

**Uhde GmbH**

Division Edeleanu Refining Technologies



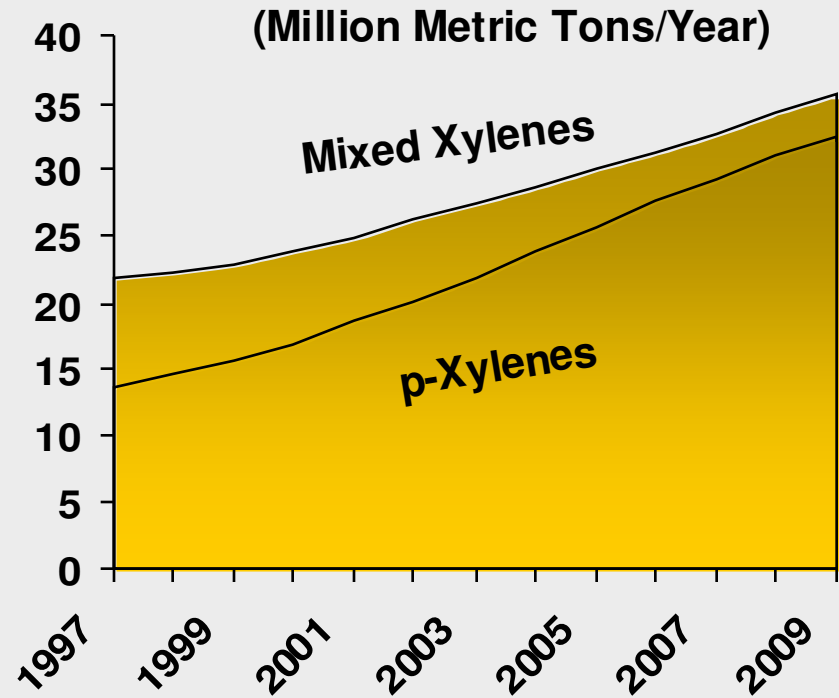
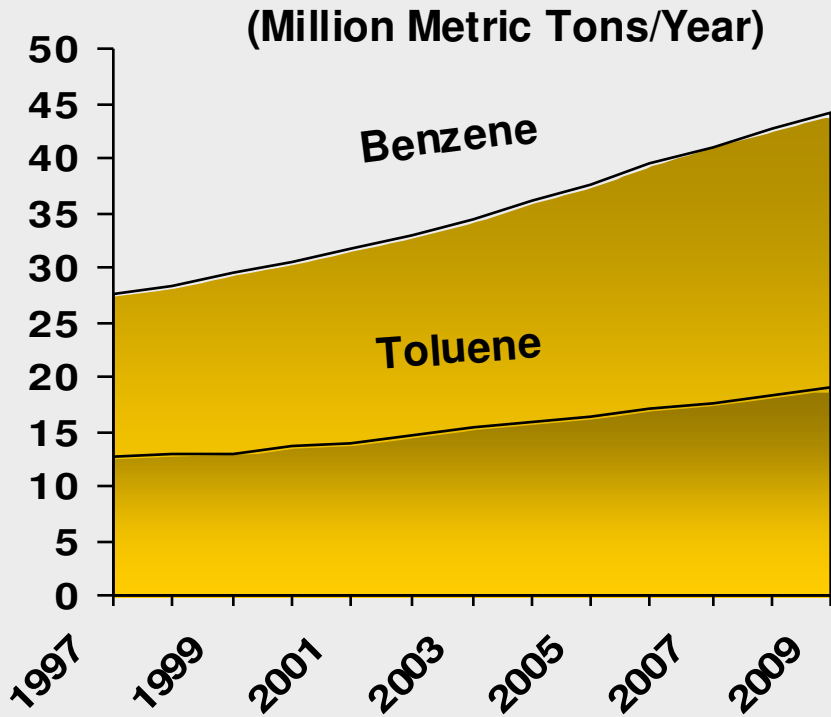
# Pure Aromatics Recovery from Coke Oven Light Oil (COLO)

**Dorothe Weimer**

6th Petchem Feedstock Asia/China Markets Conference,  
May 2007, Shenzhen, China

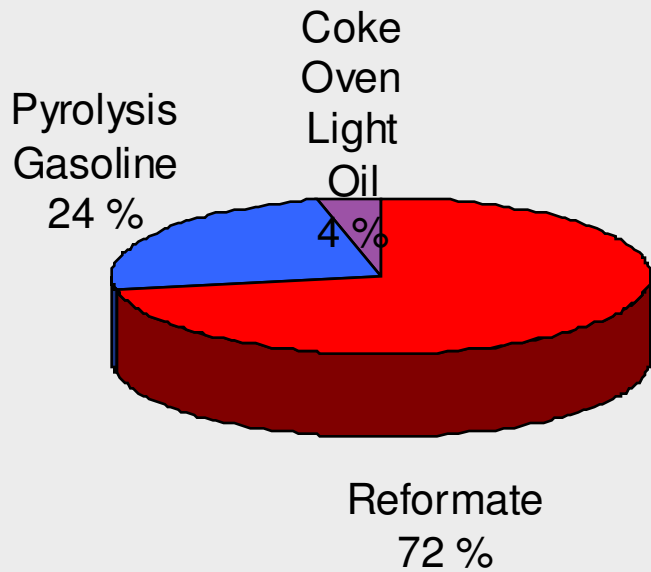
# Aromatics

## World aromatics demand

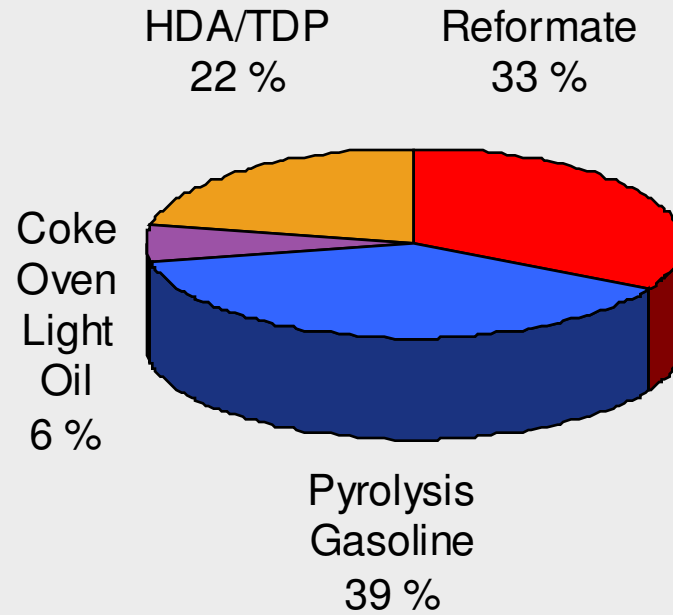


# AROMATICS

## Aromatics Supply by Sources



World aromatics supply by source



World benzene supply by source

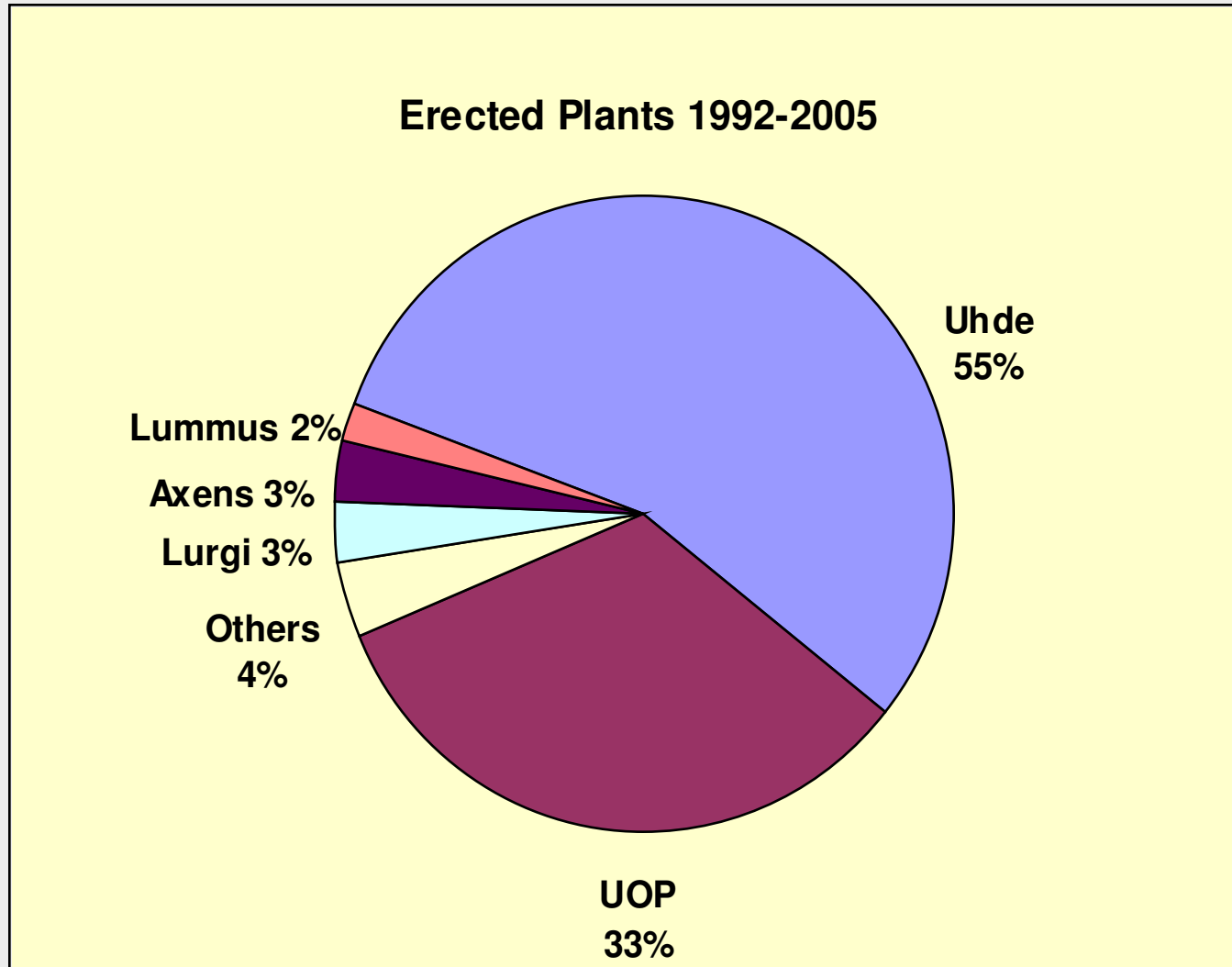
# Aromatics

## Feedstocks for Aromatics Recovery

%	Hydrotreated coke oven light oil	Hydrotreated pyrolysis gasoline	Reformate
Benzene	65	40	3
Toluene	18	20	13
Xylenes	6	4	18
Ethylbenzene	2	3	5
Higher aromatics	7	3	16
Total aromatics	98	70	55
Non aromatics	2	30	45
	100	100	100

# Aromatics

## Uhde's Market Share



**Uhde GmbH**

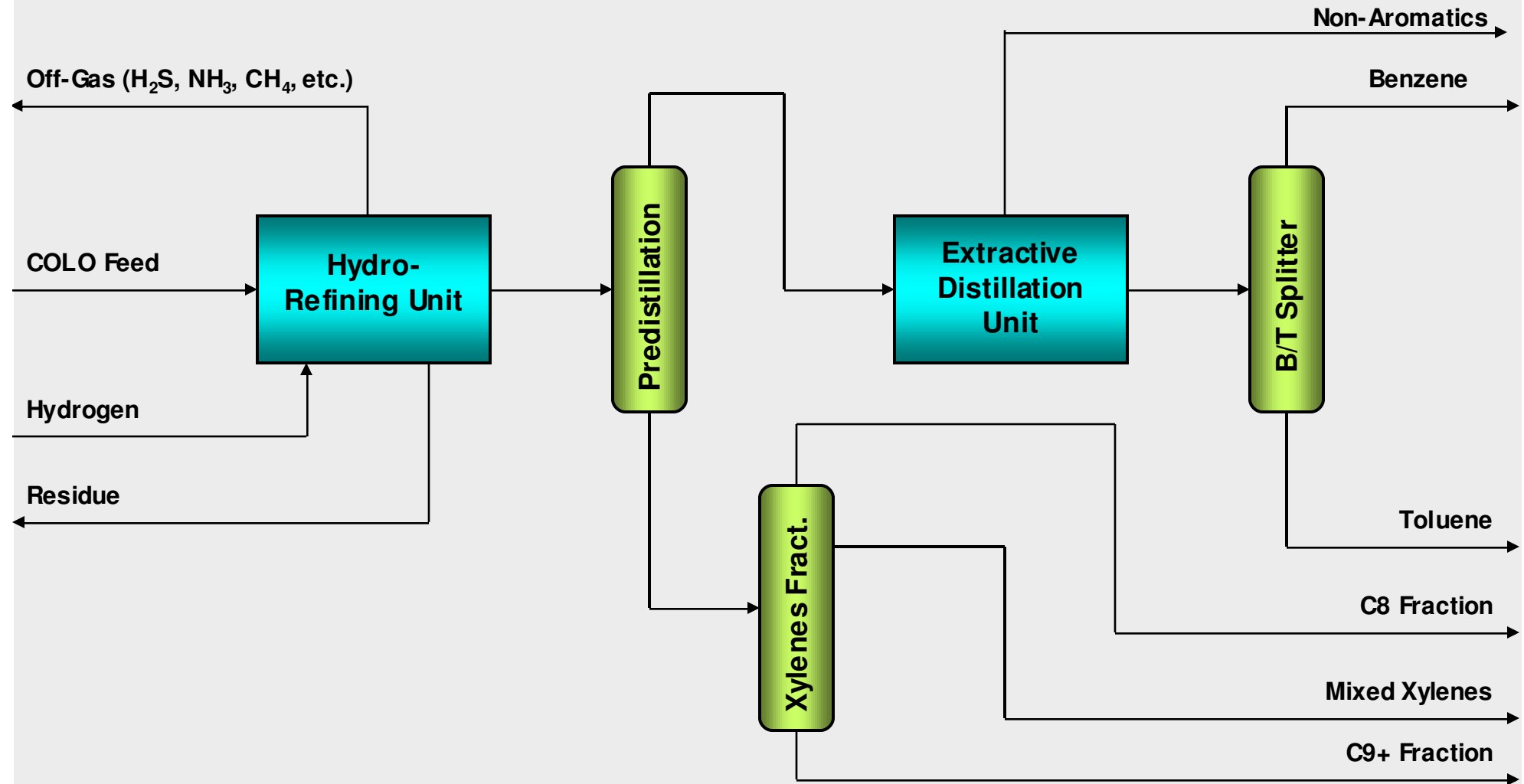
Division Edeleanu Refining Technologies



# Pure Aromatics Recovery from Coke Oven Light Oil (COLO)

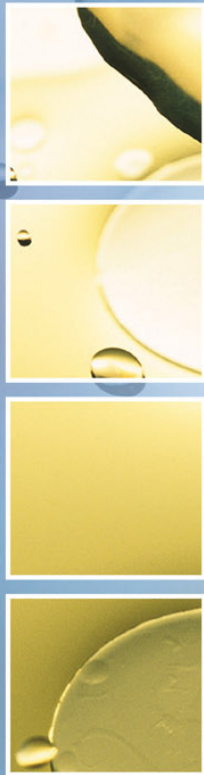
# Aromatics

## Aromatics Recovery from Coke Oven Light Oil (COLO)



**Uhde GmbH**

Division Edeleanu Refining Technologies

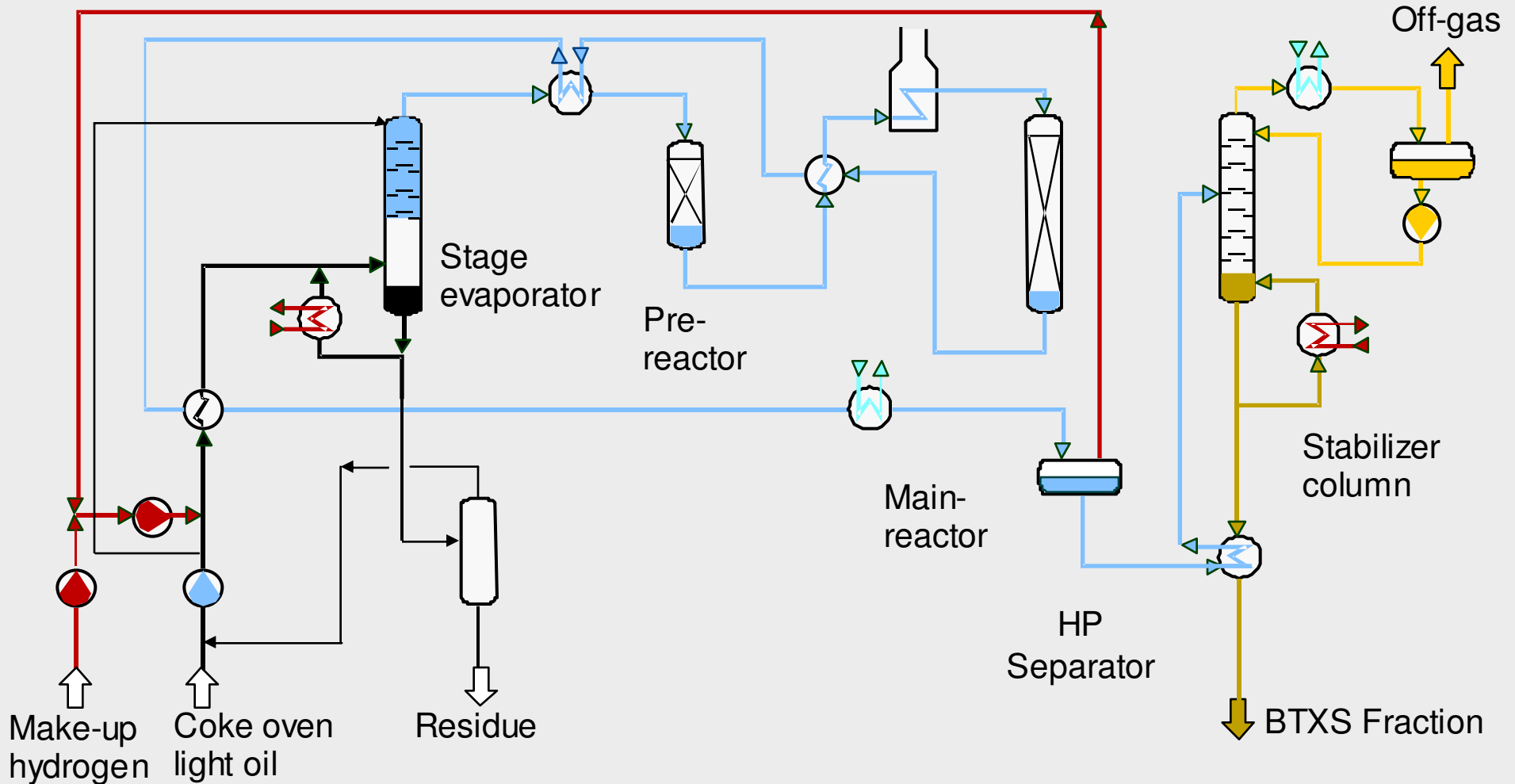


# Hydrorefining of Coke Oven Light Oil (COLO)



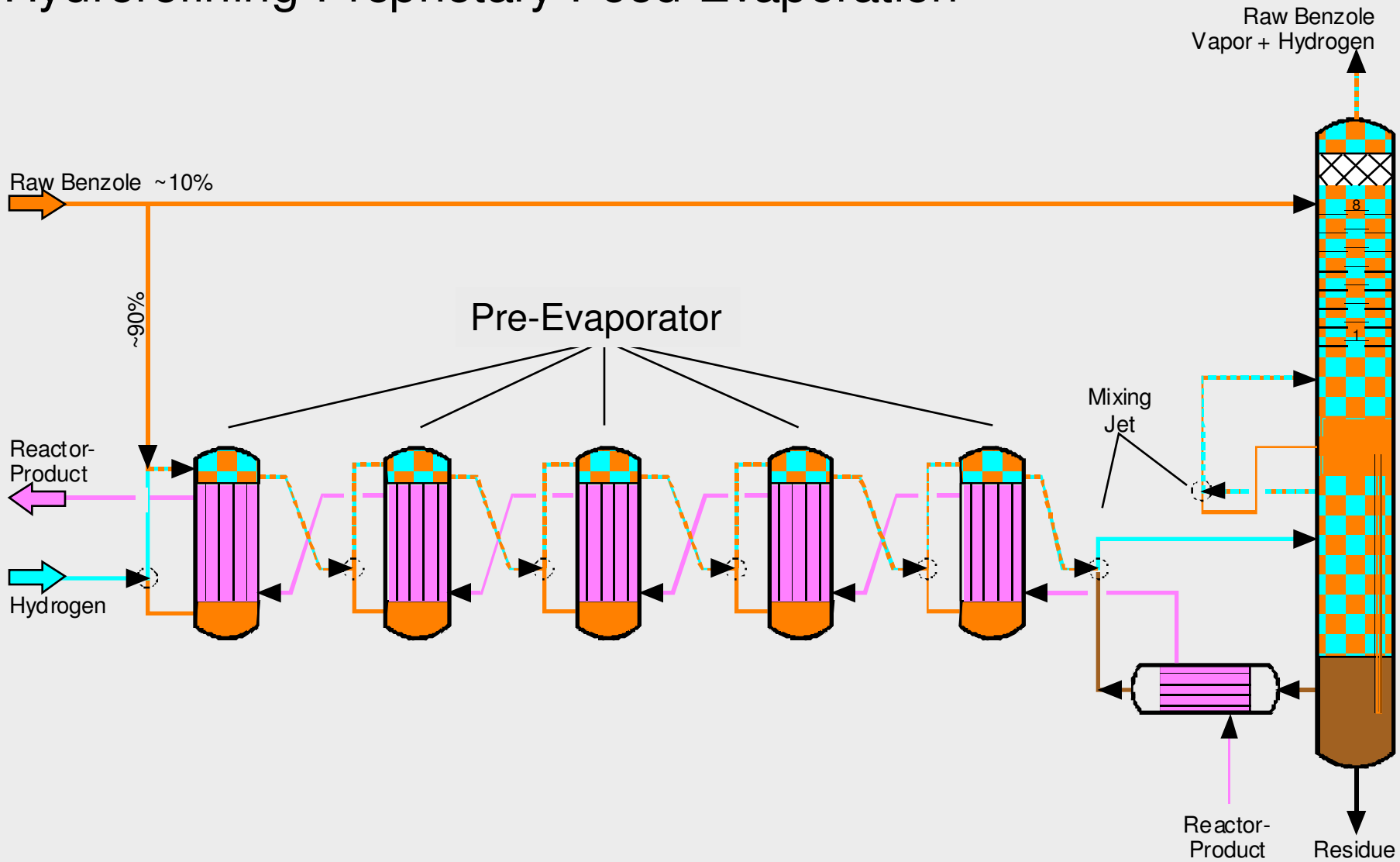
# Hydrotreating

## Hydrorefining of Coke Oven Light Oil



# Hydrotreating

## Hydrorefining Proprietary Feed Evaporation



# Hydrotreating

## BASF Hydrorefining Catalyst

### **M8 - 21 S3**

**Application:** Mainly pre-treatment, i.e. hydrogenation of unsaturated compounds (diolefins, styrene) of cuts rich in aromatic compounds originated from coke oven processes

**Composition:** NiO / MoO<sub>3</sub> on alumina oxide carrier

**Form / Size:** Extrudates, approx. 3 mm diameter

**Bulk Density:** approx. 750 kg/m<sup>3</sup>

### **M8 - 12 S3**

**Application:** Mainly hydro-refining, i.e. desulphurization, denitrification and olefin saturation of aromatic rich cuts from coke oven processes

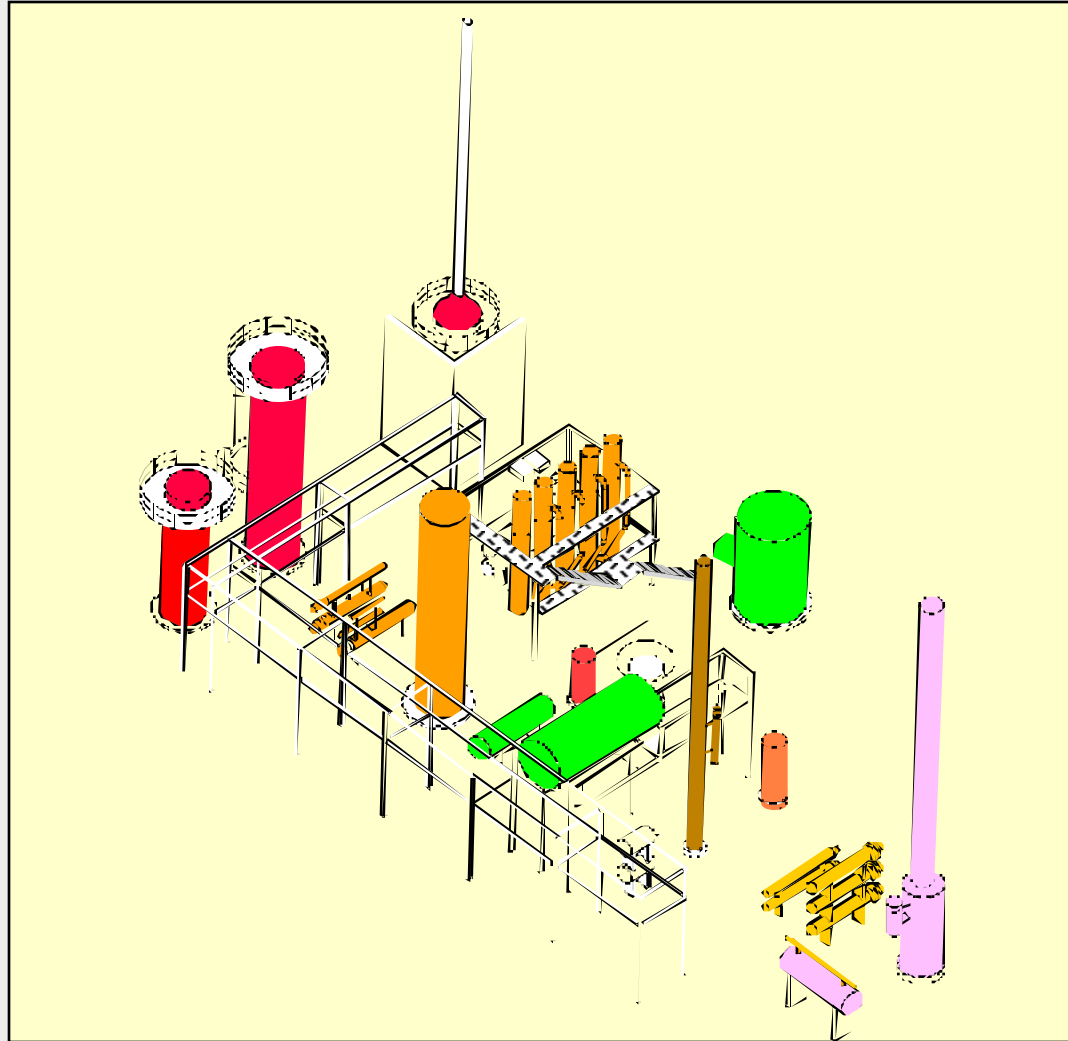
**Composition:** CoO / MoO<sub>3</sub> on alumina oxide carrier

**Form / Size:** Extrudates, approx. 3 mm diameter

**Bulk Density:** approx. 700 kg/m<sup>3</sup>

# Hydrotreating

## Hydrorefining Typical Plot Arrangement



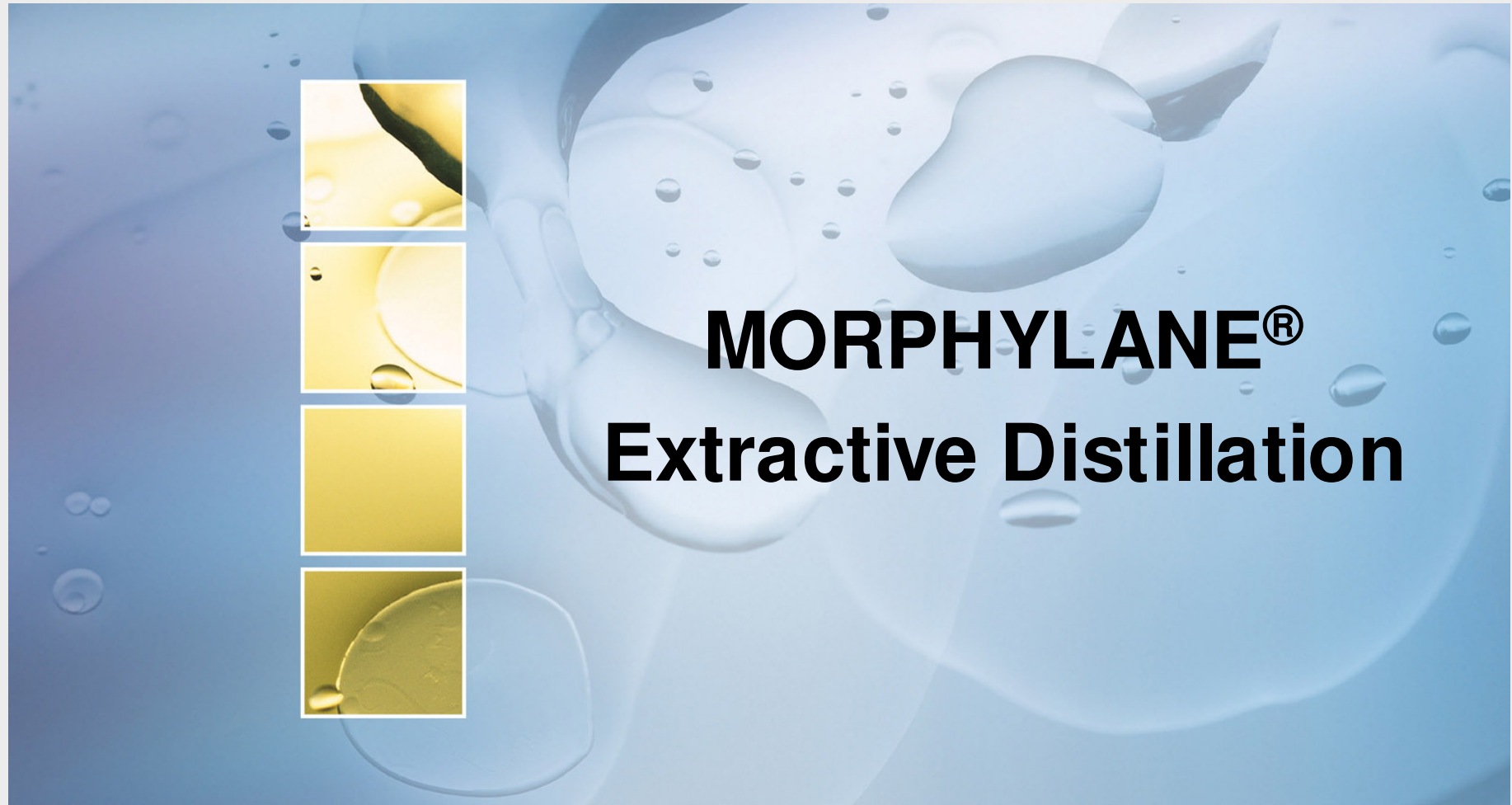
## Aromatics

### Hydrotreating: Summary of process features

- High quality, desulfurized products BTX and C9
- Simple plant arrangement at minimum space
- High on-stream time due to good operability
- No additional chemicals needed (anti polymer, anti corrosion, anti foam)
- Limited utilities (e.g. no chilled water)
- Low investment and low operating costs

# Uhde GmbH

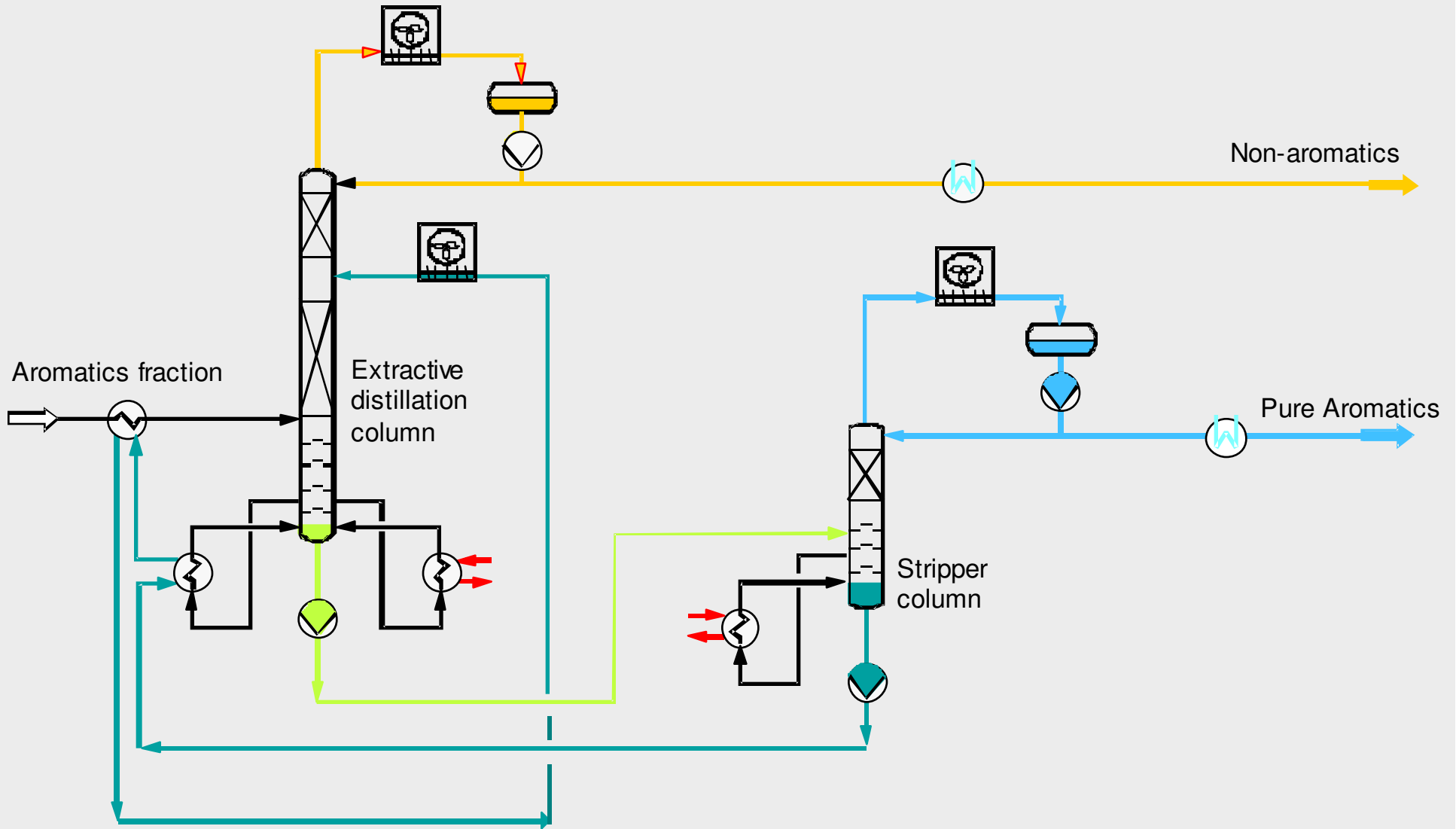
## Division Edeleanu Refining Technologies



# MORPHYLANE® Extractive Distillation

# Aromatics

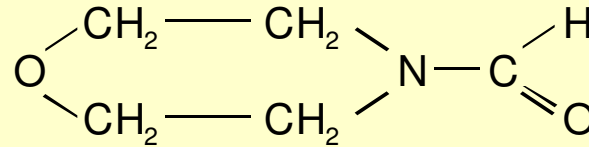
## MORPHYLANE Extractive Distillation



# Aromatics

## Properties of the MORPHYLANE Solvent NFM

N-Formylmorpholine  
 4-Formylmorpholine  
 4-Morpholinecarboxyaldehyde  
 Formylmorpholid



Structure

Spec. heat:

at 20 °C = 0.42 cal/g °C

at 50 °C = 0.44 cal/g °C

at 100 °C = 0.48 cal/g °C

at 150 °C = 0.53 cal/g °C

Vaporisation heat at Bp.

14.7 psi: 106 kcal/kg

Refractive index  $n_D^{25}$  : 1.484

Viscosity at 30 °C: 6.68 cP; 5.85 cSt

Mol. wt.: 115

Bp.: 243 °C at 14.7 psi

Melt point: 23 °C

Density at 20 °C: 1153 kg/m<sup>3</sup>

Flash point (Pensky-Martens): 125 °C

Ignition point: 370 °C

pH-Value when mixed with water 1:1 = 8.6

Miscible with benzene at any ratio

Miscible with water at any ratio

No azeotropes with C<sub>6</sub> - C<sub>9</sub> - hydrocarbons



# Aromatics

## Boiling Temperature at 1 bar

		Pure Component °C	15mol% Component + 85mol% Solvent °C
<b>Aromatics</b>			
Benzene	$C_6H_6$	80.15	135.46
Toluene	$C_7H_8$	110.64	160.70
<b>Naphthenes</b>			
Cyclohexane	$C_6H_{12}$	80.74	88.04
Methylcyclohexane	$C_7H_{14}$	100.95	107.51
Tr-1, 2 Dimethylcyclopentane	$C_7H_{14}$	91.85	98.60
Cis-1, 4 Dimethylcyclohexane	$C_8H_{16}$	124.33	130.27
<b>Paraffines</b>			
n-Heptane	$C_7H_{16}$	98.45	103.69
n-Octane	$C_8H_{18}$	125.65	132.46
2-Methylheptane	$C_8H_{18}$	117.65	124.48

## Aromatics

### MORPHYLANE Solvent Features

- High solvent selectivity and efficiency
- High thermal and chemical stability
- No corrosive effect
- No fouling and foaming effect
- Minimal solvent losses
- Negligible solvent regeneration expenditure
- No chemical agents required
- Low solvent inventory

# Aromatics

## MORPHYLANE Process Features (I)

- Low number of equipment, all carbon steel
- Simple plant arrangement at minimum space
- High on-stream time
- Proven technology for all feedstocks
- Highest aromatics purity and yield
- Low investment and low operating costs



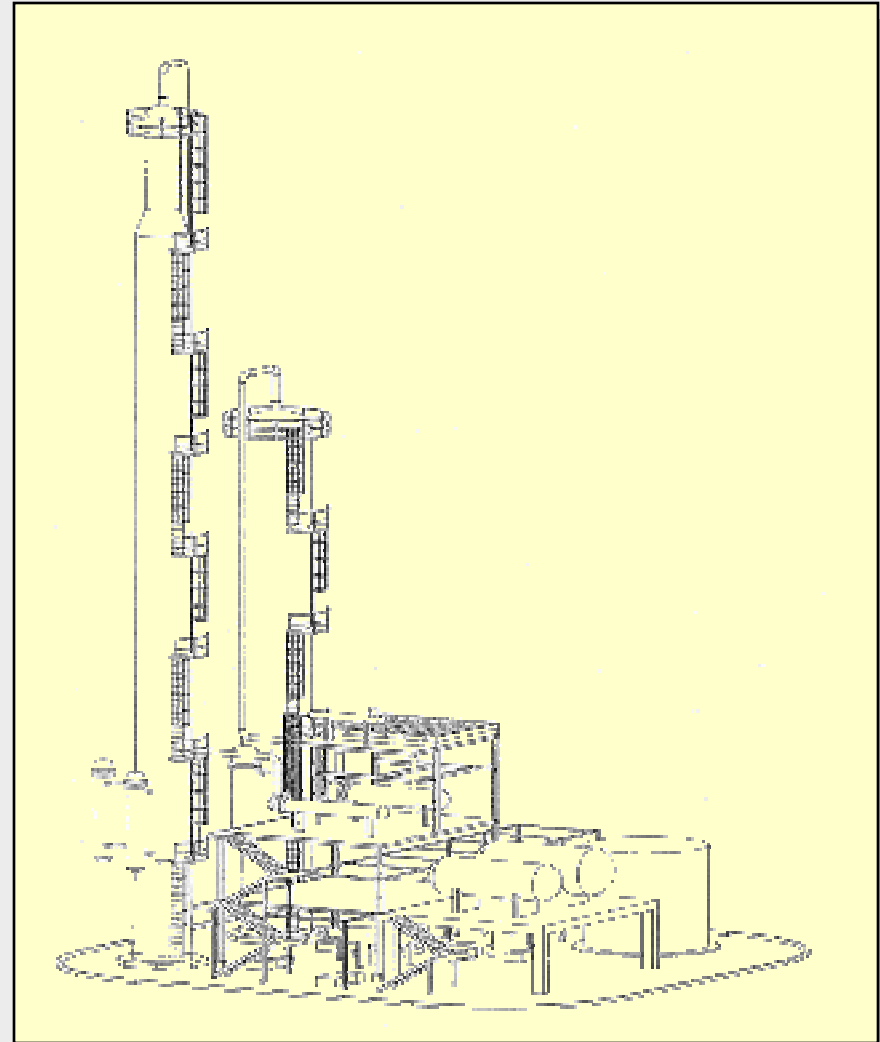
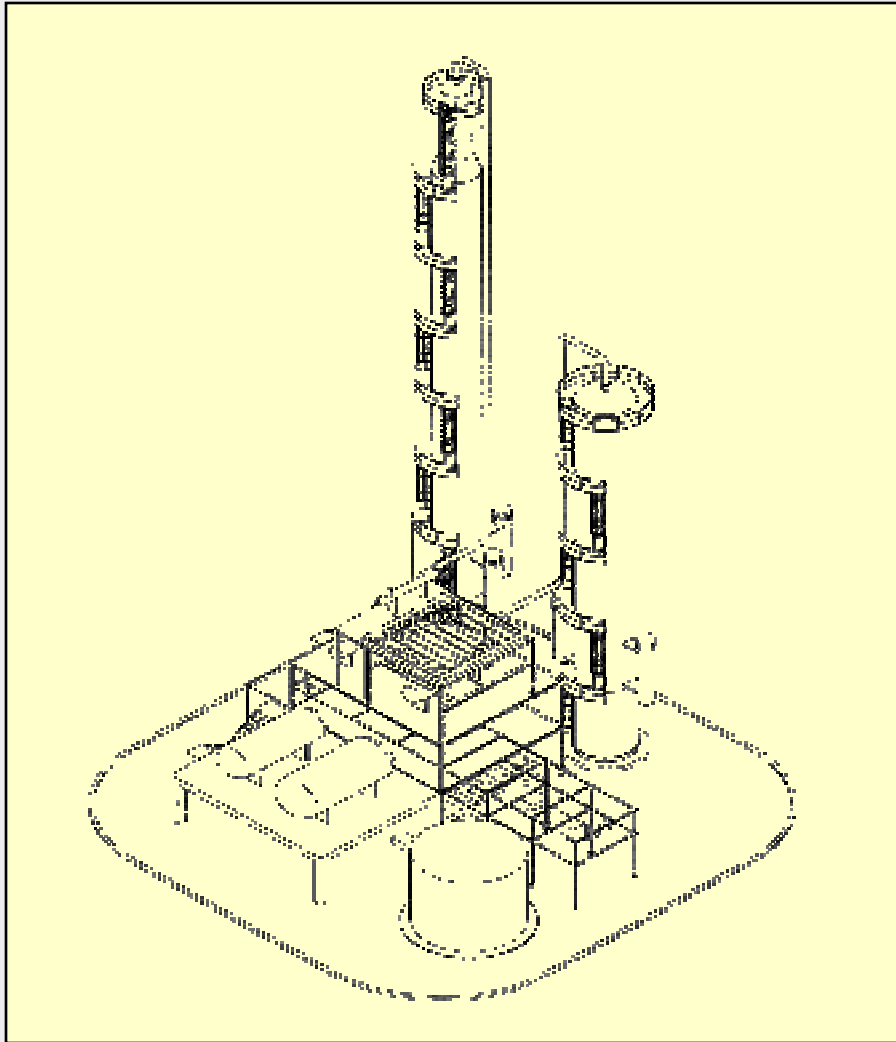
# Aromatics

## MORPHYLANE Process Features (II)

- Benzene purity of > 99.95 wt.-% possible
- Toluene purity TDI grade possible
- Aromatics yield usually between 98 - 99 wt.-%
- Solvent consumption < 10 gram/ton ED feed
- Low energy consumption
- Basic nitrogen guaranteed in pure aromatics
- On-stream time 8,600 hours/year <sup>1)</sup> possible
- Hydro-Refining plants usually with 8000 hours/year
- 1) Calculation based on MORPHYLANE plant evaluation at BASF AG, DOW Chemical, Chevron-Phillips and Shell & DEA Oil

# Aromatics

## MORPHYLANE typical Plot Arrangement

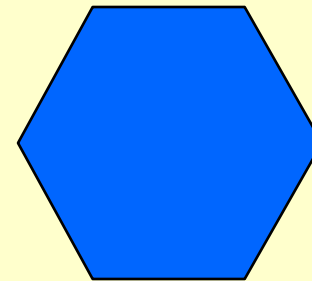
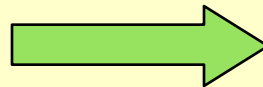
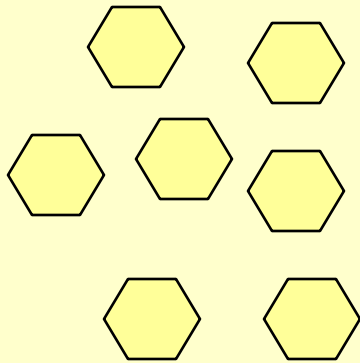


# Aromatics

## Economics of Plant Capacity for COLO Processing

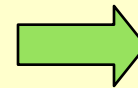
Typical capacities for Coke Oven Light Oil (COLO) plants between 30.000 tpa and 200.000 tpa

For this kind of plant, economics of plant capacity is of major impact



Advantages in:

specific TIC  
specific Product cost

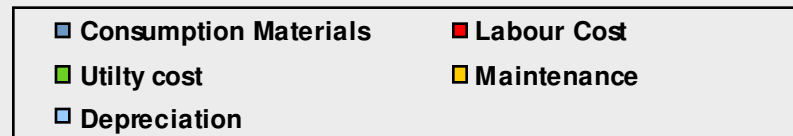
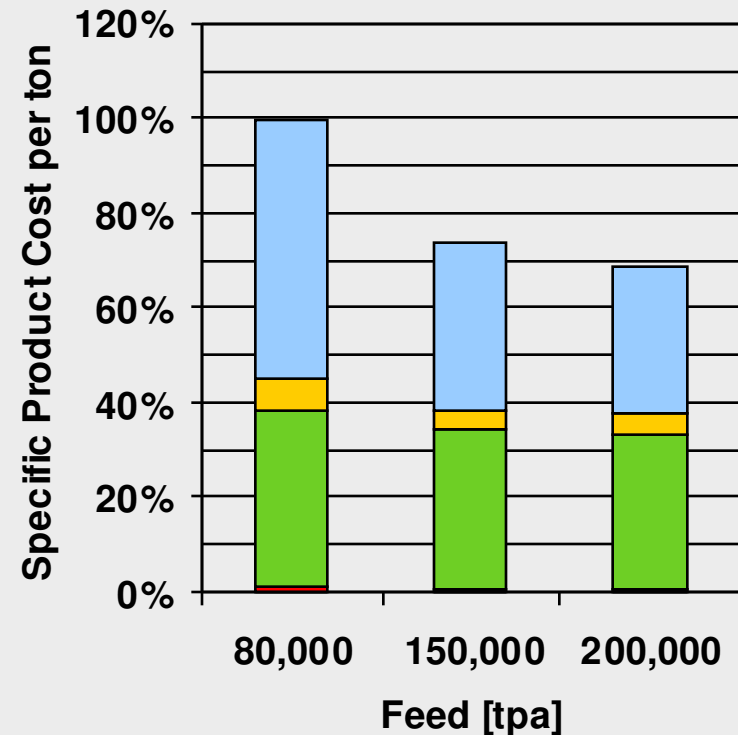


higher NPV  
shorter pay out

# Aromatics

## Economics of Plant Capacity for COLO Processing

- Conversion cost including depreciation
- Identical feed composition assumed
- Comparable plant concept (COLO Hydrogenation and BTX Recovery)
- TIC includes all equipment, first fill of catalyst & solvent, licence & engineering fee, civil, steel structure and construction



# Aromatics

## Economics of Plant Capacity for COLO Processing

### CONCLUSION:

- Requirements for equity is minimized
- Cost advantages for end products Benzene, Toluene and Xylenes up to 30%
- even under consideration of transportation cost a centralised large plant for processing COLO is more viable compared to several smaller plants
- TIC for each party involved is reduced for one larger plant compared with the TIC to be spent for separately owned smaller plants



# Uhde GmbH

## Division Edeleanu Refining Technologies



# References

# Aromatics

## MORPHYLANE® References (last 10 years)

Start-Up	Company Plant Site	Feed Process	Process Data	Aromatics Capacity [t/y]	Licensor	Contract Project Notes
2009	<b>JERP - Jubail Export Refinery Project</b> Jubail (Saudi Arabia)	Reformate <b>MORPHYLANE</b>	Benzene	140,300	Uhde	E (in cooperation with Axens)
2009	<b>Xingtai Risun Coal&amp;Chemical LTD</b> Yanjiatun (Xingtai), P.R. China	Coke Oven Light Oil <b>MORPHYLANE</b>	Benzene Toluene Xylenes	74,400 11,200 1,800	Uhde	E, P
2009	<b>Jiantao Chemical Co., Ltd.</b> Jiantao (Hebei), P.R. China	Coke Oven Light Oil <b>MORPHYLANE</b>	Benzene Toluene Xylenes	38,500 5,800 1,100	Uhde	E, P
2008	<b>Yunnan Kungang IT Co., Ltd.</b> Kunming, P.R. China	Coke Oven Light Oil <b>MORPHYLANE</b>	Benzene Toluene Xylenes	35,000 7,000 2,000	Uhde	E, P
2008	<b>GCW Anshan I&amp;S Group Co.</b> Anshan, P.R. China	Coke Oven Light Oil <b>MORPHYLANE</b>	Benzene Toluene Xylenes	100,000 20,000 8,000	Uhde	E, P
2007	<b>Sasol</b> South Africa	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	100,000	Uhde	E
2007	<b>HoodOil</b> Yemen	Reformate <b>MORPHYLANE</b>	Benzene	110,000	Uhde	E (in cooperation with Axens)
2007	<b>Shell Eastern</b> Singapore	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	210,000	Uhde	E (in cooperation with Axens)
2007	<b>Japan Energy Corporation</b> Japan	Reformate <b>MORPHYLANE</b>	Benzene/ Toluene	310,000	Uhde	E (in cooperation with Axens)

# Aromatics

## MORPHYLANE® References (last 10 years)

Start-Up	Company Plant Site	Feed Process	Process Data	Aromatics Capacity [t/y]	Licensor	Contract Project Notes
2007	<b>Oman Oil Company</b> Sohar, Oman	Reformate <b>MORPHYLANE</b>	Benzene/ Toluene	350,000	Uhde	E (in cooperation with Axens)
2006	<b>Baosteel International</b> Taiyuan, P.R. China	Coke Oven Light Oil <b>MORPHYLANE</b>	Benzene Toluene	56,000 12,000	Uhde	E
2006	<b>Repsol S.A.</b> Tarragona, Spain	Reformate and Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	221,000	Uhde	E (in cooperation)
2005	<b>Copesul Companhia Petroquimica do Sul</b> Triunfo, Brazil	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	140,000	Uhde	E (Expansion)
2006	<b>Shanxi Sanwei Group Co., Ltd.</b> Zhaocheng, P.R. China	Coke Oven Light Oil <b>MORPHYLANE</b>	Benzene Toluene Xylenes	129,000 35,000 14,000	Uhde	E, P
2006	<b>CEPSA S.A.</b> Huelva, Spain	Reformate <b>MORPHYLANE</b>	Benzene Toluene	352,000 79,000	Uhde	E
2006	<b>SK Corp.</b> Ulsan, Korea	Reformate <b>MORPHYLANE</b>	Benzene Toluene	95,000 374,000	Uhde	E (in cooperation with Axens)
2005	<b>CNOOC / Shell Petrochemicals Company Ltd.</b> Huizhou, P.R. China	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	250,000	Uhde	E
2005	<b>Borzouyeh Petrochemical Company</b> Bandar Assaluyeh, Iran	Reformate <b>MORPHYLANE</b>	Benzene/ Toluene	630,000	Uhde	E (in cooperation)

# Aromatics

## MORPHYLANE® References (last 10 years)

Start- Up	Company Plant Site	Feed Process	Process Data	Aromatics Capacity [t/y]	Licensor	Contract Project Notes
2005	<b>PKN Orlen</b> Plock, Poland	Reformate and Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene/ Toluene	400,000	Uhde	E
2004	<b>Aral Aromatics</b> Gelsenkirchen, Germany	Coke Oven Light Oil <b>MORPHYLANE</b>	Toluene	28,000	Uhde	E
2003	<b>Bouali Sina Petrochemical</b> Bandar Imam, Iran	Reformate and Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene/ Toluene	320,000	Uhde	E (in cooperation
2003	<b>Holborn Erdoel Raffinerie</b> Hamburg, Germany	Reformate <b>MORPHYLANE</b>	Benzene	67,000	Uhde	E (in cooperation with Axens)
2002	<b>Shanghai Petrochemical Company</b> Jinshanwei, P.R. China	Pyrolysis gasoline <b>MORPHYLANE</b>	Benzene/ Toluene Expansion	320,000	Uhde	E (Expansion in cooperation with SJEC)
2002	<b>Shell Nederland Chemie</b> Moerdijk, Netherlands	Reformate <b>MORPHYLANE</b>	Benzene	550,000	Uhde	E
2001	<b>BASF/FINA</b> Port Arthur, TX, USA	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene/ Toluene	280,000	Uhde	E
2000	<b>BASF Antwerpen N.V.</b> Antwerp, Belgium	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	258,000	Uhde	Turn-key
2000	<b>Tonen Corp.</b> Kawasaki, Japan	Reformate <b>MORPHYLANE</b>	Benzene	100,000	Uhde	E

# Aromatics

## MORPHYLANE® References (last 10 years)

Start-Up	Company Plant Site	Feed Process	Process Data	Aromatics Capacity [t/y]	Licensor	Contract Project Notes
2000	<b>Saudi Chevron Petrochemical</b> Al Jubail, Saudi Arabia	Reformate <b>MORPHYLANE</b>	Benzene/ Toluene	697,000	Uhde	E
2000	<b>Titan Petrochemicals</b> Pasir Gudang, Malaysia	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene/ Toluene	168,000	Uhde	Turn-key
1999	<b>DEA Mineraloel AG</b> Wesseling, Germany	Reformate <b>MORPHYLANE</b>	Benzene	43,200	Uhde	E
1999	<b>Thai Petrochemical Industries</b>  Rayong, Thailand	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	168,000	Uhde	E
1999	<b>Rayong Olefins Co.</b> Rayong, Thailand	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene Toluene	124,500 12,000	Uhde	E, P
1999	<b>Copesul Companhia Petro- quimica do Sul</b> Triunfo, Brazil	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	88,500	Uhde	E
1999	<b>Fina Raffinaderij Antwerp</b> Antwerp, Belgium	Pyrolysis Gasoline <b>MORPHYLANE</b>	Benzene	250,000	Uhde	E
1999	<b>VFT n. V.</b> Zelzate, Belgium	Coke oven light oil <b>MORPHYLANE</b>	Benzene	64,000	Uhde	E
1999	<b>Shanghai Petrochemical Company</b> Shanghai, P.R. China	Pyrolysis gasoline <b>MORPHYLANE</b>	Benzene/ Toluene	227,000	Uhde	E

# Aromatics

## MORPHYLANE® References

<b>Customer:</b>	BASF
<b>Location:</b>	Antwerp / Belgium
<b>Capacity:</b>	258,000 t/year of benzene
<b>Process:</b>	BASF SELOP + MORPHYLANE
<b>Commissioning:</b>	2000
<b>Speciality:</b>	Turnkey

