Based in Gurgaon, Mr. Mark is responsible for local resource management and operational alignment with the unit’s overall objectives and worldwide functional organizations.

A graduate chemical engineer, in his 30+ years with UOP, Mr. Mark has served in various capacities including field operating services, technical and continuing service, technology sales support and licensing, ventures and business development and management.

In addition to the US and India, his international work experience includes assignments in Europe, North Africa, S. America, and the Middle East.
Profitability Drivers in Refining

1. Maximise production of fuels and ensure compliance

2. Maximise Value from Barrel, minimise / eliminate Fuel Oil, other Low Value Products

3. Maximise Value added Products

Technology

Hydrotreating, Platforming, Isomerization

Petcoke gasification, Residue upgrading

Lubes & Specialty products Petrochemicals

Refinery - Petrochemical Integration delivers Value Added Products
Refinery Petrochemical Integration Options

- Kerosene → n-Paraffin → LAB
- Benzene
- Naphtha → pX → PTA → Polyester/PET
- VGO → Olefins (C₂, C₃, C₄) → Polyolefins (PP, PE, etc.)
India LAB Supply and Demand

**Key Highlights**

Demand expected to grow ~5% PA

- Installed capacity unable to meet the additional demand
- Kerosene and Benzene readily available

Source: CPMA India

Additional Capacity required to Meet Shortfall
Technology Innovation: UOP/CEPSA Detal-Plus Process

5% increase in LAB Production increases yearly revenue by 4-9 MM$

Transalkylation (TA) Reactor to convert HAB byproduct to LAB
Uses UOP DTA-100 Catalyst

<table>
<thead>
<tr>
<th></th>
<th>LAB (MTA)</th>
<th>HAB (MTA)</th>
<th>Normal Paraffins (MT/MT LAB)</th>
<th>Benzene (MT/MT LAB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UOP Detal™ Process</td>
<td>80,000</td>
<td>4,944</td>
<td>0.78</td>
<td>0.34</td>
</tr>
<tr>
<td>UOP/CEPSA Detal-Plus Process (Revamp)</td>
<td>83,867</td>
<td>1,492</td>
<td>0.74</td>
<td>0.34</td>
</tr>
</tbody>
</table>

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**Detal-Plus Process Advantages**

- Improves the return on investment for a new LAB complex by decreasing the overall capital investment while improving plant profitability
- Improves the profitability of existing Detal units by converting excess HAB by-product into higher valued LAB product with small capital investment
  - CAPEX investment of under 5 MM$ (for an 80 kmta LAB complex)
  - Lower normal paraffins requirement can provide yearly feed savings of 3-5 MM$
  - Flexibility to “turn on” or “turn off” Transalkylation Reactor to maximize profitability depending on the HAB-LAB price spread

**N-Paraffin Requirements**

![N-Paraffin Requirements Chart]

**Profitability Improvement vs. HAB-LAB Price Spread**

![Profitability Improvement Chart]

**Ideal for New and Revamp LAB complexes; Increase yield of more valuable LAB**

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Refinery Petrochemical Integration Options

- Kerosene
- n-Paraffin
- LAB
- Benzene

Naphtha → pX → PTA → Polyester/PET

VGO → Olefins (C₂, C₃, C₄) → Polyolefins (PP, PE, etc.)

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**Market Overview**

**Global Overview**
Demand increasing at 7.4% annually
Supply/demand continues to be tightly balanced
Plant utilization rates expected to be high until 2014

**India Overview**
Urbanization driven growth (10% CAGR)
Existing projects expected to make India long on PX by 2016
Existing players need to focus on Yield and Cost improvement

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**Polyesters**

Need for Producers to improve Yields and Production costs

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Technology Innovation: ADS-47 Development and Commercialization

ADS-47 Benefits

Drop-in replacement for existing adsorbent resulting in low capital costs for capacity additions

Up to 50% capacity increase in existing units

5-20% improved energy efficiency

(~ $2-5 / ton of pX benefit over ADS-37)

Significantly lower capital per ton of pX

(less adsorbent, smaller chambers)

Fast revamp execution; implement across a standard turnaround

First commercial installation streamed in Asia in October 2011

ADS-47 now standard for all new units

Recent Innovation delivers an Improved Cost position

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World Light Olefin Supply & Demand

90 million MTA of incremental light olefins needed between 2010 to 2020

Consumption driven by:
- Polyethylene
- Polypropylene
- Ethylene oxide
- Ethylene dichloride
- Ethylbenzene
- Acrylonitrile
- Propylene oxide
- Acrylic Acid
- Cumene

Growing share from other sources besides steam cracking and refineries
- Cost advantaged feedstocks
- On purpose propylene

Source: UOP Analysis

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“Propylene Gap” is growing
- Steam Crackers shifting to lighter feedstocks, which produce less propylene
- Refiners limited by flat gasoline growth in some regions, which limits propylene from FCCs

“On-Purpose Propylene” is filling the gap
- Propane Dehydro (PDH)
- Methanol (from gas & coal) to Olefins
- High Severity FCC
- Olefin Cracking
- Metathesis

On-Purpose Propylene will supply 25% of global propylene by 2021

Data Source: IHS Global Inc. 2012
Pathways to Olefins

Share of Production in India

- **90%**
  - **Naphtha Cracker // Gas Cracker**

- **10%**
  - **Hi severity FCC of VGO**

- **0%**
  - **Propane Dehydrogenation**

- **0%**
  - **Coal / Methanol to Olefins**

Routes

India Relevance

- **Naphtha Cracker // Gas Cracker**
  - India is long Naphtha and short on Natural Gas
  - Naphtha prices linked to Crude – challenging economics

- **Hi severity FCC of VGO**
  - Limited by FCC capacity

- **Propane Dehydrogenation**
  - India is short LPG
  - Most imported LPG allocated for domestic use

- **Coal / Methanol to Olefins**
  - Abundant Coal offers opportunities for CTO
  - Surplus Methanol capacity in Region- potential for MTO

Need for India to explore new pathways
Olefins in India

Propylene Supply / Demand (MMTPA)

Key Highlights

High growth expected across all Olefin derivatives—driven by increasing middle class growth and urbanization

Supply gap expected to grow

- Slowdown in FCC investments - Limited new refining capacities expected

- Limited new investments in cracking – driven by high Naphtha prices and slowdown in domestic gas production

Ethylene Supply / Demand (MMTPA)

Potential to meet the gap through alternatives – PDH & MTO

Source: CRISIL Research, 2012

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A UOP Oleflex plant converts one feed \((C_3\text{ LPG})\) … into one primary product (propylene) … with the option to export by-product hydrogen.

Key Features …

- One feed – one product
- Simple back integration
- Proven Investment
- Low Capital Intensity
- Highest Yield of Propylene
- Attractive Rate of Return
Oleflex is well-established technology

- 14 Units (total – all technologies) in operation today
- Locations of operating units
  - 6 Asia
  - 4 Middle East
  - 3 Europe/Africa
  - 1 North America

PDH unit capacities have been increasing

UOP Oleflex accounts for 9 of the 14 operating PDH units today
Comparison of capital intensity relative to a Naphtha cracker on a $/MTA of light olefin (C$_2$+C$_3$) basis

- 1 MMTPA Light Olefins
- 345k MTA Propylene

C$_3$ Oleflex requires <80% of the capital intensity on Light Olefin basis and <30% of the capital intensity on a Propylene basis

- 450k MTA Propylene scale assumed

A world scale Oleflex project requires about 1/3 of the capital required for a Naphtha Cracker project
UOP has been awarded 19 of the last 22 dehydro projects world-wide since 2011

2 PDH Projects at 750 kmta propylene capacity

High market activity in response to end-product demand and feedstock availability

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UOP Methanol-to-Olefins (MTO)

Feedstocks
- Natural gas or Coal or Petroleum Coke or Biomass

SynGas Reformer → Methanol Reformer
Methanol

UOP MTO Methanol to Olefins

Ethylene Propylene

Olefin Derivative Units

Commercial Technologies (By Others)

New Feedstock and Catalyst using Commercially Proven Equipment

Products (examples)
- Polyethylene
- Polypropylene
- Ethylene Dichloride
- Ethylene Oxide
- Ethyl Benzene
- Acrylonitrile
- Propylene Oxide
- Acrylic Acid
- Others

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Commercial Technologies
Fluid catalytic cracking (FCC) system best fit for SAPO-34 characteristics

Fast fluidized bed reactor
- Temperature uniformity
- Temperature control
- Catalyst inventory reduction

UOP has licensed over 280 fluid catalytic cracking (FCC) units in petroleum refineries

MTO reactor & regenerator equipment is within the range of sizes and operating conditions (temperature, pressure, velocities) of UOP FCC experience

- High pressure design to reduce size and cost
- Low catalyst attrition design
- Maximum single-train capacity in excess of 1.8 million MTA of light olefin capacity

Source: UOP

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Advanced MTO provides the highest light olefin yields over a broad range of propylene/ethylene (P/E) product ratios.

2.65 tons of Methanol consumed per ton of Light Olefin produced

MTO Rx Pressure > 2 barg

First UOP MTO unit (300kMTA) to come on stream at Wison Clean Energy in 2013
Petrochemical integration offers a proven route to enhancing Refinery Profitability over the long term.

Expensive feedstock (Naphtha, India Gas pricing) represents a challenge to Conventional petrochemical processes.

Novel technologies processing cost advantaged feedstocks provide a profitable alternative to traditional Petrochemical integration schemes.
THANK YOU