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## Welcome

# Development of AMI Melamine Technology

Low pressure versus High pressure

# Agenda

- History
- Chemistry
- Overview on Melamine Process
- AMI Melamine Processes

# History 1/2

- Melamine was first described by Liebig in 1834
- Approx. 100 years later the condensation with formaldehyde as an important application was discovered
- 1943 American Cyanamid Co discovered that Melamine could be obtained by thermal decomposition of urea
- Until 1960 Melamine was manufactured from dicyandiamide in autoclaves in batch processes

# History 2/2

- 1960 Allied Chemical operated first urea-based high pressure melamine plant (license from American Cyanamid)
- During same period Nissan Chemical and Montedison developed their own high pressure process
- Between 1960 and 1965 BASF, DSM/Stamicarbon and AMI*) developed their own low pressure technology
- 1990 AMI bought the Montedison process and developed the high pressure technology further (mid 1990's).
- Today both types, high and low pressure processes, are worldwide in operation

*) at that time Österreichische Stickstoffwerke, later Chemie Linz

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# Chemistry

Urea decomposition:

$$6\ (NH_2)_2\ CO \Leftrightarrow 6\ HNCO + 6\ NH_3 \qquad \Delta H > 0$$

Urea — Isocyanic Acid + Ammonia

Melamine formation:

$$6\ HNCO \Leftrightarrow C_3N_3\ (NH_2)_3 + 3\ CO_2 \qquad \Delta H < 0$$

Isocyanic Acid — Melamine + Carbon Dioxide

**Overall:**

$$6\ (NH_2)_2\ CO \Leftrightarrow C_3N_3\ (NH_2)_3 + 6\ NH_3 + 3\ CO_2 \qquad \Delta H > 0$$

**Urea — Melamine + Ammonia + Carbon Dioxide**

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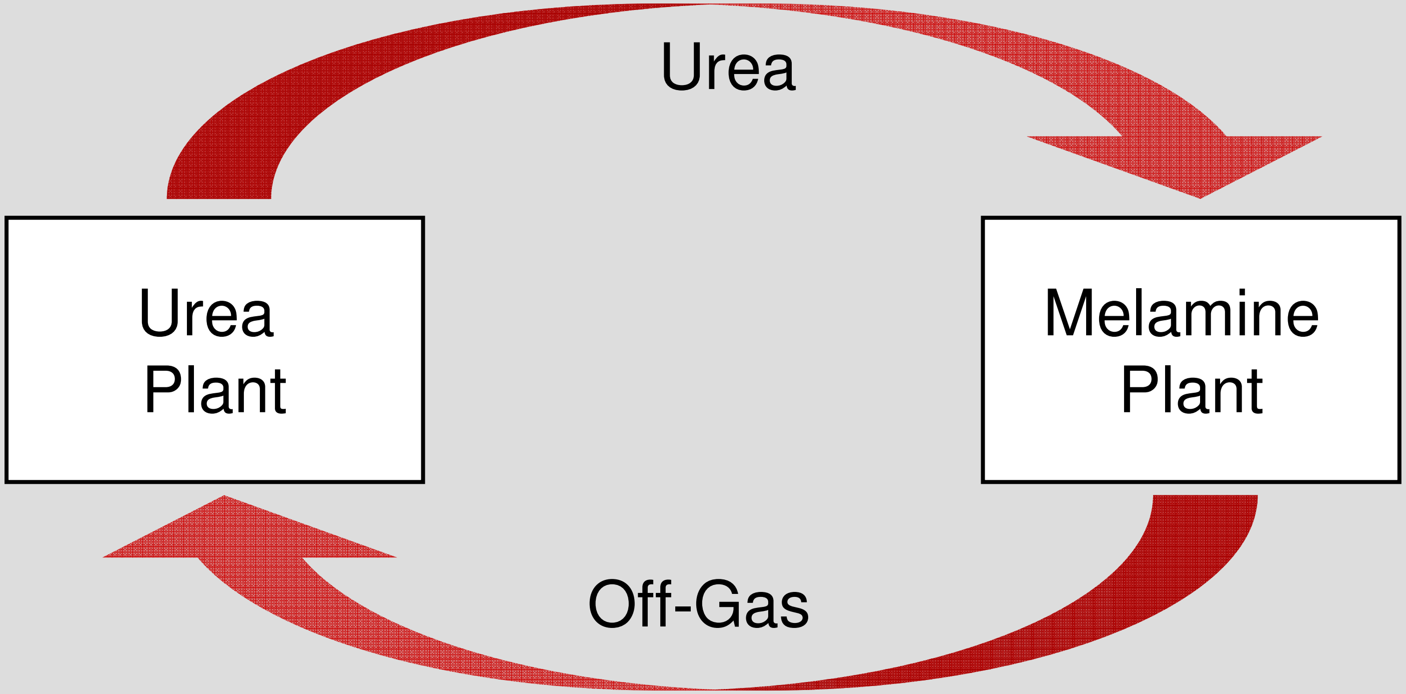
# Arrangement Urea – Melamine Plant

Today all industrial processes use Urea as feedstock




Off-Gas recycle to Urea Plant for efficient feedstock use

# Process Basics

## High Pressure Synthesis

- Synthesis Conditions:

  370 - 400 °C

  80 - 150 bar

- No catalyst required
- Reaction in Liquid Phase

## Low Pressure Synthesis

- Synthesis Conditions:

  370 - 400 °C

  1 - 7 bar

- Catalyst required
- Reaction in Fluidized/Fixed Bed

# Competing Technologies in Melamine Recovery

## High Pressure

***Aqueous Recovery***

- **AMI Agrolinz**
- Nissan
- Eurotechnica [1)]

***Dry Recovery***

- DSM (SLP) [2)]

## Low Pressure

***Aqueous Recovery***

- **AMI Agrolinz**
- DSM / Stamicarbon

***Dry Recovery***

- BASF
- LURGI/Tsingda Huaye

1) Formerly Allied Chemicals
2) Formerly MCI (Melamine Chemicals)

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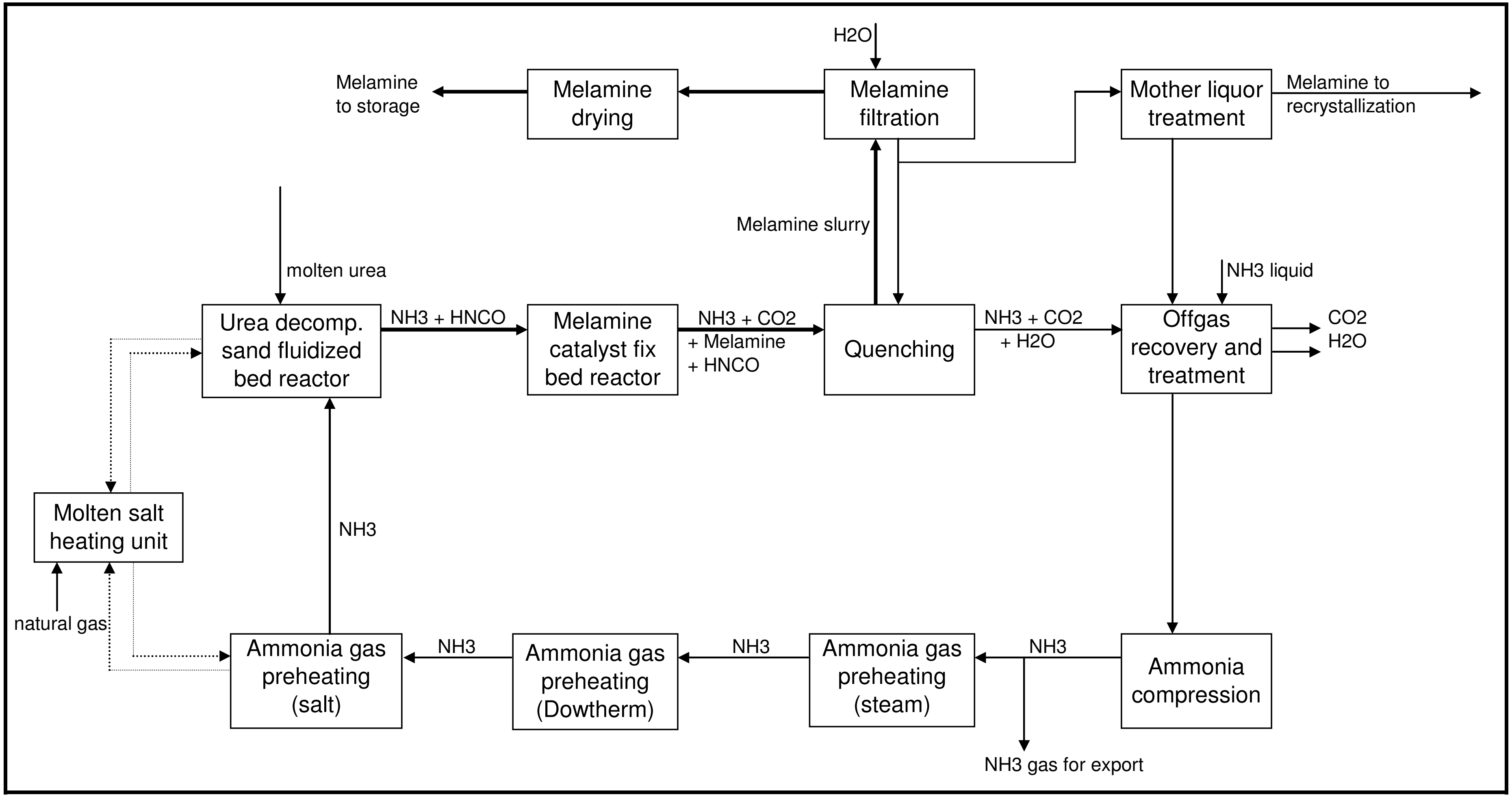
# AMI LP-Process 1/2

- Two stage, low pressure, vapour phase, catalytic process
- Decomposition of Urea and synthesis of Melamine in separate reactors
- Melamine will be recovered from reactor effluent by quenching with mother liquor
- Removal of unreacted urea by thermal treatment of mother liquor and re-crystallization of the Melamine obtained in this process
- Product purity > 99,8 %
- Off-gas treatment is integral part of the plant; $NH_3$ and $CO_2$ are obtained as pure gases
- By-product Guanidin Carbonate (approx. 3%)

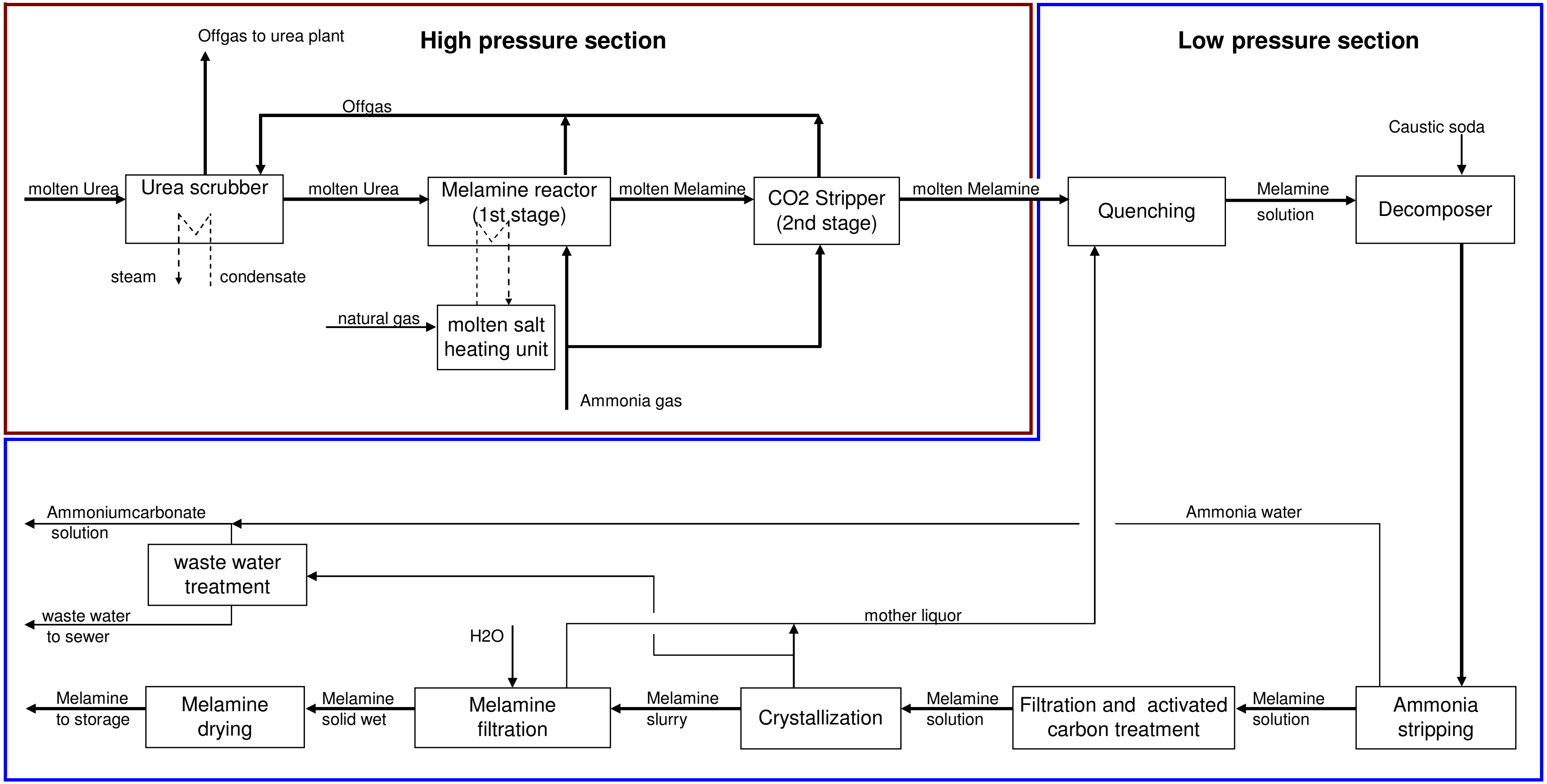
# AMI LP-Process 2/2



# AMI HP-Process 1/2

- Two stage, high pressure, liquid phase, non-catalytic process
- Urea scrubber for off-gas treatment; off-gas is dry and has same pressure as reactor
- Melamine recovered from reactor effluent (2nd stage) by quenching with mother liquor and process condensate
- Purification by decomposition of poly-condensated by-products with caustic soda
- Treatment with activated carbon before crystallization
- Product purity: > 99,8 %
- Off-gas can be condensed without additional water in an Urea plant

# AMI HP-Process 2/2



# AMI steps in HP-Technology

- 1990: Acquisition of Montedison process and Castellanza (I) site
- 1990's: Laboratory tests in Linz (A) and Castellanza
- 1996/97: Pilot plant in Castellanza
- 2000: Start-up of 30,000 mtpa production plant in Linz
- 2001: Start-up of 30,000 mtpa production plant in Castellanza
- 2004: Start-up of 80,000 mtpa production plant in Piesteritz (D)
- 2006: Process design for 80,000 mtpa production plant in Ruwais (UAE)

# Lates Improvements in AMI HP-Process

- Urea scrubber for off-gas treatment
  => dry off-gas at p> 80 bar can be condensed and fed to the reactor of an Urea plant
- Quantitative removal of $CO_2$ from melamine melt
  => no $CO_2$ entering in LP-section
- Less by-products in melamine melt
  => higher yield on urea
- Lower temperature and pressure required for by-products degradation in LP-section
- Reduction of specific urea consumption
- Reduction of specific steam and cooling water consumption

# AMI LP- / HP-Process

## LP-Process

- High gas volumina
- Catalyst
- High energy demand for separation of off-gas
- High energy demand for compression and recompression of ammonia/carbon dioxide
- Off-spec product in start-up-phase (catalyst fines)

## HP-Process

- No gas circulation
- Off-gas condensation produces energy
- Product is recrystallized
- Thermal degradation of by-products
- Recycling of ammonia carbonate solution to urea plant
- On-spec product shotly after start-up

# Consumption figures Melamine-Processes

| Item | Unit *1) | AMI-HP | AMI-LP | Other-HP | Other-LP |
|---|---|---|---|---|---|
| Urea Melt | t | 3,10 | 3,25 | 3.00 - 3.26 | 3.01 - 3.10 |
| Ammonia | t | 0,2 | 0,3 | 0.6 - 0.7 | 0.2 - 0.5 |
| catalyst | kg | - | 1,5 | - | 3 - 6 |
| Caustic Soda | kg | 100 | - | - | - |
| el. Power | kWh | 300 | 880 | 490 - 530 | 500 - 1250 |
| Steam | t | 2,2 | 8,7 | 0.7 - 10.0 | 0.8 - 7.4 |
| Cooling Water | $m^3$ | 180 | 500 | 40 - 900 | 20 - 700 |
| Fuel Gas | GJ | 6,8 | 11,9 | 7.0 - 7.5 | 9.7 - 15.8 |

*1) per metric ton melamine

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Thank you

for your

attention!