continuous process while optimizing critical process parameters.*

## A

### OBJECTIVES

Demonstrate feasibility of converting the batch process to continuous manufacturing process

## B

### ACTIVITIES

1. Design experimental campaign
2. Replicate reaction on PILON lab flow reactors by developing necessary systems
3. Resolve challenges (mixing, heat transfer, clogging, catalyst, kinetics)
4. Optimize reaction parameters
5. Compare results with batch process (Yield/Conversion  $\pm 5\%$  target)
6. Improve, yield, conversion, residence time, selectivity etc.

**Results will establish a validated continuous process, providing the engineering confidence required for Pilot Plant execution. Raw materials and analytical part execution can be discussed during final stages.**

**OUTCOME:** POC trials will confirm process feasibility, optimize critical operating parameters, mitigate technical risks, and deliver the engineering data necessary for successful pilot-scale implementation

PHASE 02 • POC  
1-5 kg/day

## Cost Structure & Deliverables

### Cost Structure

- Chemical cost
- Resources cost
- Plant & facility cost
- Investment cost (plant modification)
- Project management & travel cost
- Analytical & RM cost in client scope. Catalyst scope to be discussed.

**₹2.5 to 4.5 Lakh / week for MGFR/ SFR/  
ContiHYflow reaction feasibility**

**Optimization of reactions is secondary  
which can be extended after feasibility**

Minimum support cost to be paid to the Pilon team weekly, for fast execution. This is full-time equivalent cost invested for 24X7 running of plant

**Milestone-01 Overall Cost can be  
proposed after witnessing reactions  
at client premises\_(Nitration/ Hydrogenation,  
other homogeneous/ heterogeneous reactions)**

### Deliverables

#### Safety

Process safety validated during continuous run, utility optimization, Life Cycle Reduction etc.

#### Utility Cost

Utility consumption benchmarked at pilot scale

#### Batch Cycle Reduction

Limited by reaction kinetics — an inherent, chemistry-dependent property. Some molecules improve; others remain unchanged.

# Pilot Plant

*Upon successful completion of the POC, the Pilot Plant phase will be initiated for further process validation and continuous trials.*

## A OBJECTIVES

1. Pilot Scale Validation
2. Validate the process at pilot scale.
3. Optimize operating parameters.
4. Generate scale-up data.
5. Verify continuous process stability.
6. Minimize scale-up risks.

## B ACTIVITIES

1. Witness plant trials
2. Continuous pilot plant trials.
3. Process optimization.
4. Catalyst performance evaluation.
5. Product quality validation.
6. Data collection for commercial scale-up.

**Results will provide the confidence and engineering data required to proceed with the Demonstration Plant (500 kg/day–1 TPD).**

**Pilot plant trials will validate continuous operation, process stability, and product quality, enabling scale-up to the Demonstration Plant phase.**

# Approach & Execution Timeline

*Goal: Scale production ahead of the larger commercial investment — steps run in parallel with Milestone 1.*



*Resourcing note: Pilon provides supervisory support during testing; plant is operated by the client, with all HAZOP and site requirements in the client's scope. Pilon resources to be billed on monthly basis.*

# Cost & Completion

## Cost Components

- Engineering Cost
- Plant and resources cost
- Cost of technology
- Installation of plant, completed before start-up

### Analytical Handoff

Unlike Milestone 1, analytical work for Milestone 2 moves fully to the client's own facility.

### Milestone Stages

- Stage-A: Pilon acts as EPC partner for Milestone-2 plant development
- Stage-B: Pilon acts in a Supervisory role while Operations will be carried by client.

### Milestone 2 Completion

All Technology rights to be reserved with Pilon.

### Investment Milestones:

- **Proposal Report for Capex investment**
- **Plant & Machinery Cost**

## Demonstration Plant to Commercial

*Upon successful completion of the Pilot Plant phase, the Demonstration Plant will be established to validate long-duration continuous operation, confirm process robustness, and generate commercial-scale operating data*

### **A** Demonstration Plant (500-2000 kg/day)

1. Basic & Detailed Engineering
2. Procurement, Manufacturing
3. FAT, SAT & Trial Runs
4. Duration: 5–7 Months

### **B** Commercial Plant

1. Detailed Engineering
2. Fabrication & Installation
3. Commissioning & Performance Guarantee
4. Duration: 8–12 Months

**Results will establish a fully operational commercial process, delivering sustainable production with proven performance and reliability.**

**Outcome:** Commercial Plant commissioning will confirm process guarantees, production capacity, product quality, and operational reliability, enabling long-term commercial manufacturing with minimized technical risk.

# Approach & Ownership Model

*Goal: Build the full commercial plant, using validated Milestone 2 data.*

1

## Capex BEP Preparation & Purchase Order

Cost, resources, simulation, CFD, sizing, datasheets, automation, mechanical 3D & GA drawings.

12 weeks after M2

## Ownership Model

### Pilon develops BEP

Engineering of Plant to be done by Pilon

### Plant Exclusivity

Exclusivity applies specifically to commercial-scale work.

### If Built by Another Vendor

Pilon acts as reviewer and supervisor of the commercial plant. Pilon to earn royalty on total production or Client may pay one time technology cost against exclusivity for 5 years.

*Loss of Opportunity clause will be implemented in case development doesn't proceed beyond Milestone-02 due to unforeseen circumstances.*

## Build Timeline



**~30-45 weeks total, PO to commercial production**

Detailing, build-up, and trial durations are largely fixed by engineering and safety requirements.

# Continuous Process Challenges

*Eight variables that must be engineered and controlled together to run safely at scale.*

- Transport & Hydraulics
- Reaction Control & Safety

01

## Gas–Liquid–Solid Mass Transfer

Uneven contact limits conversion

02

## Material Solubility

Caps reaction rate at scale

03

## Catalyst Wetting

Uneven liquid coverage on catalyst

04

## Pressure Drop

Rises with bed length & flow

05

## Hot Spot Formation

Localized overheating, runaway risk

06

## Catalyst Deactivation

Fouling, poisoning, sintering over time

07

## Residence Time

Balances conversion against throughput

08

## Gas Distribution & Safety

Even feed, leak prevention

# Why Choose Pilon Engineering?

**End-to-End Scale-Up Partner** — *from laboratory proof-of-concept to commercial production, complete hydrogenation scale-up solutions under one roof.*

## OUR EXPERTISE

### 1 Process Development

- Reaction feasibility studies
- Catalyst screening & optimization
- Process intensification

### 2 Reactor Portfolio

- Continuous Flow & Fixed Bed
- Slurry & CSTR Cascade
- Trickle Bed Reactors & many more..

### 3 High-Pressure Reactions

- Design pressure up to 100+ bar
- Temperature up to 500°C
- Safe hydrogen handling

### 4 Process Safety

- HAZOP-oriented engineering
- H<sub>2</sub> leak prevention & inert purging
- Automated safety interlocks

### 5 Automation

- PLC-SCADA & recipe control
- Remote monitoring
- Complete data logging

### 6 Global Project Execution

- Design, manufacturing & FAT
- Installation, SAT & commissioning
- Operator training

## SCALE-UP PATHWAY

POC



Pilot Plant



Demonstration Plant



Commercial EPC

## WHY CUSTOMERS CHOOSE PILON

- ✓ End-to-End Engineering Partner
- ✓ Reduced Scale-Up Risk
- ✓ Faster Time-to-Commercialization
- ✓ Proven Continuous Hydrogenation Expertise
- ✓ Customized Pilot & Demonstration Plants
- ✓ Complete EPC Solution

# PILON'S CONTIHYFLOW

## CONTINUOUS HYDROGENATION CAPABILITIES



### TECHNOLOGY SCALE-UP JOURNEY

FROM PILOT SCALE TO DEMONSTRATION SCALE



**PILOT SCALE**  
5 KG PER DAY



SCALABLE  
DESIGN.  
SEAMLESS  
TRANSITION.

ENGINEERED  
FOR GROWTH.  
BUILT FOR  
SUCCESS.

**DEMONSTRATION SCALE**  
5 TONNES PER DAY



### PROCESS PARAMETER RANGE

| Parameter      | Typical Range                                                                  |
|----------------|--------------------------------------------------------------------------------|
| Pressure       | 1–350 barg                                                                     |
| Temperature    | Ambient to 950°C                                                               |
| Hydrogen Flow  | 1 mL/min to several thousand Nm <sup>3</sup> /h                                |
| Reactor Volume | mL scale to commercial plants                                                  |
| Residence Time | Seconds to several hours                                                       |
| Catalyst       | Pd, Pt, Ru, Rh, Ni, Cu, Co, Raney Ni, Raney Co, noble metals, custom catalysts |



PROVEN  
TECHNOLOGY



SCALABLE  
PERFORMANCE



RELIABLE  
& SAFE



OPTIMIZED  
EFFICIENCY



READY FOR  
COMMERCIAL SCALE

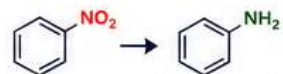
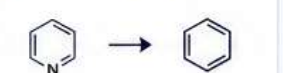
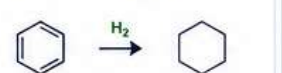
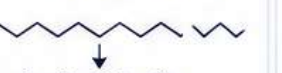
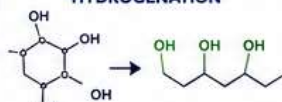
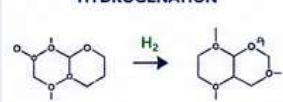
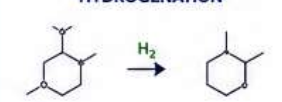
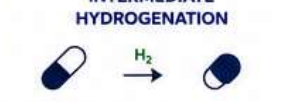
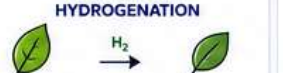
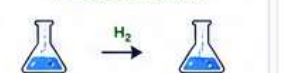
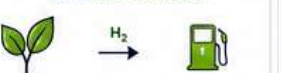
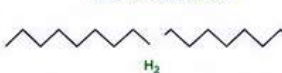
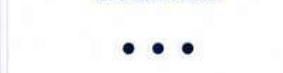
FROM INNOVATION TO IMPACT – SCALING TODAY FOR A SUSTAINABLE TOMORROW

# Why go for Continuous Process

| PARAMETER               | BATCH HYDROGENATION          | CONTINUOUS HYDROGENATION               |
|-------------------------|------------------------------|----------------------------------------|
| Operation               | One batch at a time          | Continuous feed and product withdrawal |
| Impurities              | Higher                       | Lower                                  |
| Production              | Intermittent                 | Steady, uninterrupted                  |
| Product Quality         | Can vary batch to batch      | Highly consistent                      |
| Hydrogen Utilization    | Lower efficiency             | Higher efficiency, better contact      |
| Heat Transfer           | Difficult, highly exothermic | Excellent removal & control            |
| Safety                  | Larger reactant inventory    | Smaller volume, reduced risk           |
| Pressure & Temp Control | Can fluctuate                | Maintained at setpoints                |
| Catalyst Use            | Slurry, needs separation     | Fixed-bed / continuous system          |
| Scale-up                | Increase reactor size        | Number-up or run longer                |
| Automation              | Limited                      | High level of automation               |
| Downtime                | Charge/heat/cool/clean cycle | Minimal downtime                       |
| Operating Cost          | Higher labor & utility cost  | Lower cost over time                   |
| Capital Cost            | Lower initial investment     | Higher initial investment              |
| Best For                | Small volumes, R&D           | Large-volume, consistent production    |



# REACTIONS IN CONTINUOUS FLOW

|                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>01</b> <b>NITRO GROUP HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Nitrobenzene → Aniline</li> <li>Dinitro compounds → Diamines</li> <li>Nitro pyridines</li> <li>Nitro heterocycles</li> <li>Nitro aromatics</li> </ul> | <b>02</b> <b>OLEFIN HYDROGENATION</b><br>$\text{R}-\text{CH}=\text{CH}-\text{R}' \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{CH}_2-\text{R}'$ <ul style="list-style-type: none"> <li>Alkene → Alkane</li> <li>Styrene → Ethylbenzene</li> <li>Vinyl toluene hydrogenation</li> <li>Diene saturation</li> <li>Polyunsaturated compounds</li> </ul> | <b>03</b> <b>ALKYNE HYDROGENATION</b><br>$\text{R}-\text{C}\equiv\text{C}-\text{R}' \xrightarrow{\text{H}_2 \text{ (partial)}} \text{R}-\text{CH}=\text{CH}-\text{R}' \xrightarrow{\text{H}_2 \text{ (complete)}} \text{R}-\text{CH}_2-\text{CH}_2-\text{R}'$ <ul style="list-style-type: none"> <li>Alkyne → Alkene (partial)</li> <li>Alkyne → Alkane (complete)</li> <li>Acetylene removal</li> <li>Selective semi-hydrogenation</li> </ul> | <b>04</b> <b>AROMATIC RING HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Benzene → Cyclohexane</li> <li>Toluene → Methylcyclohexane</li> <li>Naphthalene → Tetralin/Decalin</li> <li>Phenol → Cyclohexanone/Cyclohexanol</li> </ul> | <b>05</b> <b>CARBONYL HYDROGENATION</b><br>$\text{R}-\text{C}(=\text{O})-\text{R}' \xrightarrow{\text{H}_2} \text{R}-\text{CH}(\text{OH})-\text{R}'$ <ul style="list-style-type: none"> <li>Aldehydes → Alcohols</li> <li>Ketones → Secondary alcohols</li> <li>Aromatic ketones</li> <li><math>\alpha,\beta</math>-Unsaturated ketones</li> </ul> | <b>06</b> <b>ESTER HYDROGENATION</b><br>$\text{R}-\text{C}(=\text{O})-\text{OR}' \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{OR}'$ <ul style="list-style-type: none"> <li>Fatty esters</li> <li>Methyl esters</li> <li>Biodiesel intermediates</li> <li>Specialty esters</li> </ul>                                                                                      | <b>07</b> <b>CARBOXYLIC ACID HYDROGENATION</b><br>$\text{R}-\text{C}(=\text{O})-\text{OH} \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{OH}$ <ul style="list-style-type: none"> <li>Organic acids</li> <li>Aromatic acids</li> <li>Fatty acids</li> </ul>                                                           |
| <b>08</b> <b>AMIDE HYDROGENATION</b><br>$\text{R}-\text{C}(=\text{O})-\text{NH}_2 \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{NH}_2$ <ul style="list-style-type: none"> <li>Primary amides</li> <li>Secondary amides</li> <li>Specialty intermediates</li> </ul>                                                      | <b>09</b> <b>NITRILE HYDROGENATION</b><br>$\text{R}-\text{C}\equiv\text{N} \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{NH}_2$ <ul style="list-style-type: none"> <li>Benzonitrile → Benzylamine</li> <li>Aliphatic nitriles</li> <li>Dinitriles</li> </ul>                                                                                        | <b>10</b> <b>IMINE HYDROGENATION</b><br>$\text{R}-\text{CH}=\text{N}-\text{R}' \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{NH}-\text{R}'$ <ul style="list-style-type: none"> <li>Schiff bases</li> <li>Pharmaceutical intermediates</li> </ul>                                                                                                                                                                                         | <b>11</b> <b>OXIME HYDROGENATION</b><br>$\text{R}-\text{CH}=\text{NOH} \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{NH}_2$ <ul style="list-style-type: none"> <li>Oximes → Amines</li> </ul>                                                                                                                                    | <b>12</b> <b>AZIDE HYDROGENATION</b><br>$\text{R}-\text{N}_3 \xrightarrow{\text{H}_2} \text{R}-\text{NH}_2$ <ul style="list-style-type: none"> <li>Organic azides → Amines</li> </ul>                                                                                                                                                              | <b>13</b> <b>REDUCTIVE AMINATION</b><br>$\text{R}-\text{C}(=\text{O})-\text{R}' + \text{R}'''\text{NH}_2 \xrightarrow{\text{H}_2} \text{R}-\text{CH}(\text{R}'')-\text{R}'-\text{NHR}'''$ <ul style="list-style-type: none"> <li>Carbonyl + Amine + <math>\text{H}_2</math></li> <li>One-pot reductive amination</li> <li>Pharmaceutical APIs</li> <li>Fine chemicals</li> </ul> | <b>14</b> <b>HYDRODEHALOGENATION</b><br>$\text{R}-\text{X} \xrightarrow{\text{H}_2} \text{R}-\text{H}$ <ul style="list-style-type: none"> <li>Chlorinated compounds</li> <li>Brominated compounds</li> <li>Iodinated compounds</li> </ul>                                                                                 |
| <b>15</b> <b>HYDRODESULFURIZATION (HDS)</b><br><br><ul style="list-style-type: none"> <li>Benzothiophene</li> <li>Dibenzothiophene</li> <li>Thiophenes</li> <li>Benzol sulfur removal</li> <li>Fuel purification</li> </ul>                   | <b>16</b> <b>HYDRODENITROGENATION (HDN)</b><br><br><ul style="list-style-type: none"> <li>Heteroaromatic N removal</li> <li>Fuel upgrading</li> <li>Specialty chemicals</li> </ul>                                                                                       | <b>17</b> <b>HYDRODEOXYGENATION (HDO)</b><br>$\text{R}-\text{O}-\text{R}' \xrightarrow{\text{H}_2} \text{R}-\text{H} + \text{R}'-\text{H}$ <ul style="list-style-type: none"> <li>Bio-oils</li> <li>Phenolics</li> <li>Renewable feedstocks</li> </ul>                                                                                                                                                                                         | <b>18</b> <b>HYDRODEAROMATIZATION (HDA)</b><br><br><ul style="list-style-type: none"> <li>Aromatic saturation</li> <li>Lube base oil production</li> <li>Specialty chemicals</li> </ul>                                                              | <b>19</b> <b>HYDROCRACKING (LAB &amp; PILOT SCALE)</b><br><br><ul style="list-style-type: none"> <li>Heavy molecules → lighter fractions</li> <li>Pilot scale hydrocracking</li> </ul>                                                                          | <b>20</b> <b>HYDROISOMERIZATION</b><br><br><ul style="list-style-type: none"> <li>Straight chain → Iso-paraffins</li> <li>Improve fuel &amp; lube properties</li> </ul>                                                                                                                       | <b>21</b> <b>SELECTIVE HYDROGENATION</b><br>$\text{R}-\text{CH}=\text{CH}-\text{R}' \xrightarrow{\text{H}_2} \text{R}-\text{CH}_2-\text{CH}_2-\text{R}'$ <ul style="list-style-type: none"> <li>Trace impurity removal</li> <li>Color body removal</li> <li>Unsaturated impurity removal</li> </ul>                       |
| <b>22</b> <b>HYDROGENOLYSIS</b><br>$\text{R}-\text{CH}_2-\text{X} \xrightarrow{\text{H}_2} \text{R}-\text{CH}_3$ <ul style="list-style-type: none"> <li>C-O bond cleavage</li> <li>C-N bond cleavage</li> <li>Protecting group removal</li> </ul>                                                                             | <b>23</b> <b>DEPROTECTION REACTIONS</b><br>$\text{R}-\text{O}-\text{CH}_2\text{Ph} \xrightarrow{\text{H}_2} \text{R}-\text{OH}$ <ul style="list-style-type: none"> <li>Cbz removal</li> <li>Benzyl removal</li> <li>N-O bond reduction</li> </ul>                                                                                                         | <b>24</b> <b>SUGAR HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Glucose → Sorbitol</li> <li>Xylose → Xylitol</li> </ul>                                                                                                                                                                                                                   | <b>25</b> <b>FAT &amp; OIL HYDROGENATION</b><br>$\text{R}_1-\text{C}(=\text{O})-\text{O}-\text{R}_2 \xrightarrow{\text{H}_2} \text{R}_1-\text{CH}_2-\text{CH}_2-\text{O}-\text{R}_2$ <ul style="list-style-type: none"> <li>Vegetable oils</li> <li>Fatty acid derivatives</li> <li>Waxes</li> </ul>                                   | <b>26</b> <b>RESIN HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Hydrocarbon resins</li> <li>Petroleum resins</li> <li>C5/C9 resins</li> </ul>                                                                                               | <b>27</b> <b>FRAGRANCE &amp; FLAVOUR HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Citral, Ionones, Terpenes</li> <li>Menthone derivatives</li> <li>Aroma &amp; flavour compounds</li> </ul>                                                                               | <b>28</b> <b>PHARMACEUTICAL INTERMEDIATE HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>API intermediates</li> <li>Chiral hydrogenation</li> <li>Heterocyclic reductions</li> <li>Final API hydrogenation</li> </ul> |
| <b>29</b> <b>AGROCHEMICAL INTERMEDIATE HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Herbicide intermediates</li> <li>Insecticide intermediates</li> <li>Fungicide intermediates</li> </ul>                               | <b>30</b> <b>SPECIALTY CHEMICAL HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>Electronic chemicals</li> <li>Dye intermediates</li> <li>Pigment intermediates</li> <li>UV absorber intermediates</li> </ul>                                           | <b>31</b> <b>MINERAL OIL HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>White oil production</li> <li>Cosmetic oils</li> <li>Pharmaceutical oils</li> <li>Transformer oils</li> <li>Heavy mineral oil upgrading</li> </ul>                                                                                                                 | <b>32</b> <b>BIOMASS UPGRADING (HYDROGENATION)</b><br><br><ul style="list-style-type: none"> <li>Platform molecules</li> <li>Levulinic acid derivatives</li> <li>Furfural → Furfuryl alcohol</li> <li>HMF hydrogenation</li> </ul>                 | <b>33</b> <b>POLYMER INTERMEDIATE HYDROGENATION</b><br>$(-\text{CH}=\text{CH}-)_n \xrightarrow{\text{H}_2} (-\text{CH}_2-\text{CH}_2-)_n$ <ul style="list-style-type: none"> <li>Latex intermediates</li> <li>Functional monomers</li> </ul>                                                                                                       | <b>34</b> <b>FISCHER-TROPSCH WAX HYDROGENATION</b><br><br><ul style="list-style-type: none"> <li>FT wax upgrading</li> </ul>                                                                                                                                                                | <b>35</b> <b>OTHER APPLICATIONS</b><br><br><ul style="list-style-type: none"> <li>Ketimine reduction</li> <li>Sulfoxide → Sulfide</li> <li>N-O bond reduction</li> <li>And many more...</li> </ul>                                   |

# PILON'S MICRO CHANNEL REACTORS



### MICROGRID REACTOR SYSTEM

The Future of Safe, Smart and Sustainable Chemistry

**PFRx-Alpha**  
5 mL

- 3 mL Reactor Volume
- Compact & Efficient
- Precise Microchannel Flow

**PFRx-Beta**  
10 mL

- 10 mL Reactor Volume
- Enhanced Heat Transfer
- Scalable Performance

**PFRx-Gamma**  
40 mL

- 40 mL Reactor Volume
- Heat for Scale-Up
- Consistent & Reliable

**PFRx-Delta**  
100 mL

- 100 mL Reactor Volume
- High Throughput
- Industrial Ready

**PFRx-Epsilon**  
200 mL

- 200 mL Reactor Volume
- Maximized Performance
- Built for Demanding Processes

Related Microgrid Reactor Architecture

- Excellent Heat & Mass Transfer
- Plug-and-Play Modular Design
- Materials: SS316L / Hastelloy / PTFE
- Designed for Real-World Chemistry

ONE ARCHITECTURE. FIVE VOLUMES. LIMITLESS POSSIBILITIES.

ENHANCED SAFETY

Minimized Hazards by Design

SUPERIOR CONTROL

Precise Flow, Temp & Pressure

SUSTAINABLE BY DESIGN

Less Waste, Lower Footprint

SCALABLE PERFORMANCE

From Discovery to Production

SMART CHEMISTRY

INTELLIGENT FLOW. SUSTAINABLE FUTURE.

Continuous Flow

High Heat Transfer

Modular & Scalable

Real-Time Monitoring

Data & Compliance

| PILON'S MICROGRID REACTORS  |             |                      |                                   |                                                                                                                |
|-----------------------------|-------------|----------------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------|
| Reactor Model               | Volume (mL) | Pressure             | Temperature                       | MOC                                                                                                            |
| PFRx-Alpha ( $\alpha$ )     | 5           | FV<br>to<br>200 Barg | (-) 100 Deg C<br>to<br>1000 Deg C | Silicon Carbide, Titanium, Inconel-600, Incolloy, Monel, Duplex, Glass, SS316, SS304, Hastelloy, Tantalum etc. |
| PFRx-Beta ( $\beta$ )       | 10          |                      |                                   |                                                                                                                |
| PFRx-Gamma ( $\gamma$ )     | 40          |                      |                                   |                                                                                                                |
| PFRx-Delta ( $\Delta$ )     | 100         |                      |                                   |                                                                                                                |
| PFRx-Epsilon ( $\epsilon$ ) | 200         |                      |                                   |                                                                                                                |

ALPHA | BETA | GAMMA | DELTA | EPSILON

CUSTOM MICRO CHANNELS AVAILBALE

# REACTIONS IN MICRO CHANNEL FLOW REACTORS

|                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>01</div> <div>NITRATION</div> <div></div> <div>Examples:<ul style="list-style-type: none"><li>Nitrobenzene</li><li>Nitrotoluene</li><li>Nitroanilines</li></ul></div> <div>★★★★★</div> | <div>02</div> <div>DIAZOTIZATION</div> <div><math>ArNH_2 \longrightarrow R_3N^+ Cl^-</math></div> <div>Examples:<ul style="list-style-type: none"><li>Aniline</li><li>p-Toluidine</li></ul></div> <div>★★★★★</div>                                                             | <div>03</div> <div>AZO COUPLING</div> <div></div> <div>Examples:<ul style="list-style-type: none"><li>Azo dyes</li><li>Pigment intermediates</li></ul></div> <div>★★★★★</div>               | <div>04</div> <div>BROMINATION</div> <div><math>Ar-H \xrightarrow{Br_2 / Solvent} Ar-Br</math></div> <div>Examples:<ul style="list-style-type: none"><li>Bromobenzenes</li><li>Brominated intermediates</li></ul></div> <div>★★★★★</div>                                                                      | <div>05</div> <div>CHLORINATION</div> <div><math>Ar-H \xrightarrow{Cl_2 / Solvent} Ar-Cl</math></div> <div>Examples:<ul style="list-style-type: none"><li>Chlorobenzenes</li><li>Chlorinated aromatics</li></ul></div> <div>★★★★★</div>                                                                      | <div>06</div> <div>FLUORINATION</div> <div><math>R-H \xrightarrow{Selectfluor / HF} R-F</math></div> <div>Examples:<ul style="list-style-type: none"><li>Fluoroarenes</li><li>Fluorinated intermediates</li></ul></div> <div>★★★★☆</div>                                                                                                                                                                                                                                                                                           | <div>07</div> <div>IODINATION</div> <div><math>Ar-H \xrightarrow{I_2 / Oxidant} Ar-I</math></div> <div>Examples:<ul style="list-style-type: none"><li>Iodoarenes</li><li>Iodinated heterocycles</li></ul></div> <div>★★★★★</div>                                       | <div>08</div> <div>SULFONATION</div> <div><math>Ar-H \xrightarrow{SO_3 / oleum} Ar-SO_3H</math></div> <div>Examples:<ul style="list-style-type: none"><li>Benzenesulfonic acid</li><li>Aromatic sulfonates</li></ul></div> <div>★★★★★</div>                                 |
| <div>09</div> <div>ACYLATION</div> <div><math>Ar-H \xrightarrow{RCOCl / AlCl_3} Ar-C(=O)R</math></div> <div>Examples:<ul style="list-style-type: none"><li>Friedel-Crafts acylation</li><li>Aromatic ketones</li></ul></div> <div>★★★★☆</div>                              | <div>10</div> <div>ALKYLATION</div> <div><math>Ar-H \xrightarrow{R-X / Catalyst} Ar-R</math></div> <div>Examples:<ul style="list-style-type: none"><li>Alkylbenzenes</li><li>Alkylated aromatics</li></ul></div> <div>★★★★☆</div>                                              | <div>11</div> <div>ESTERIFICATION</div> <div><math>R-COOH + R'-OH \xrightarrow{Acid / Catalyst} R-COOR'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Methyl benzoate</li><li>Specialty esters</li></ul></div> <div>★★★★★</div>                          | <div>12</div> <div>TRANSESTERIFICATION</div> <div><math>R-COOR_1 + R_2OH \xrightarrow{Catalyst} R-COOR_2 + R_1OH</math></div> <div>Examples:<ul style="list-style-type: none"><li>Biodiesel intermediates</li><li>Fine chemical esters</li></ul></div> <div>★★★★★</div>                                       | <div>13</div> <div>AMIDATION</div> <div><math>R-COOH + R'-NH_2 \xrightarrow{Coupling / Base} R-CNHR'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Amides</li><li>Pharma intermediates</li></ul></div> <div>★★★★☆</div>                                                                   | <div>14</div> <div>IMINE FORMATION</div> <div><math>R-CHO + R'-NH_2 \xrightarrow{-H_2O} R-CH=N-R'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Imines</li><li>Heterocycle synthesis</li></ul></div> <div>★★★★★</div>                                                                                                                                                                                                                                                                                           | <div>15</div> <div>OXIME FORMATION</div> <div><math>R-C=O + r-NH_2H \xrightarrow{-H_2O} R-CH=NOH</math></div> <div>Examples:<ul style="list-style-type: none"><li>Oximes</li><li>Analytical derivatization</li></ul></div> <div>★★★★★</div>                            | <div>16</div> <div>SCHIFF BASE SYNTHESIS</div> <div><math>R-CHO + R'-NH_2 \xrightarrow{-H_2O} R-CH=N-R'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Schiff bases</li><li>Ligand synthesis</li></ul></div> <div>★★★★★</div>                             |
| <div>17</div> <div>KNOEVENAGEL CONDENSATION</div> <div><math>R-CHO + R'-CHO \xrightarrow{NaCC / CuH_3} R-CH=CH-R'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Fine chemicals</li><li>Heterocycles</li></ul></div> <div>★★★★★</div>                    | <div>18</div> <div>ALDOL CONDENSATION</div> <div><math>R-CHO + R'-CHO \xrightarrow{Base} \beta\text{-Hydroxy carbonyl}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Flavors &amp; fragrances</li><li>Pharma intermediates</li></ul></div> <div>★★★★★</div> | <div>19</div> <div>CLAISEN CONDENSATION</div> <div><math>R-COOR' + R''-COOR' \xrightarrow{Base / Catalyst} \beta\text{-Keto ester}</math></div> <div>Examples:<ul style="list-style-type: none"><li>β-Keto esters</li><li>Building blocks</li></ul></div> <div>★★★★★</div>  | <div>20</div> <div>MICHAEL ADDITION</div> <div><math>R-COOR' + R''-CH_2-CH_2-COOR' \xrightarrow{Base / Catalyst} \beta\text{-Keto ester}</math></div> <div>Examples:<ul style="list-style-type: none"><li>C-C bond formation</li><li>API synthesis</li></ul></div> <div>★★★★☆</div>                           | <div>21</div> <div>GRIGNARD REACTIONS</div> <div><math>RMgX + R'-COOR' \rightarrow R-C(OH)(R')R''</math></div> <div>Examples:<ul style="list-style-type: none"><li>Alcohols</li><li>Building blocks</li></ul></div> <div>★★★★☆</div>                                                                         | <div>22</div> <div>ORGANOLITHIUM REACTIONS</div> <div><math>RLi + R'-COOR' \rightarrow R-C(OH)(R')R''</math></div> <div>Examples:<ul style="list-style-type: none"><li>Complex synthons</li><li>Specialty chemicals</li></ul></div> <div>★★★★☆</div>                                                                                                                                                                                                                                                                               | <div>23</div> <div>ORGANOMETALLIC CHEMISTRY</div> <div><math>R-MgX / R-Li / R-ZnX</math><br/>Various electrophiles</div> <div>Examples:<ul style="list-style-type: none"><li>Cross coupling precursors</li><li>Advanced intermediates</li></ul></div> <div>★★★★☆</div> | <div>24</div> <div>CYANATION</div> <div><math>R-X \xrightarrow{NaCN / Catalyst} R-CN</math></div> <div>Examples:<ul style="list-style-type: none"><li>Nitriles</li><li>Pharma intermediates</li></ul></div> <div>★★★★★</div>                                                |
| <div>25</div> <div>NUCLEOPHILIC SUBSTITUTIONS (SN1 / SN2)</div> <div><math>R-X \xrightarrow{Nu^-} R-Nu</math></div> <div>Examples:<ul style="list-style-type: none"><li>Alcohols, amines</li><li>Ethers, thioethers</li></ul></div> <div>★★★★★</div>                       | <div>26</div> <div>AROMATIC SUBSTITUTIONS</div> <div><math>Ar-H \xrightarrow{E^+ / Catalyst} Ar-E</math></div> <div>Examples:<ul style="list-style-type: none"><li>Nitration, sulfonation</li><li>Halogenation</li></ul></div> <div>★★★★★</div>                                | <div>27</div> <div>CLICK CHEMISTRY</div> <div><math>R-N_3 + \text{Alkyne} \xrightarrow{Cu(I)} \text{1,4-disubstituted 1,2,3,5-tetrazole}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Triazoles</li><li>Bioconjugation</li></ul></div> <div>★★★★★</div> | <div>28</div> <div>UGI REACTION</div> <div><math>R-CHO + R'-NH_2 + R''-COOH + R'''-NC \rightarrow \text{Peptide-like product}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Multicomponent synthesis</li><li>Drug discovery</li></ul></div> <div>★★★★☆</div>                               | <div>29</div> <div>PASSERINI REACTION</div> <div><math>R-CHO + R'-COOH + R''-NC \rightarrow \alpha\text{-acyloxy amide}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Multicomponent synthesis</li><li>Library generation</li></ul></div> <div>★★★★☆</div>                                | <div>30</div> <div>SUZUKI COUPLING</div> <div><math>Ar-B(OH)_2 + Ar'-X \xrightarrow{Pd / Base} Ar-Ar'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Biaryls</li><li>Pharma &amp; agro intermediates</li></ul></div> <div>★★★★☆</div>                                                                                                                                                                                                                                                                            | <div>31</div> <div>HECK COUPLING</div> <div><math>Ar-X + \text{Alkene} \xrightarrow{Pd / Base} Ar-CH=CH_2</math></div> <div>Examples:<ul style="list-style-type: none"><li>Styrenes</li><li>Fine chemicals</li></ul></div> <div>★★★★☆</div>                            | <div>32</div> <div>SONOGASHIRA COUPLING</div> <div><math>Ar-X + \text{Alkyne} \xrightarrow{Pd / Cu / Base} Ar-C \equiv C-R</math></div> <div>Examples:<ul style="list-style-type: none"><li>Alkynyl aromatics</li><li>Electronic chemicals</li></ul></div> <div>★★★★☆</div> |
| <div>33</div> <div>BUCHWALD-HARTWIG AMINATION</div> <div><math>Ar-X + R_2NH \xrightarrow{Pd / Base} Ar-NR_2</math></div> <div>Examples:<ul style="list-style-type: none"><li>Anilines</li><li>API intermediates</li></ul></div> <div>★★★★☆</div>                           | <div>34</div> <div>NEGISHI COUPLING</div> <div><math>R-ZnX + R'-X \xrightarrow{Pd / Ligand} R-R'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Biaryls</li><li>Complex molecules</li></ul></div> <div>★★★★★</div>                                           | <div>35</div> <div>KUMADA COUPLING</div> <div><math>R-MgX + R'-X \xrightarrow{Ni / Pd} R-R'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Cross coupling</li><li>Fine chemicals</li></ul></div> <div>★★★★★</div>                                         | <div>36</div> <div>STILLE COUPLING</div> <div><math>R-SnR_3 + R'-X \xrightarrow{Pd / Ligand} R-R'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Complex coupling</li><li>Pharmaceutical intermediates</li></ul></div> <div>★★★★★</div>                                                     | <div>37</div> <div>MITSUNOBU REACTION</div> <div><math>R-OH + R'-COOH \xrightarrow{PPh_3 / DIAD} R-OR'</math></div> <div>Examples:<ul style="list-style-type: none"><li>Ether formation</li><li>Inversion reactions</li></ul></div> <div>★★★★★</div>                                                         | <div>38</div> <div>CYCLIZATION REACTIONS</div> <div><math>\text{Linear precursor} \xrightarrow{Acid / Catalyst} \text{Ring product}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Lactams, lactones</li><li>Heterocycles</li></ul></div> <div>★★★★★</div>                                                                                                                                                                                                                                                       | <div>39</div> <div>OXIDATIONS</div> <div><math>R-CH_2OH \xrightarrow{Oxidant} R-CHO / R-COOH</math></div> <div>Examples:<ul style="list-style-type: none"><li>Alcohols to aldehydes</li><li>Alcohols to acids</li></ul></div> <div>★★★★☆</div>                         | <div>40</div> <div>REDUCTIONS</div> <div><math>R-NO_2 + R-C=O \xrightarrow{Reductant} R-NH_2 / R-CH_2OH</math></div> <div>Examples:<ul style="list-style-type: none"><li>Nitro reduction</li><li>Carbonyl reduction</li></ul></div> <div>★★★★☆</div>                        |
| <div>41</div> <div>EPOXIDATION</div> <div><math>\text{Alkene} \xrightarrow{Peracid / Catalyst} \text{Epoxide}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Epoxides</li><li>Specialty chemicals</li></ul></div> <div>★★★★★</div>                       | <div>42</div> <div>HYDROLYSIS</div> <div><math>R-COOR' \xrightarrow{Acid / Base} R-COOH + R'-OH</math></div> <div>Examples:<ul style="list-style-type: none"><li>Esters</li><li>Amides, nitriles</li></ul></div> <div>★★★★★</div>                                              | <div>43</div> <div>POLYMER PRECURSOR SYNTHESIS</div> <div><math>\text{Monomers} \xrightarrow{Catalyst / Initiator} \text{Polymer}</math></div> <div>Examples:<ul style="list-style-type: none"><li>Monomers</li><li>Oligomers</li></ul></div> <div>★★★★★</div>              | <div>44</div> <div>API INTERMEDIATE SYNTHESIS</div> <div></div> <div>Examples:<ul style="list-style-type: none"><li>Multi-step intermediates</li><li>Active pharmaceutical intermediates</li></ul></div> <div>★★★★★</div> | <div>45</div> <div>AGROCHEMICAL INTERMEDIATE SYNTHESIS</div> <div></div> <div>Examples:<ul style="list-style-type: none"><li>Herbicide intermediates</li><li>Insecticide intermediates</li></ul></div> <div>★★★★★</div> | <div>FIT GUIDE FOR MICRO GRID FLOW REACTOR</div> <div>★★★★★ EXCELLENT FIT<br/>Ideal for fast, exothermic, multi-step, high-mixing reactions with precise residence time control.</div> <div>★★★★☆ GOOD FIT (WITH SPECIALIZED DESIGN)<br/>Feasible with gas-liquid handling, catalyst integration or specialized configurations.</div> <div>★☆☆☆☆ NOT SUITABLE<br/>Require large catalyst inventory, long residence time, solids handling or high pressure/temperature typical of packed bed, slurry or trickle bed reactors.</div> |                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                             |

NOTE: Reaction suitability depends on chemistry, conditions, solvent, concentration, scale and safety considerations.



**MGFR** (Micro Grid Flow Reactor) & **ContiHYflow** (Continuous Hydrogenation Flow)  
Units that every Lab must have

# PILON'S SLURRY FLOW REACTORS

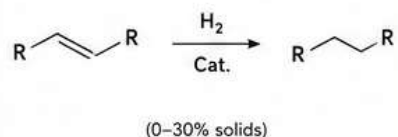


| PILON'S MICROGRID REACTORS |                              |                             |                                           |                                                                                                                |
|----------------------------|------------------------------|-----------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Reactor Model              | Volume (mL)                  | Pressure                    | Temperature                               | MOC                                                                                                            |
| PILON Core™                | 300mL to m3 production scale | FV to Custom High Pressures | (-) 100 Deg C to Custom High Temperatures | Silicon Carbide, Titanium, Inconel-600, Incolloy, Monel, Duplex, Glass, SS316, SS304, Hastelloy, Tantalum etc. |
| PILON Vector™              |                              |                             |                                           |                                                                                                                |
| PILON Nexus™               |                              |                             |                                           |                                                                                                                |
| PILON Vertex™              |                              |                             |                                           |                                                                                                                |
| PILON Apex™                |                              |                             |                                           |                                                                                                                |

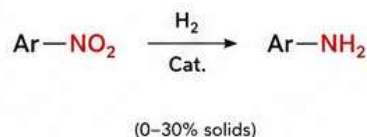
CORE | VECTOR | NEXUS | VERTEX | APEX  
CUSTOM CELLS AVAILBALE

# REACTIONS IN SLURRY FLOW REACTORS

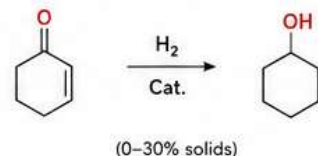
## 1 Liquid-Liquid Hydrogenation



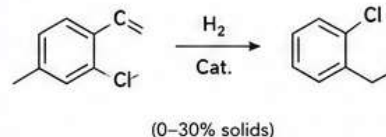
## 2 Liquid-Solid Hydrogenation



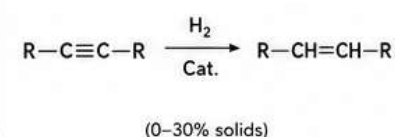
## 3 Slurry Hydrogenation



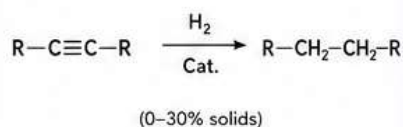
## 4 Selective Hydrogenation



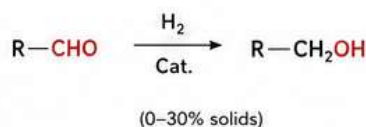
## 5 Partial Hydrogenation (Alkyne)



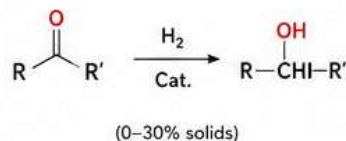
## 6 Complete Hydrogenation (Alkyne)



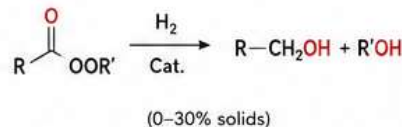
## 7 Carbonyl Hydrogenation (Aldehyde)



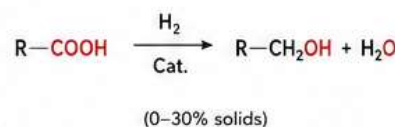
## 8 Carbonyl Hydrogenation (Ketone)



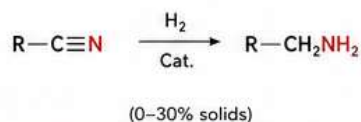
## 9 Ester Hydrogenation



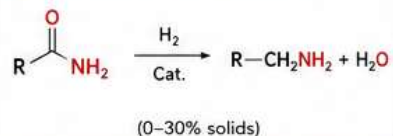
## 10 Carboxylic Acid Hydrogenation



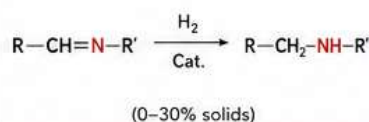
## 11 Nitrile Hydrogenation



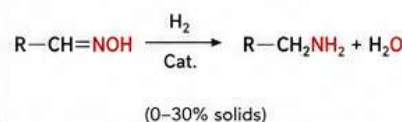
## 12 Amide Hydrogenation



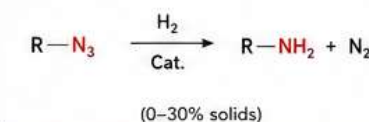
## 13 Imine Hydrogenation



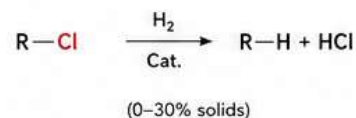
## 14 Oxime Hydrogenation



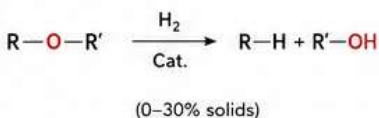
## 15 Azide Hydrogenation



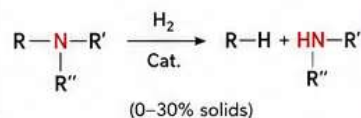
## 16 Hydrodehalogenation



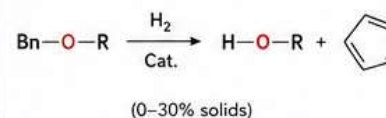
## 17 Hydrogenolysis (C–O)



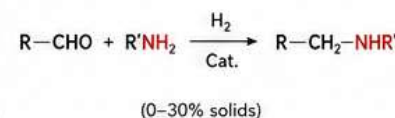
## 18 Hydrogenolysis (C–N)



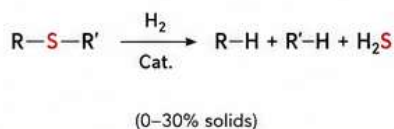
## 19 Hydrogenolysis (Benzyl Deprotection)



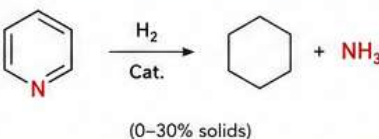
## 20 Reductive Amination



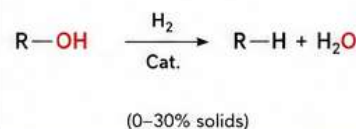
## 21 Hydrosulfurization (HDS)



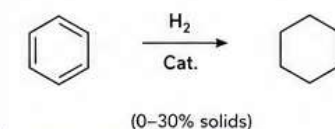
## 22 Hydrodenitrogenation (HDN)



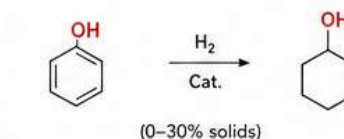
## 23 Hydrodeoxygenation (HDO)



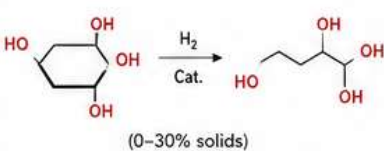
## 24 Hydrodearomatization (HDA)



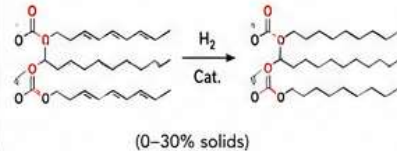
## 25 Phenol Hydrogenation



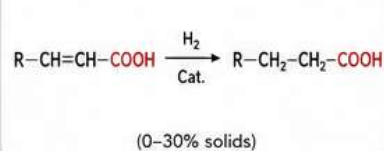
## 26 Sugar Alcohol Production



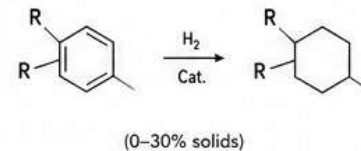
## 27 Vegetable Oil Hydrogenation



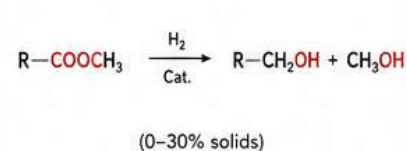
## 28 Fatty Acid Hydrogenation



## 29 Resin Hydrogenation



## 30 Biodiesel Intermediate Hydrogenation



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|  | PFRx-Gamma   | 40 mL  |
|  | PFRx-Delta   | 100 mL |
|  | PFRx-Epsilon | 200 mL |

#### MICROGRID REACTOR SYSTEM

#### MICROGRID REACTOR SYSTEM

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#### FIXED BED REACTOR SYSTEM

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#### HYDROGENATION PILOT PLANT

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# THANK YOU..!

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