



# Commercial Benefit of Green Chemistry at a Large Business

**Yvonne Armitage**

**Ciba UK plc (now part of BASF)**

**Bradford, UK**

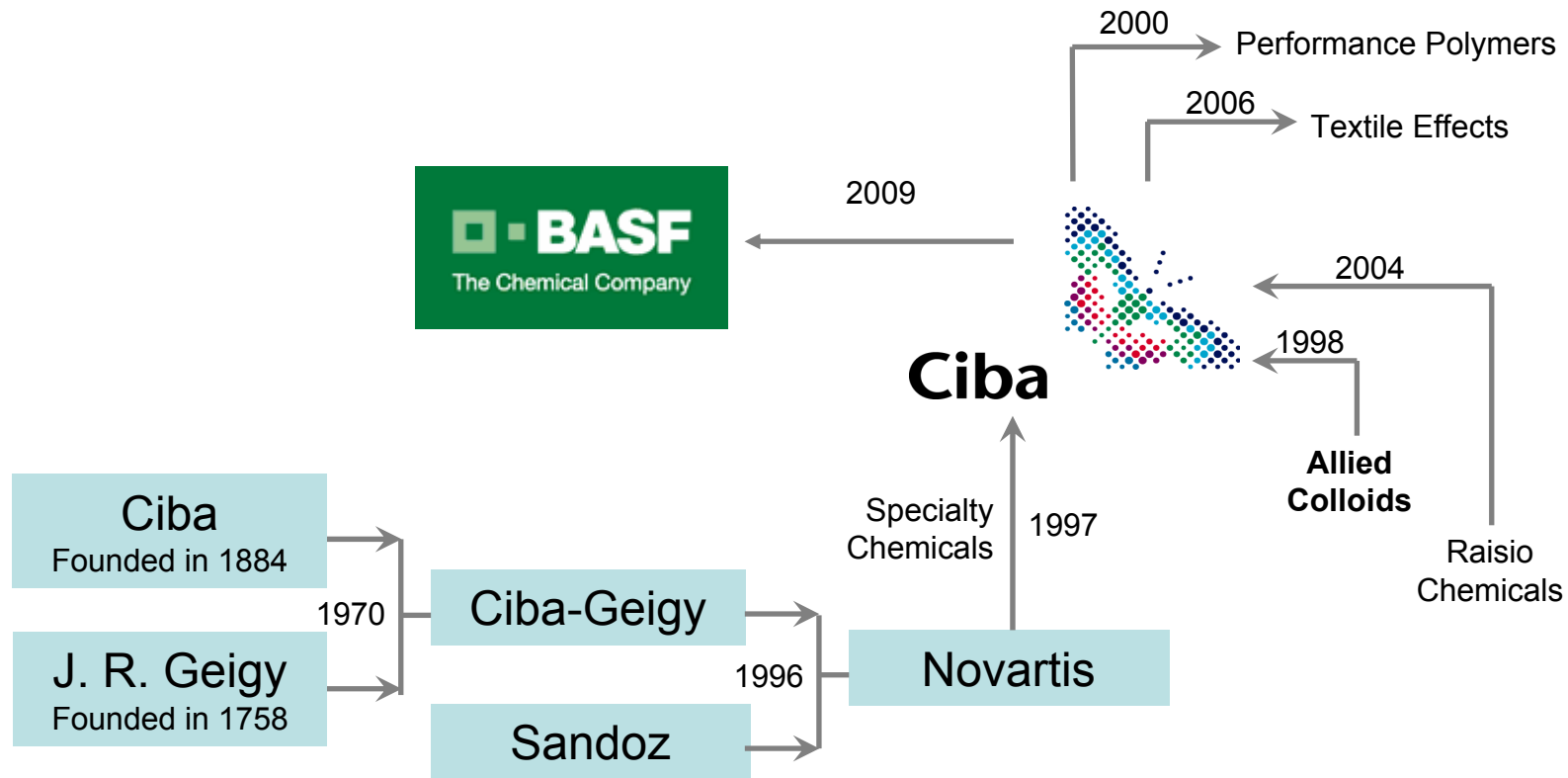


# Content

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- Company background
- Drivers and trends
- Case studies
- Concluding remarks

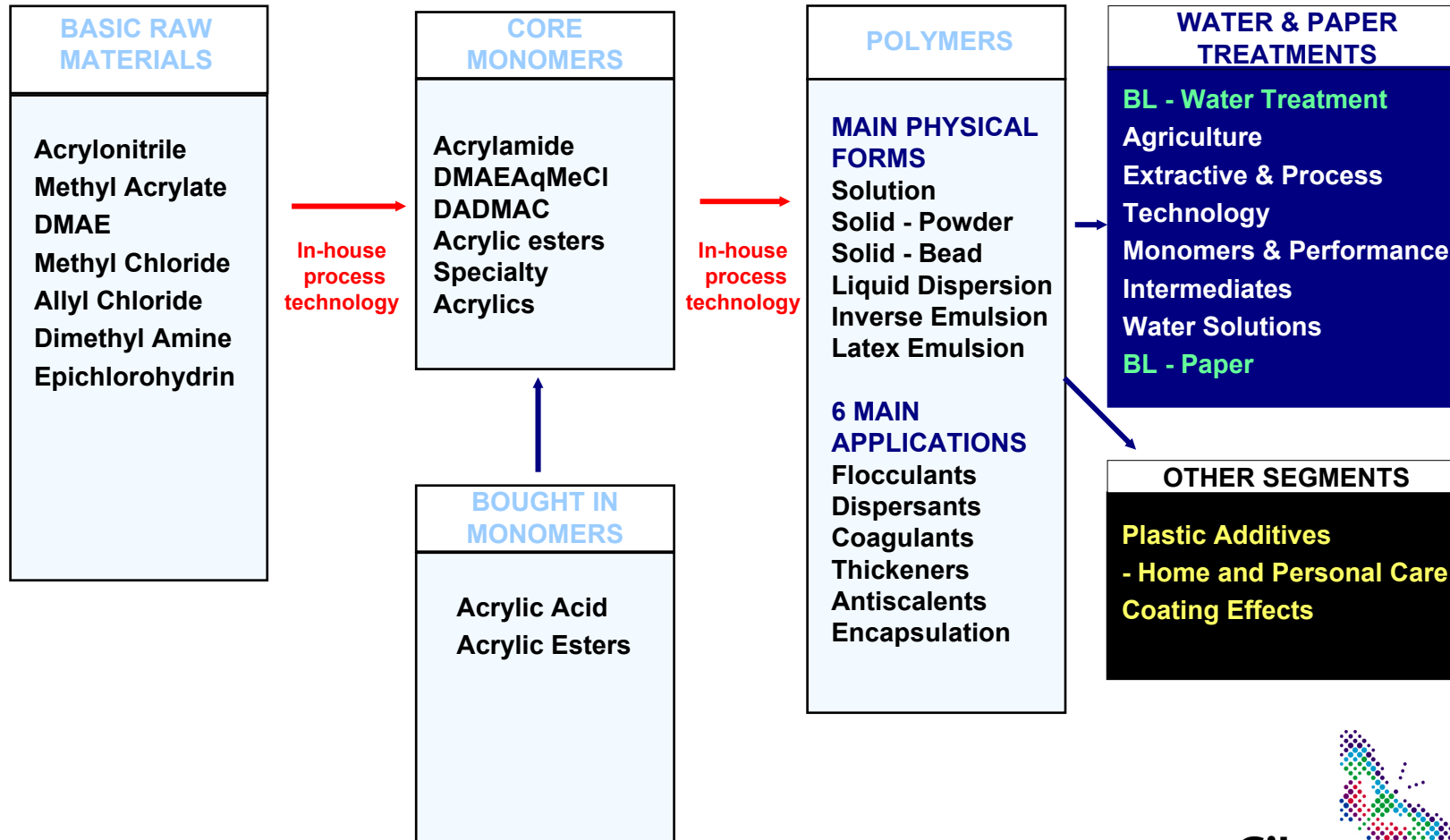
# Company History



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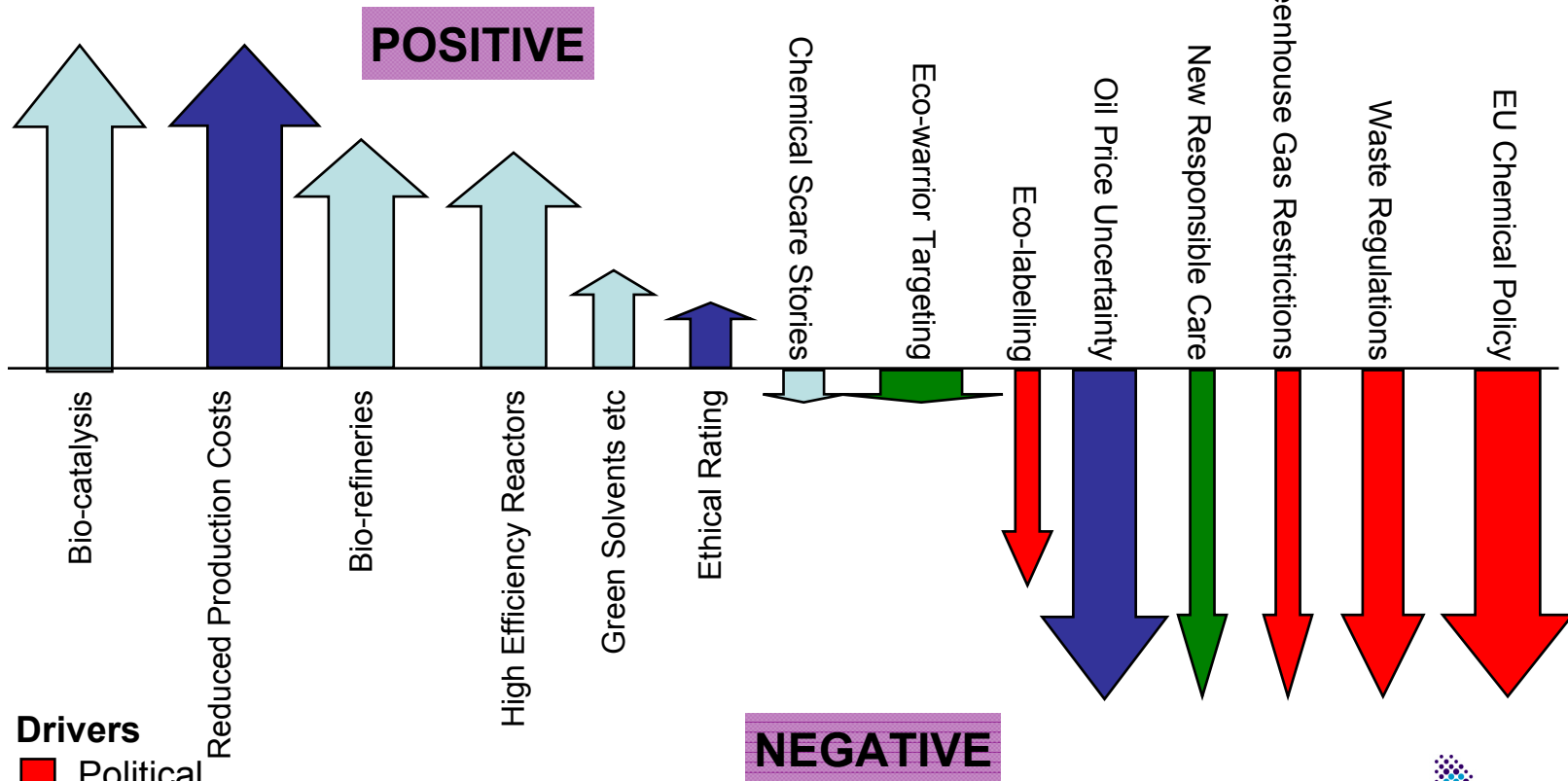
# Ciba Water Treatment Business Line

## Raw Materials - Monomers - Products - Customers



# Potential Drivers

Impact (width) and Likelihood (length)

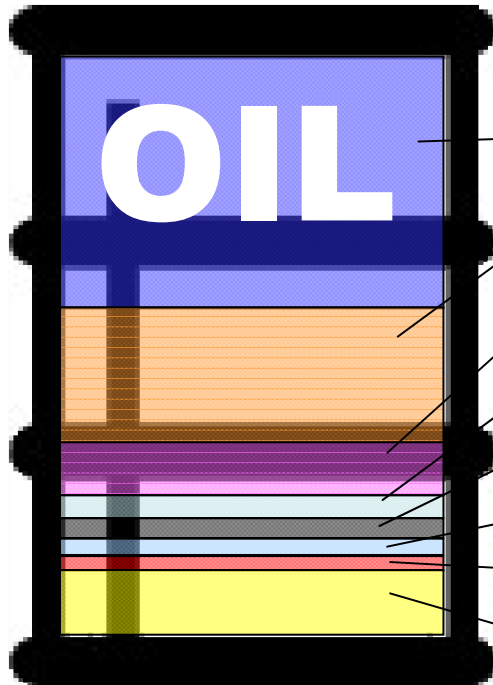


- Drivers**
- Political
  - Economical
  - Sociological
  - Technological



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# Drivers – Oil Price



Gasoline	19.4 gallons
Diesel Fuel & Heating Oil	10.5
Jet Fuel	4.1
Heavy Fuel Oil	1.7
Propane	1.5
Asphalt & Road Oil	1.3
Petrochemical Feedstocks	1.1
Other Products	5

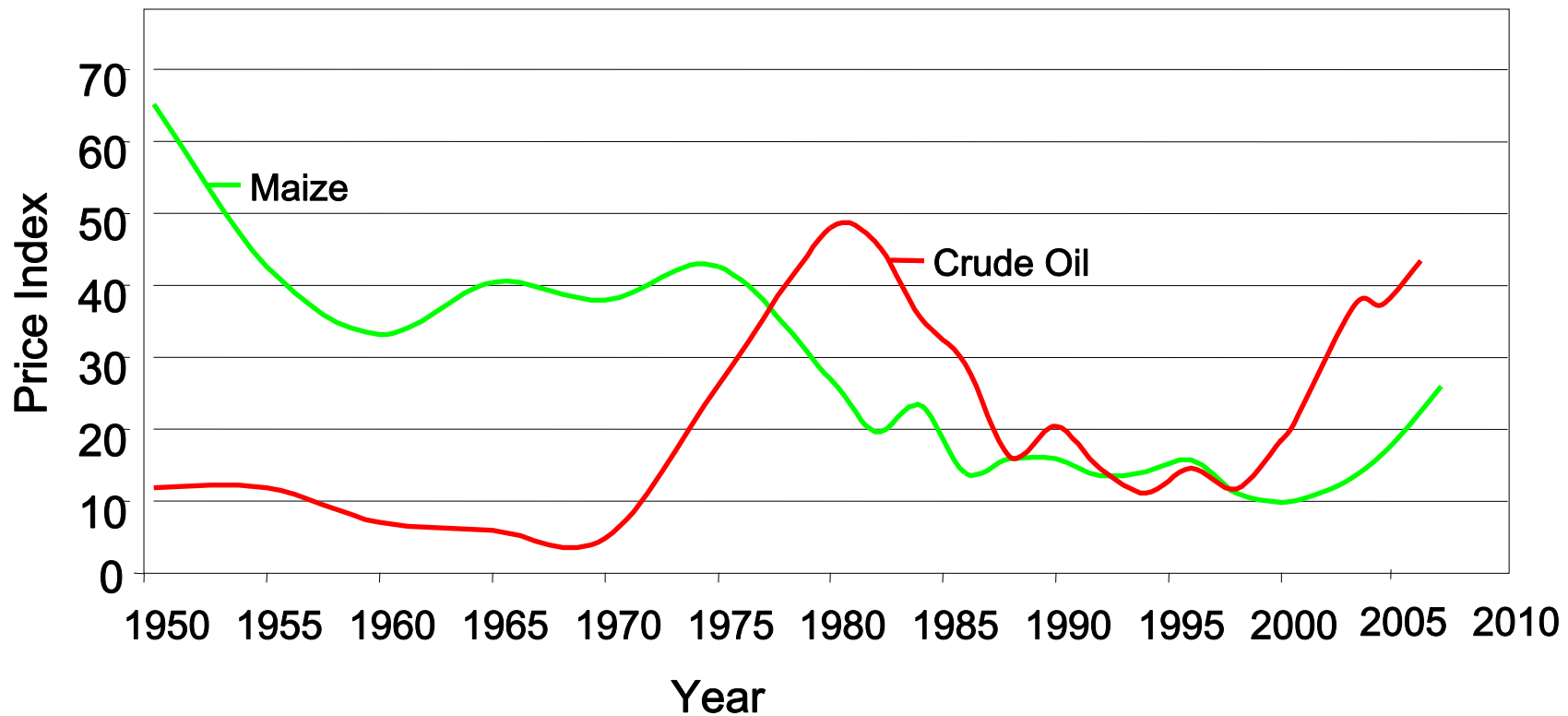
## Price of oil

Raw material costs for chemicals driven by consumption for 'energy'

Oil crisis of 1970s starting point for many companies

– also current oil price major driver to investigate alternatives

# World Price Trends 1950-2010

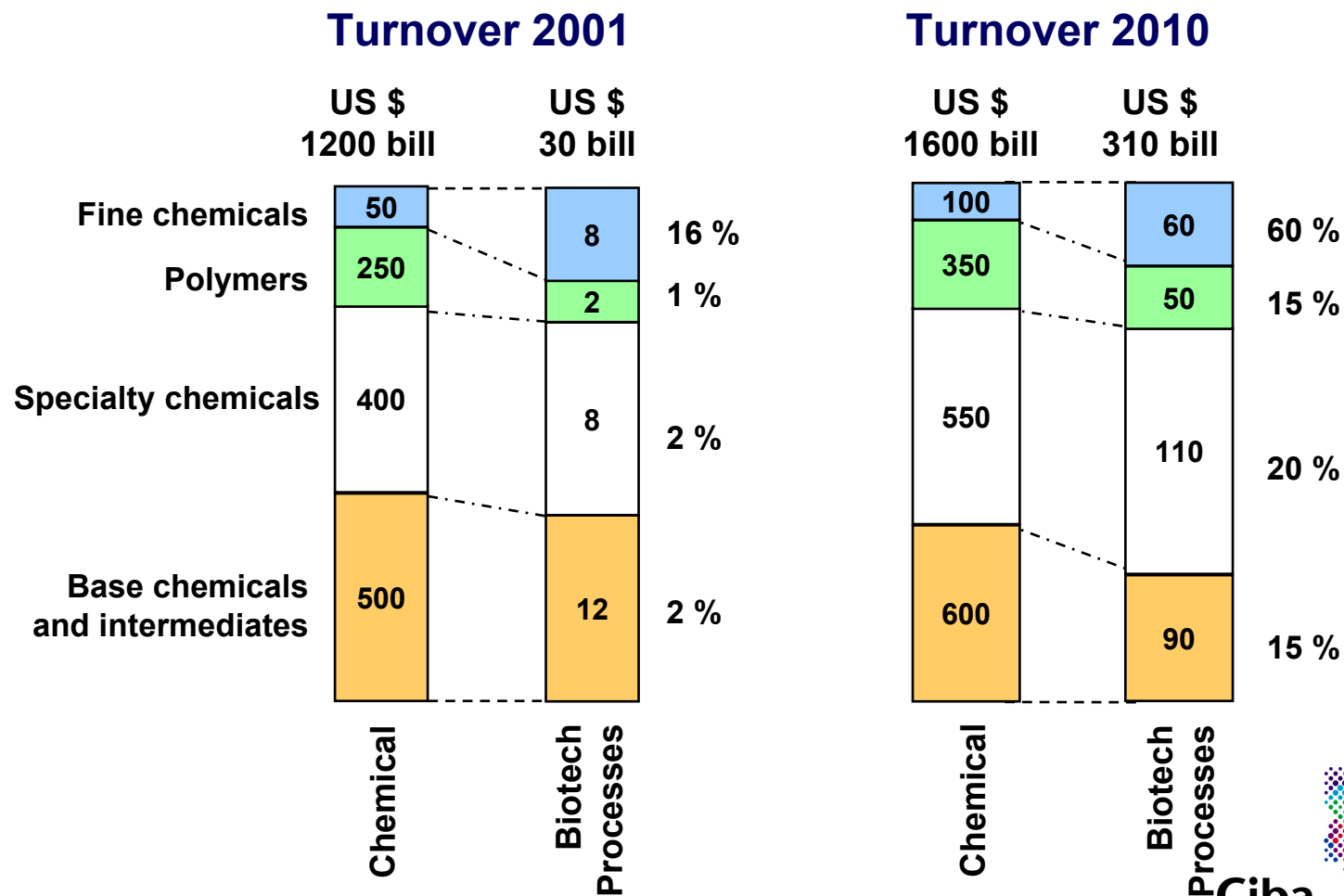


Historically new uses for agricultural crops needed – not any more!



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# Chemical v Biotech Processes



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*Festel Capital (2004)*

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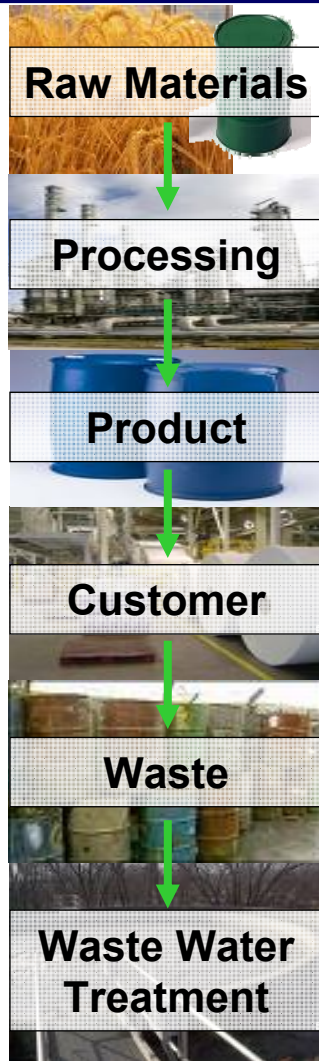
# Success Criteria

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## For use of bio-based products and processes

- Improve profitability or lower cost
- Cost effective
- Equal or better technical performance than existing product
- Must not generate any more waste/toxic by-products

# The Supply Chain



## What can bio contribute?

- Alternative feedstocks
- Biocatalysis
- Unique properties of bio-products for existing and new applications
- Biodegradability
- Bioremediation



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# The Ciba Green Approach

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**Consideration of trends and drivers for bio-based products**

**Audit of Company experience and history in this field**

**Survey of relevant chemistry & technology available**

**Generation of a series of project options**

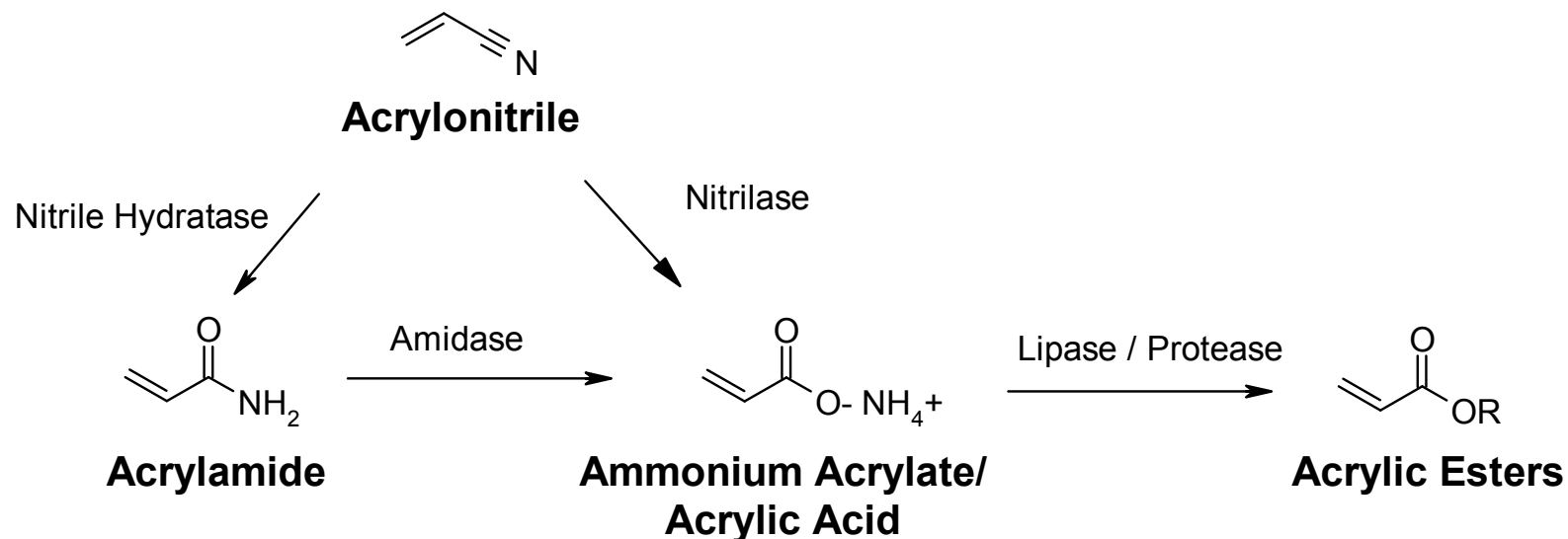
**Recommendations for future R&D activities**



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# Production of Acrylic Monomers

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## Acrylamide

Commodity chemical for water soluble polymers  
Global capacity >500,000 tonnes/annum

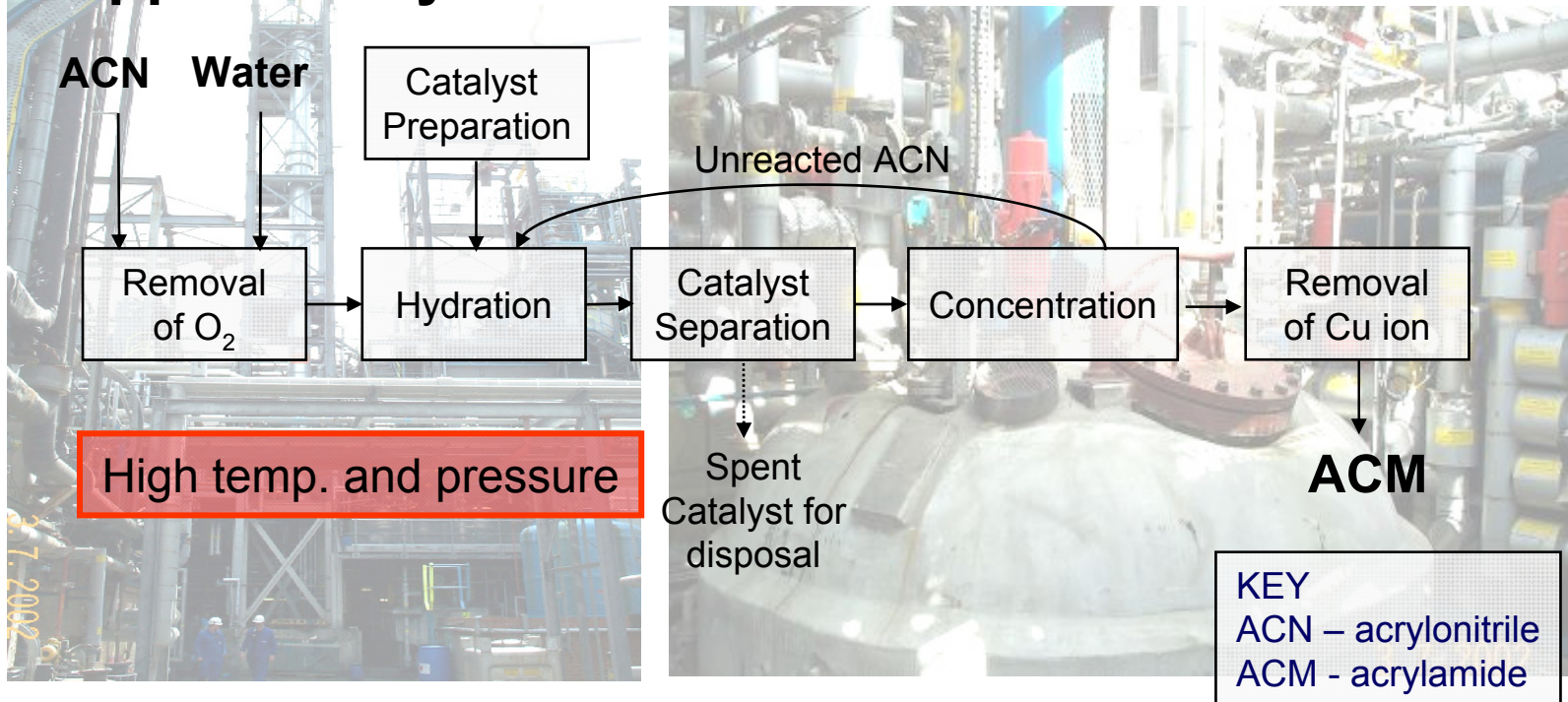
## Acrylic Acid

World production : ~4 million t/a  
Used for superabsorbents, resins, coatings, acrylic esters



# Current Technology - Acrylamide

## Copper Catalyst Process

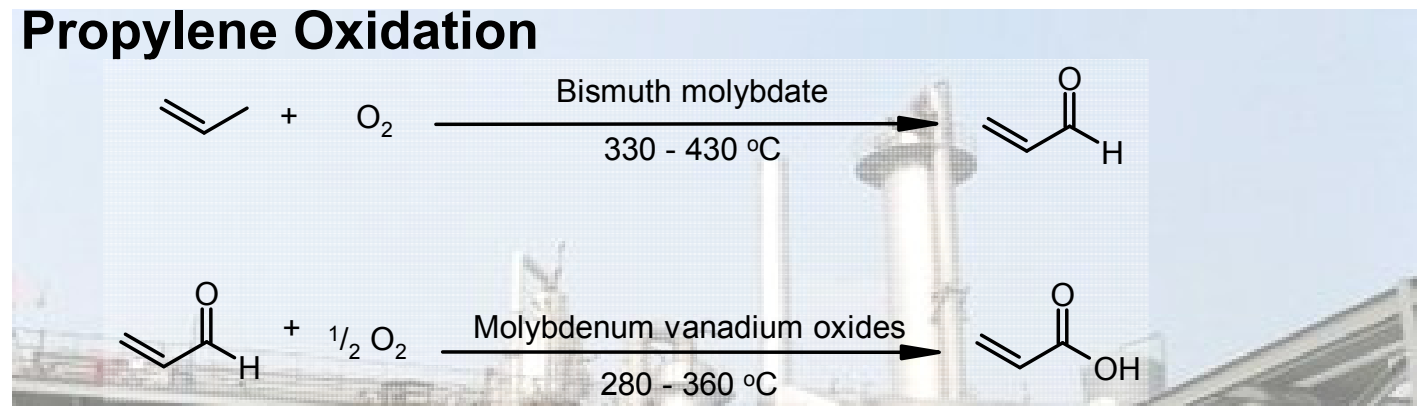


- uses specific grade of acrylonitrile
- most of process is separation of reactants

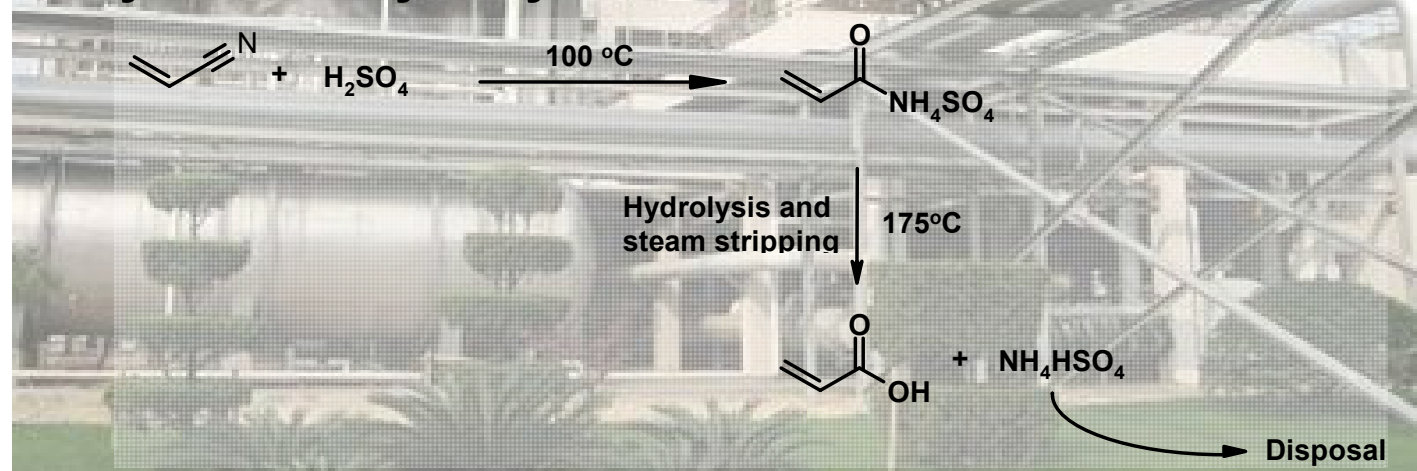


# Current Technology - Acrylic Acid

## Propylene Oxidation



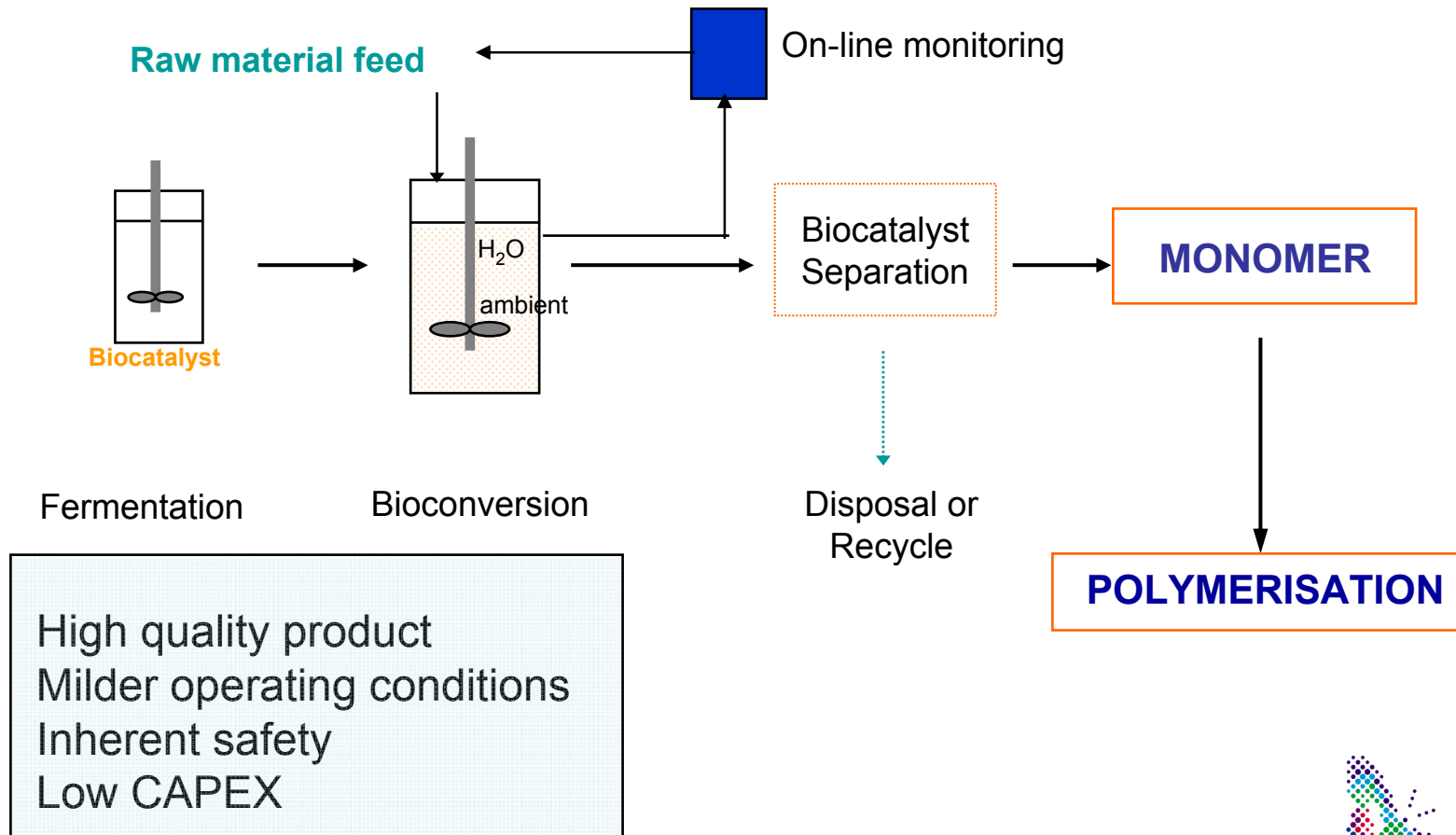
## Acrylonitrile Hydrolysis



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# Bio- Acrylamide Process



# Acrylamide Evaluation: Monomer Impurities

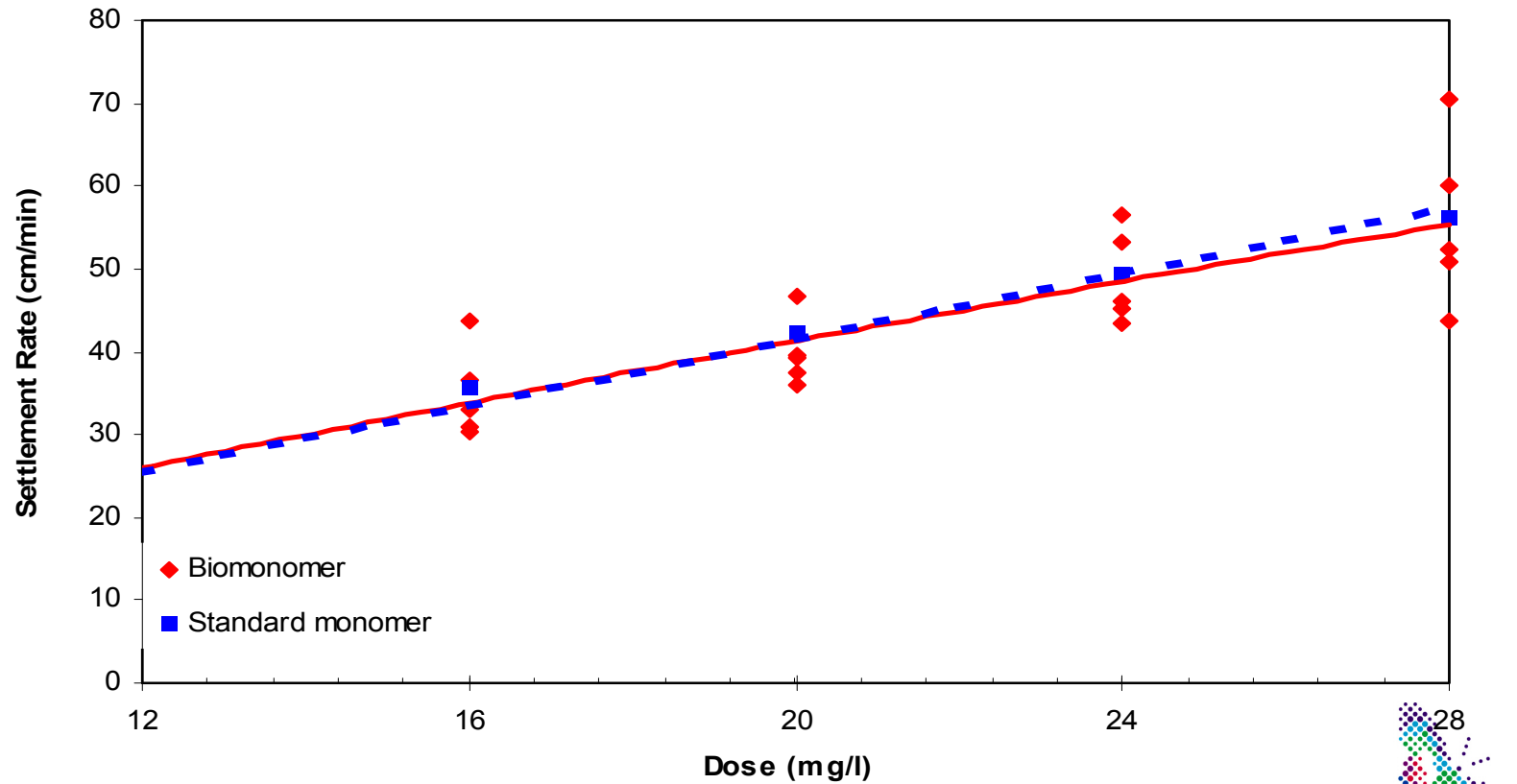
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By-product	Biocatalysed (ppm)	Cu catalysed (ppm)
1	nd (<2 )	400
2	nd (<5 )	7
3	nd (<50 )	228
4	nd (<50 )	554
5	nd (<10 )	42
6	<20	46
7	80	24
8	446	110
9	nd	150



# Product Evaluation

## Performance Evaluation of Polymer



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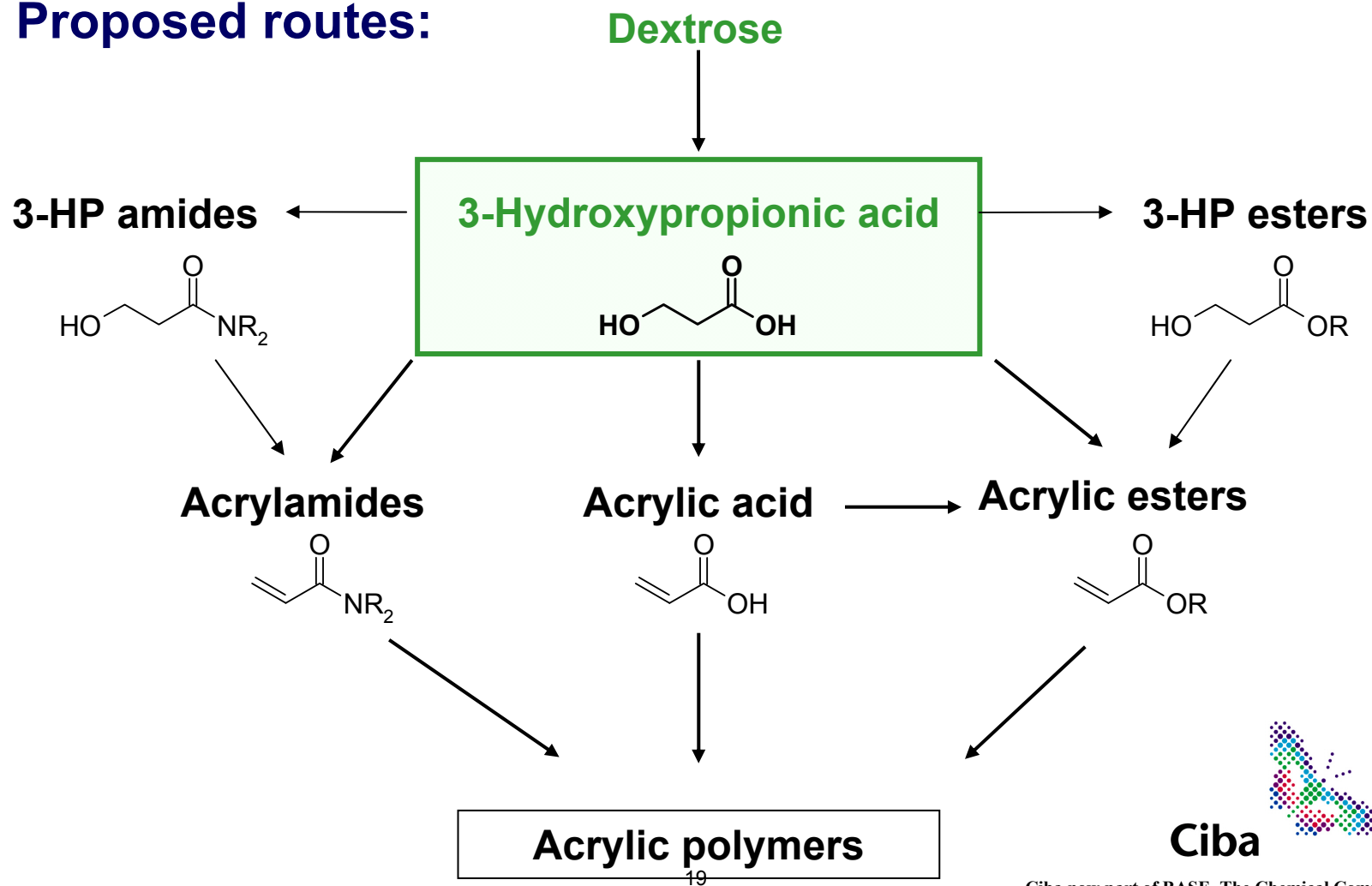
# Bio-Acrylamide: Advantages

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- Fundamentally simple
- Cost effective and scaleable
- Highly selective, environmentally benign catalyst
- Mild process conditions
- Low acrylonitrile concentration-greatly reduced hazard
- Robust process
- Little or no downstream processing

# Acrylic Monomers from 3-Hydroxypropionic Acid

Proposed routes:

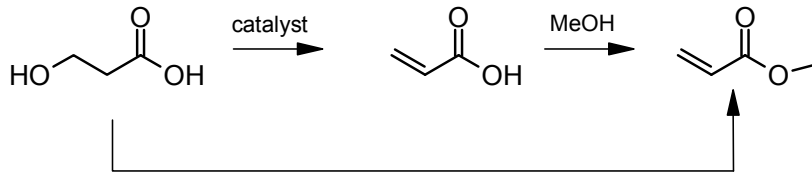


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# Monomers from 3-Hydroxypropionic Acid

Acrylic acid > 98%

## Acrylic esters



Simultaneous dehydration and esterification

>90% yield

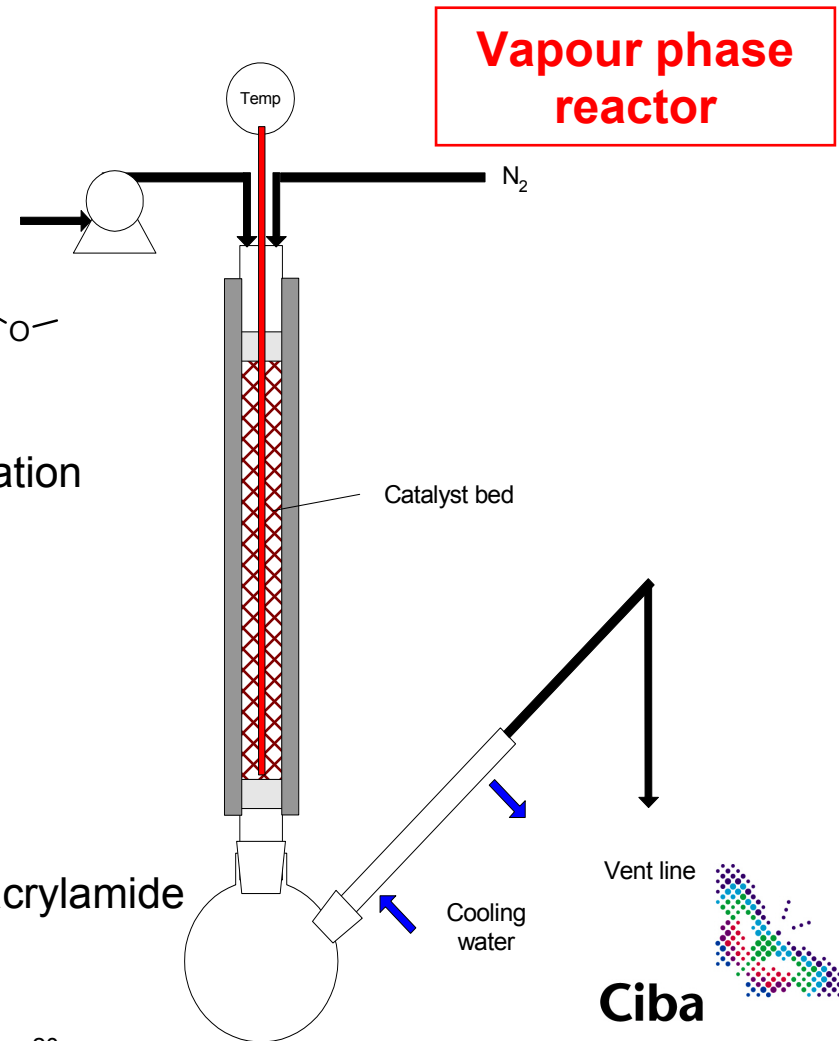
- Need for lower temperature reactions

## Substituted Acrylamides

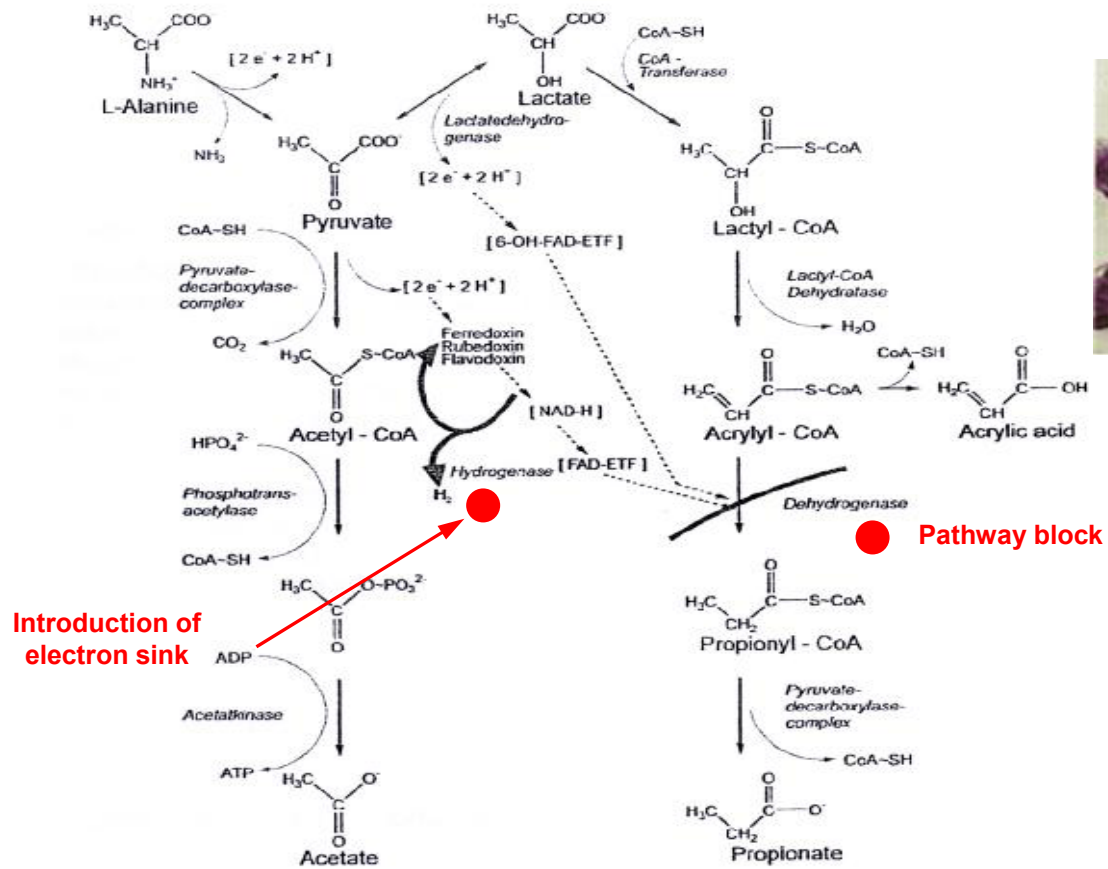
Neutralisation of 3HP with amine

Up to 80% conversion to *N,N*-dimethylacrylamide

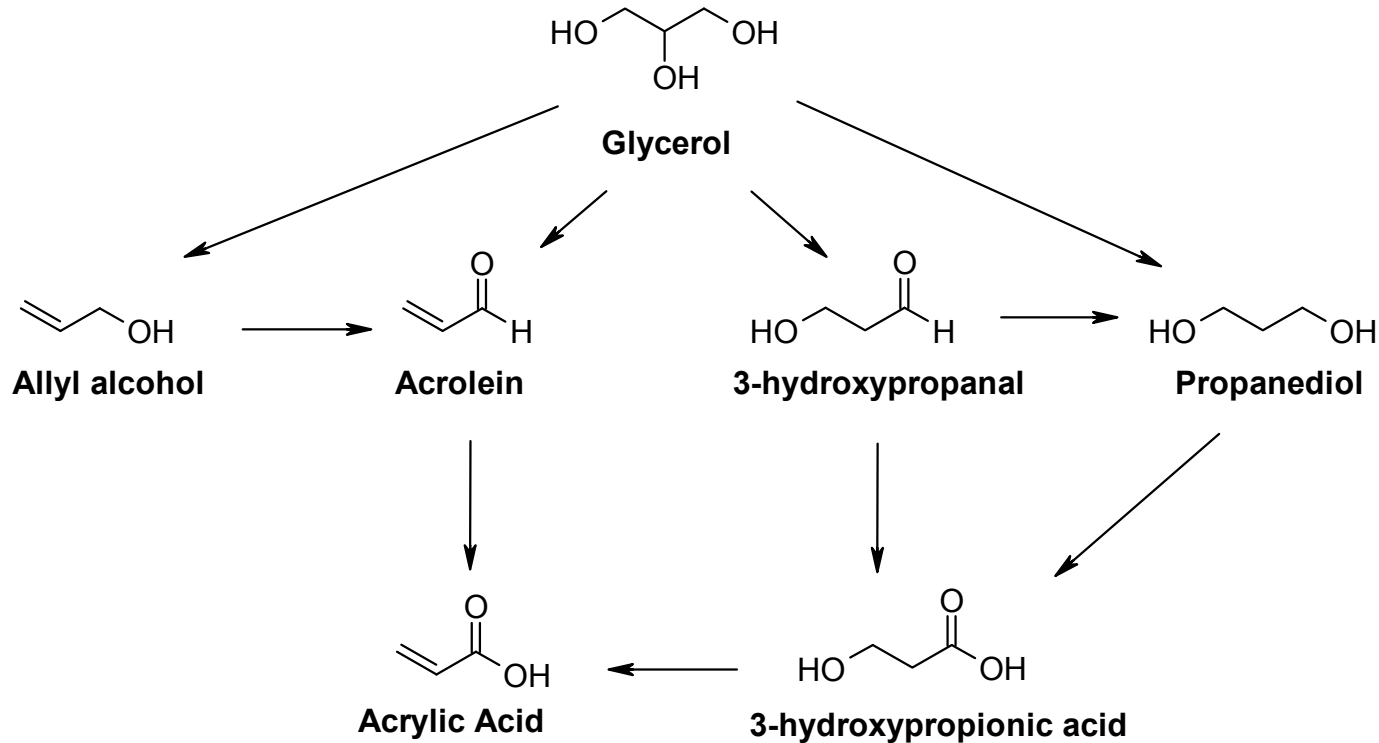
Other acrylamides prepared



# Acrylic Acid by Fermentation



# Acrylic Monomers from Glycerol



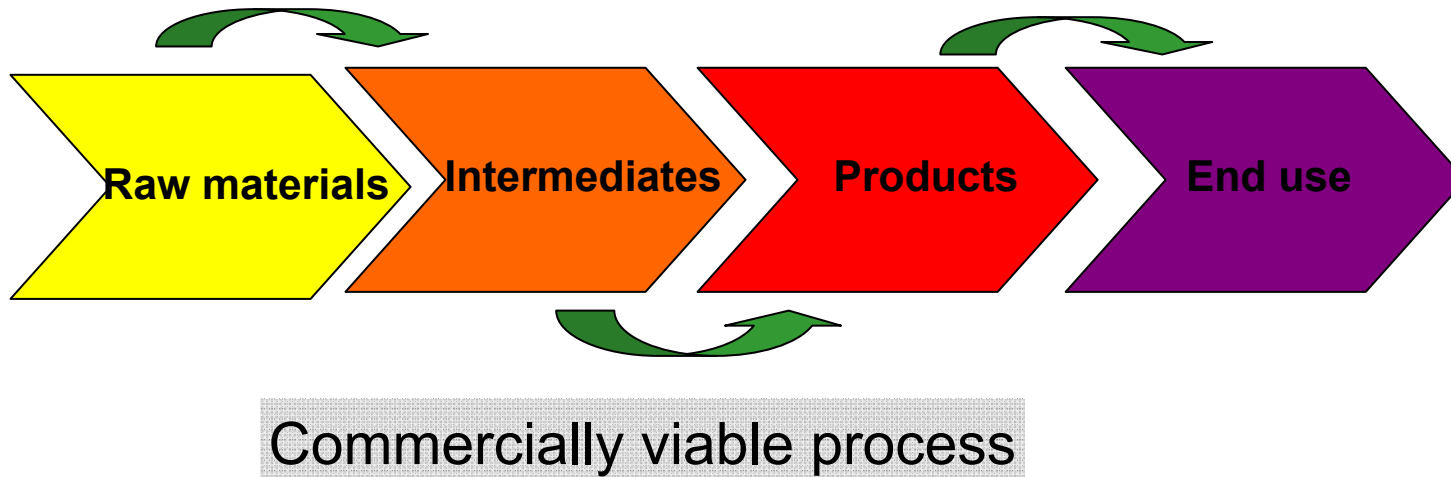
Mostly high temperature / pressure, catalytic reactions

Renewable starting material has no advantage unless cost is low



# Concluding Remarks

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We must align the technology to market needs

We need to develop cost-effective processes to be successful

We need to prepare for the future

A bio-based economy is a reality but it won't be applicable for everything