igcw 2023 industrial green chemistry world

UPL OpenAg™

# *"Catalysts & Catalytic Processes being explored by UPL for Economical & Environmental Competitiveness"*

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# Outline

- UPL Introduction
- Green chemistry principles
- Catalysis & types
- Homo & Heterogeneous catalysis
- Case studies of Homogeneous catalysis
- Case studies of Heterogeneous catalysis
- Conclusion

# UPL Crop Protection Global Reach
With a sales presence in 138 countries



**138**
countries sales presence

**43**
Manufacturing facilities

**18**
R&D facilities

UPL

# UPL in numbers


| #1 | #5 | 10k+ | 13k+ | 138 |
|---|---|---|---|---|
| In Biosolutions | In the industry[1] | Employees globally | Product Registrations | Countries with sales presence |

| $6.2b | — | 19% | $1.4b | — | 19% |
|---|---|---|---|---|---|
| ₹ 462b FY22 Revenue | | Growth vs PY | ₹ 102b FY22 EBITDA | | Growth vs PY |

[1] Based on revenue

# 12 Principles of Green Chemistry

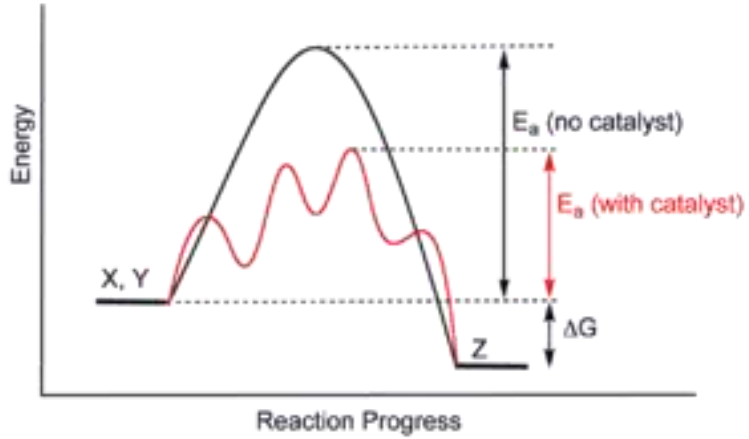
1. **Prevention.** It is better to prevent waste than to treat or clean up waste after it is formed.
2. **Atom Economy.** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Synthesis.** Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals.** Chemical products should be designed to preserve efficacy of the function while reducing toxicity.
5. **Safer Solvents and Auxiliaries.** The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary whenever possible and, when used, innocuous.
6. **Design for Energy Efficiency.** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable Feedstocks.** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practical.
8. **Reduce Derivatives.** Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible .
9. **Catalysis.** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation.** Chemical products should be designed so that at the end of their function they do not persist in the environment and instead break down into innocuous degradation products.
11. **Real-time Analysis for Pollution Prevention.** Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention.** Substance and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.



Anastas, P. T.; Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press,1998.

# CATALYSIS: INTRODUCTION

- Catalysis is the increase in rate of a chemical reaction due to an added substance known as a catalyst.
- Catalysts are not consumed by the reaction and remain unchanged after it.




CATALYSIS: TYPES

- Homogeneous catalysis
- Heterogeneous catalysis
- Autocatalysis
- Enzyme catalysis
- Photo catalysis
- Positive catalysis
- Negative catalysis

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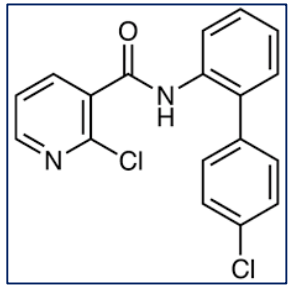
# CATALYST: Global Industrial Market


| Market Dynamics |
| --- |
| Diverse<br>• Increase in consumption of industrial catalysts in fuel and other refineries<br>• Rise in demand for industrial catalysts in various end-use applications |
| Restraints<br>• Limited availability of raw materials and high production costs<br>• Technological advancements in chemical synthesis |
| Opportunities<br>• Surge in R&D activities |
| ➢ Major producers are BASF, DOW and JM etc. |

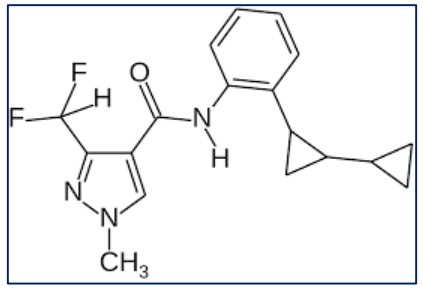
# CATALYSIS: Applications in Agrochemicals

***Classified by MOA:***

1. SDHI class

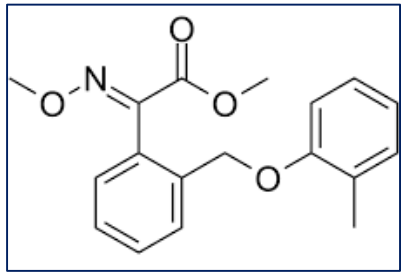


Boscalid

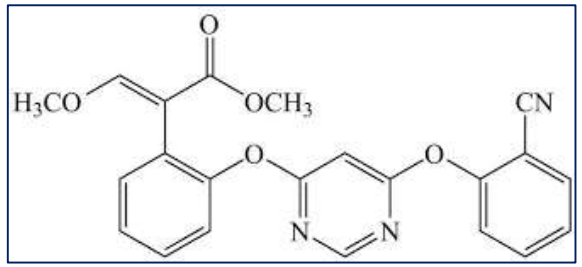


Sedaxane

2. Strobulirin class

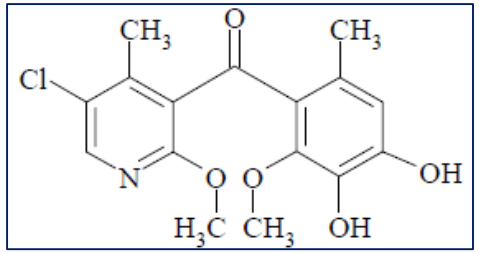


Kresoxin-methyl



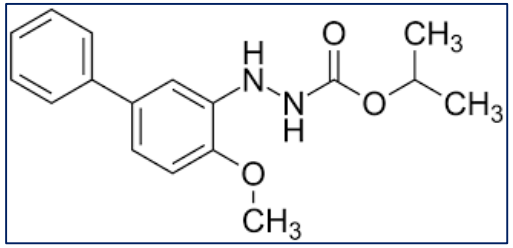
Azoxystrobin

3. Enzyme inhibitors



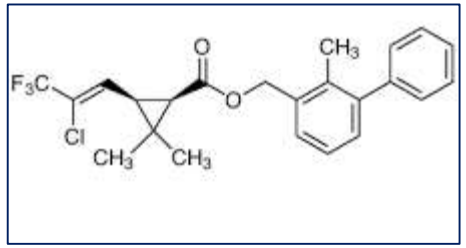
Pyriofenone

4. Mitochondrial inhibitor



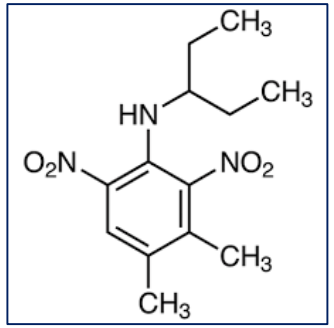
Bifenazate

5. Sodium gated channels



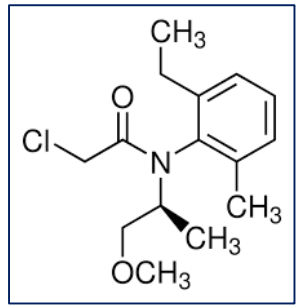
Bifenthrin

6. Plant cell inhibitor



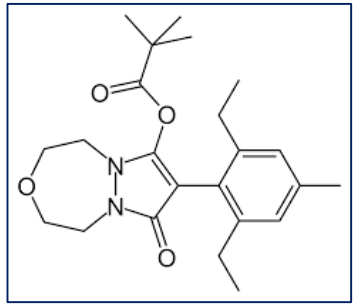
Pendimethalin

7. GGPP inhibitor



S-Metolachlor

8. ACCase inhibitor



Pinoxaden

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# CATALYSIS: Heterogeneous Vs Homogeneous

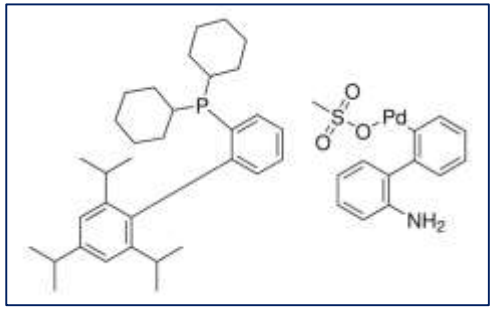
**Heterogeneous catalysts**

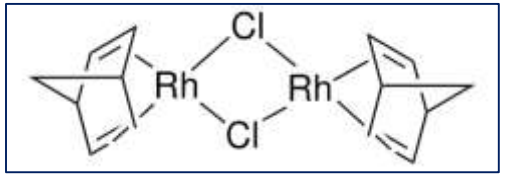
- Solid phase
- Easily separable
- Recyclability and regeneration
- Low rate of reaction
- Diffusion control
- Poisoning, deactivation
- Low selectivity
- Long catalytic life
- Energy- consuming process
- Poor mechanism understanding

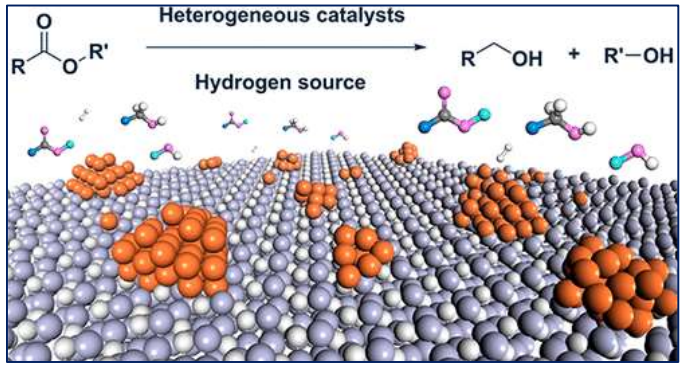
**Vs**

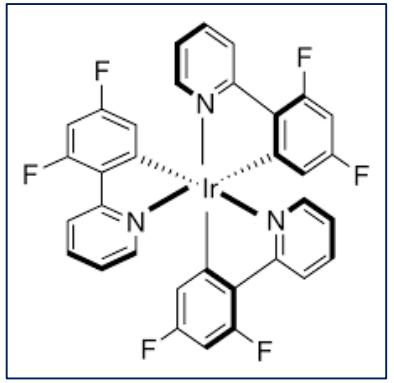
**Homogeneous catalysts**

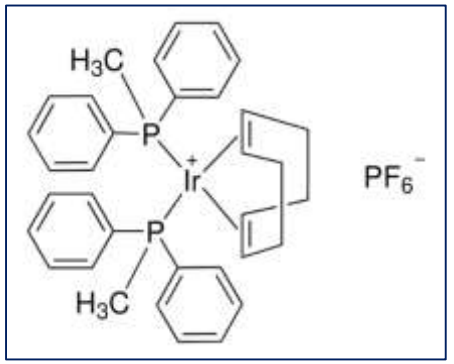
- Same phase as reaction medium
- Difficult separation
- No recyclability
- Often high rates of reaction
- No diffusion control
- Robust to poisoning
- High selectivity
- Short life
- Mild conditions
- Well understood mechanism

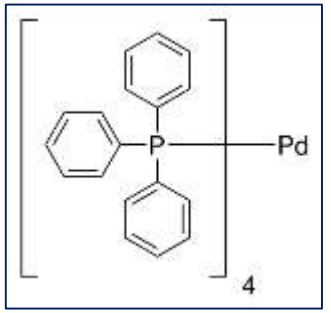
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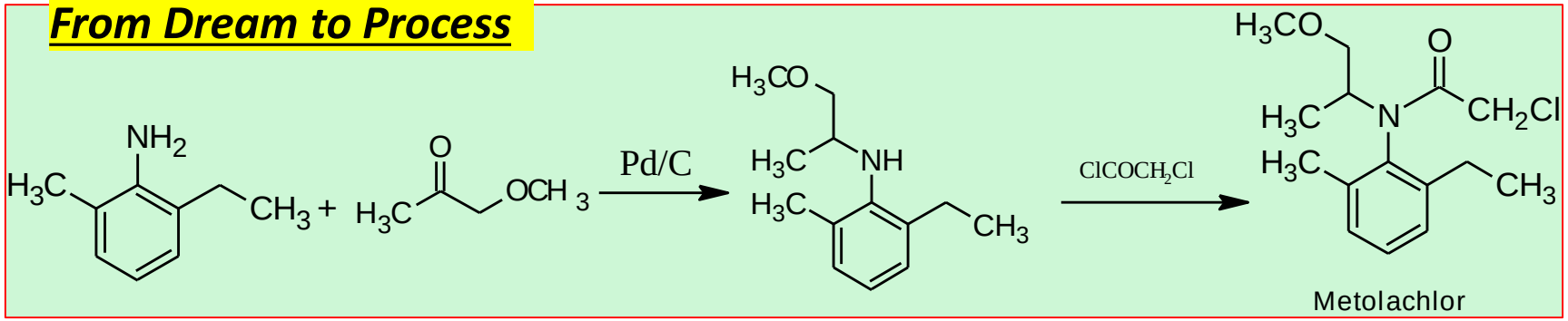
# CATALYSIS: By UPL (Economical & Environmental Competitiveness)

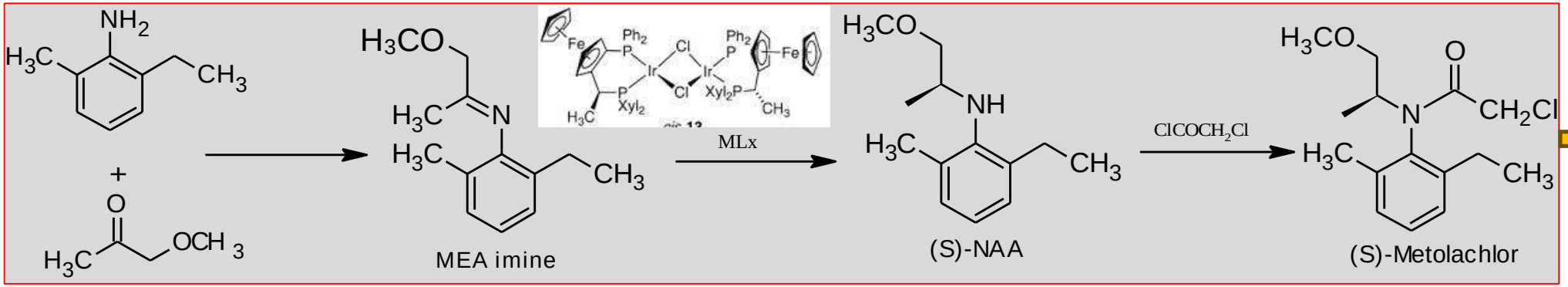
❑ ***Process development of Metolachlor & S-metolachlor:***

***From Dream to Process***




***By heterogeneous catalysis***

- Low catalyst loadings with quantitative yield
- More no recycles and high recovery of cat.
- Highly economic process with low COGs
- Minimum effluent



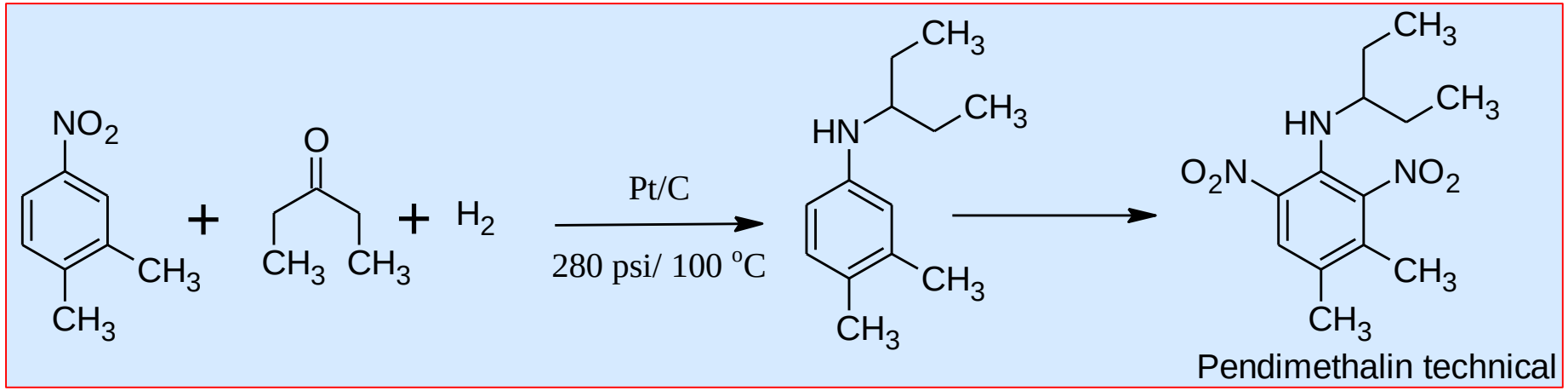

***By homogeneous catalysis***

- UPL has developed a new catalyst for S-metolachlor
- High Turnover number (TON) and high TOF
- Recycle and recovery of the catalyst
- Low catalyst loadings with high selective er= 90:10
- Low COGs with reduced dosage on fields
- Minimum effluent

***Scale of production 30000 MT/A***

# CATALYSIS: By UPL (Economical & Environmental Competitiveness)

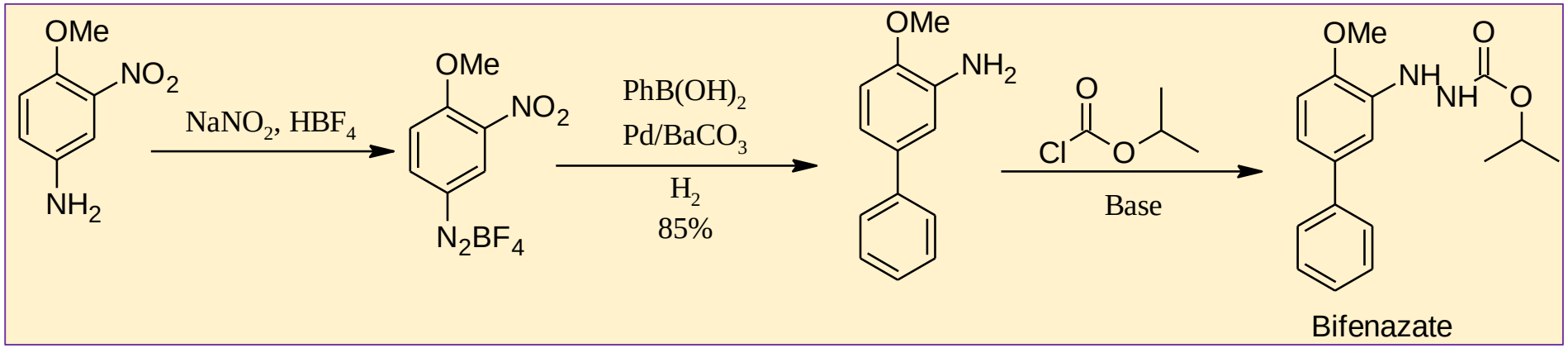
❑ ***Process development of Pendimethalin: By heterogeneous catalysis***




- **Developed the process based on Pt/C catalyst**
- **Low catalyst ladings to yield >99% of the product**
- **Catalyst recycled more than 300 times with 90% recovery**
- **Low COGs**
- **High quality with 97% (900 g/Kg UFSA guidelines)**
- **Nitroso-Pendimethalin 0.1% (45 mg/Kg USFA guidelines)**
- **Environmentally benign as reduced toxic nitroso impurity**

# CATALYSIS: By UPL (Economical & Environmental Competitiveness)

❑ ***Process development of Bifenazate: By heterogeneous catalysis***

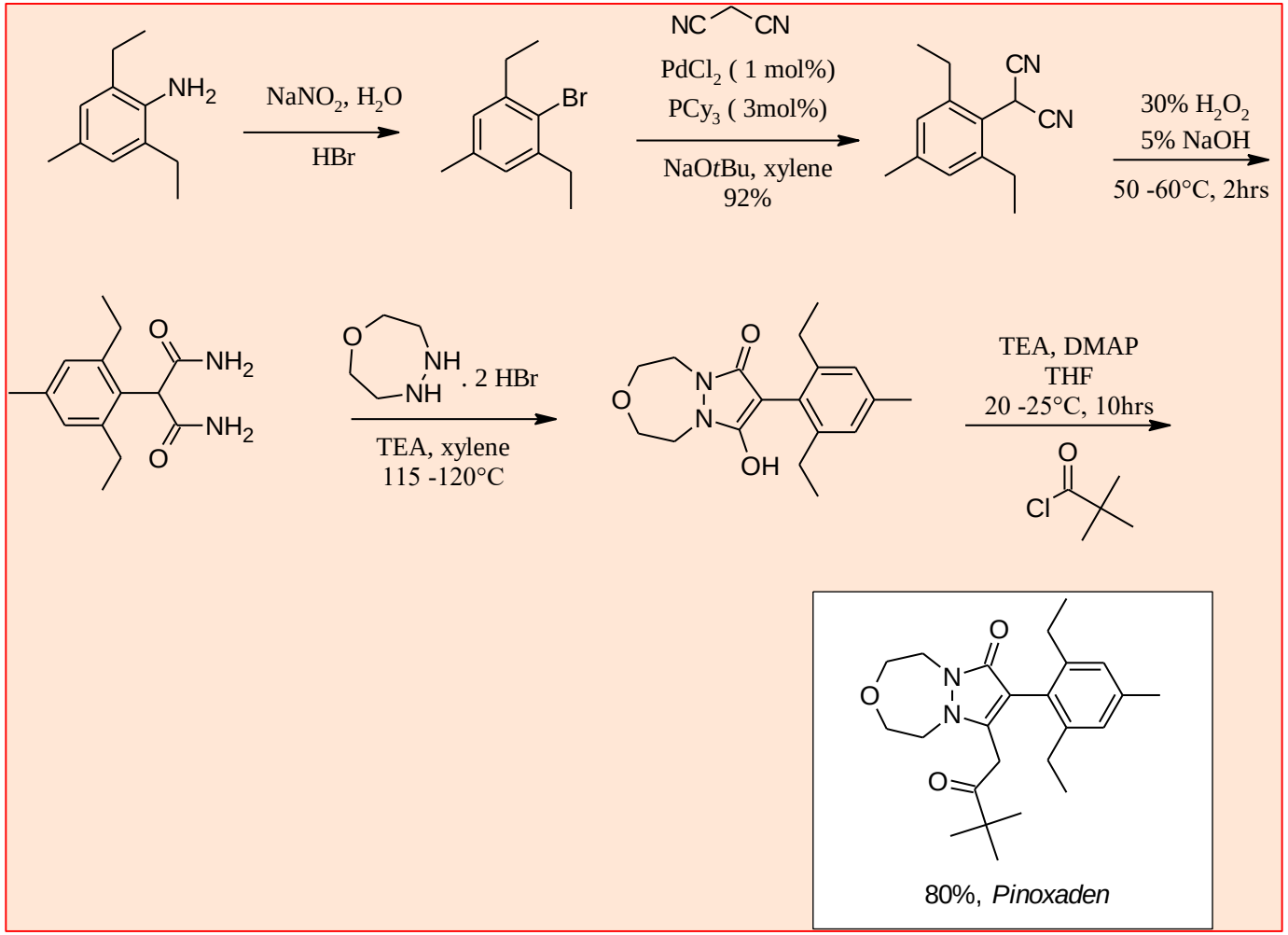



- **Developed a heterogeneous catalyst for Suzuki coupling**
- **No phosphorous ligands required**
- **No halogen required as another partner**
- **No homocoupling formation unlike Homogeneous catalysis**
- **Low catalyst loadings and Low temperature reaction**
- **High recovery and recycle of the catalyst**
- **Cheap and commercial viability**

- **Bifenazate is an insecticide used for mite control**
- **It has a low water solubility, volatile**
- **Would not be expected to leach to groundwater**
- **It is also not expected to persist in soil or water systems.**

# CATALYSIS: By UPL (Economical & Environmental Competitiveness)

❑ ***Process development of Pinoxaden: By homogeneous catalysis***




- **Under development**

# CONCLUSION

- Demonstrated importance of catalysis in chemical industry
- Developed various homo & heterogeneous catalysts
- Applied them to various processes in agrochemical applications
- Catalysis makes processes is greener (green chemistry principles)
- UPL having different capabilities in developing various catalysts

# UPL - no.1 in the world for sustainability

## Sustainalytics

UPL ranked no.1 for Sustainability Performance amongst its peers of global crop protection companies for second year running

## Asian Sustainability Leadership

Award to UPL in June 2021 for Excellent in Sustainability Performance

## Dow Jones

UPL is the only crop protection company featuring in the Dow Jones Sustainability Yearbook

UPL

[1] Sustainalytics rating based on report dated November 18 2021

# What next?

Single atom catalysis describes a process in which a single atom on a catalyst surface drives a catalytic reaction. The catalyst with a single atom on its surface is called a single atom catalyst (SAC).