THE PHENOL-ACETONE VALUE CHAIN: PROSPECTS AND OPPORTUNITIES

RAJEEV M. PANDIA
THE BENZENE-PROPYLENE-CUMENE-PHENOL-ACETONE-BPA VALUE CHAIN

TECHNOLOGIES FOR CUMENE MANUFACTURE

GLOBAL AND REGIONAL PHENOL-ACETONE BALANCE

APPLICATIONS AND GROWTH RATES

MAJOR PRODUCERS AND CONSUMERS

NEW DEVELOPMENTS/ CAPACITIES/ PROJECTS

CONCLUSIONS
PHENOL & ACETONE
FROM
BENZENE & PROPYLENE
THROUGH
CUMENE

BENZENE
0.872 TONS

CUMENE-1.31 TONS

PROPYLENE
0.47 TON

CUMENE HYDROPEROXIDE

PHENOL
1 TON

ACETONE
0.612 TONS
TECHNOLOGIES FOR CUMENE PRODUCTION
GENERATIONS OF CUMENE TECHNOLOGY:

- **FIRST** - USING SULFURIC ACID CATALYST
- **SECOND** - WITH ALUMINIUM CHLORIDE CATALYST
- **THIRD** - BASED ON SOLID PHOSPHORIC ACID (SPA) CATALYST
- **FOURTH** - IN PRESENCE OF ZEOLITE CATALYST
  - CATALYTIC DISTILLATION - A VARIATION OF ZEOLITE BASED TECHNOLOGY
  - BETA-ZEOLITE CATALYST - PREFERRED OVER OTHER ZEOLITES
INCREASING IMPORTANCE OF ZEOLITE TECHNOLOGY

1994

AICI3
ZEOLITE
SPA

2004

SPA
ZEOLITE
AICI3

2013

SPA
AICI3
ZEOLITE
GLOBAL AND REGIONAL BALANCE FOR CUMENE, PHENOL AND ACETONE
CUMENE CAPACITIES ACROSS REGIONS 2012

USA - 3.885 MN TPA

EUROPE - 4.331 MN TPA

ASIA PACIFIC - 6.214 MN TPA

AMERICAS-OTHERS - 0.300 MN TPA

WORLD - TOTAL - 14.73 MN TPA

INCLUDES THOSE IN EAST EUROPE/RUSSIA
PHENOL CAPACITIES ACROSS REGIONS

2012

USA - 2.927 MN TPA
EUROPE - 3.147 MN TPA
ASIA PACIFIC - 5.282 MN TPA
AFRICA - 0.040 MN TPA
AMERICAS-OTHERS - 0.250 MN TPA
WORLD TOTAL - 11.646 MN TPA
PHENOL DEMAND ACROSS REGIONS 2012

USA - 2.632 MN TPA
EUROPE - 2.899 MN TPA
ASIA PACIFIC - 4.120 MN TPA
AMERICAS-OTHERS - 0.226 MN TPA
AFRICA - 0.082 MN TPA
WORLD - TOTAL - 9.959 MN TPA
PHENOL SURPLUS ACROSS REGIONS 2012

US - 0.295 MN TPA
EUROPE - 0.248 MN TPA
ASIA PACIFIC - 1.162 MN TPA
AFRICA - (0.042) MN TPA
AMERICAS-OTHERS - 0.024 MN TPA
WORLD - TOTAL - 1.687 MN TPA
ACETONE CAPACITIES ACROSS REGIONS 2012

USA - 1.982 MN TPA
EUROPE - 1.992 MN TPA
ASIA PACIFIC - 3.278 MN TPA
ROW - 0.348 MN TPA
WORLD - TOTAL - 7.6 MN TPA
ACETONE DEMAND ACROSS REGIONS 2012

USA - 1.697 MN TPA

ASIA PACIFIC - 2.275 MN TPA

EUROPE - 1.526 MN TPA

ROW - 0.468 MN TPA

WORLD - TOTAL - 5.966 MN TPA
ACETONE SURPLUS ACROSS REGIONS 2012

ASIA PACIFIC - 1.003 MN TPA

USA - 0.285 MN TPA

EUROPE - 0.466 MN TPA

ROW - (0.12) MN TPA

WORLD - TOTAL – 1.634 MN TPA
CUMENE SURPLUS ACROSS REGIONS
2012

USA - 0.58 MN TPA

USA - 0.58 MN TPA

W. EUROPE - 0.777 MN TPA

ASIA PACIFIC - 0.249 MN TPA

REST OF THE WORLD - TOTAL - 0.013 MN TPA

WORLD - TOTAL - 1.619 MN TPA

BASED ON 85.5% OPERATING RATE FOR PHENOL

SURPLUS IN ASIA TO BE HIGHER NOW WITH ADDITIONS IN 2012, 2013

DEMAND TO GROW FROM 13.1 MN TPA TO >18 MN TPA BY 2020
NORTHEAST ASIA PHENOL SUPPLY & DEMAND

 SOURCE: ICIS Consulting
NORTH AMERICAN PHENOL SUPPLY & DEMAND

SOURCE: ICIS Consulting
EUROPEAN PHENOL SUPPLY & DEMAND

SOURCE: ICIS Consulting
MAJOR CUMENE CAPACITIES INTEGRATED WITH PHENOL

- **NORTH AMERICA**
  - SHELL, TEXAS (CUMENE: 725,000 TPA; PHENOL: 600,000 TPA)

- **WEST EUROPE**
  - DOMO CHEM, GERMANY (CUMENE: 270,000 TPA; PHENOL: 175,000 TPA)
  - NOVAPEX, FRANCE (CUMENE: 230,000 TPA; PHENOL: 155,000 TPA)
  - VERSALIS, ITALY (CUMENE: 300,000 TPA; PHENOL: 180,000 TPA)
  - CEPSA, SPAIN (CUMENE: 800,000 TPA; PHENOL: 600,000 TPA)

MOST ASIAN CAPACITIES ARE INTEGRATED WITH PHENOL, EXCEPT TOSOH AND NIPPON OIL
MAJOR STAND ALONE CUMENE CAPACITIES

- **NORTH AMERICA**
  - MARATHON PETROLEUM (ASHLAND), KENTUCKY (375,000 TPA)
  - CITGO, CORPUS CHRISTI (500,000 TPA)
  - FLINT HILLS, CORPUS CHRISTI (680,000 TPA)

- **WEST EUROPE**
  - BP CHEMICALS (FORMERLY VEBA), GERMANY (498,000 TPA)
  - VERSALIS, PRIOLO, ITALY (320,000 TPA)
COMPANIES WITH CUMENE AND PHENOL CAPACITIES AT DIFFERENT LOCATIONS

- **DOW** - CUMENE IN EUROPE AND PHENOL IN USA
- **INEOS**, EUROPE - CUMENE AT MARL (FORMERLY BP CHEMICALS) AND PHENOL AT ANTWERP, BELGIUM AND GLADBECK, GERMANY
- **CHANGCHUN, SINGAPORE** TO FOLLOW
APPLICATIONS AND GROWTH RATES
PHENOL DEMAND SEGMENTWISE

WORLD PHENOL DEMAND - APPLICATIONWISE

BISPHENOL-A, 43%

CYCLOHEXANONE, 13%

PHENOLIC RESINS, 30%

OTHERS, 12%

ANILINE, 2%
PHENOL- GROWTH RATES ACROSS REGIONS

- USA - 2.8% P.A.
- EUROPE - 2% P.A.
- ASIA - 6.2% P.A.
- OVERALL - 4% P.A.

DEMAND COULD GROW FROM 9.96 MN TPA IN 2012 TO 14.17 MN TPA BY 2020
PHENOL - GLOBAL GROWTH RATES ACROSS SECTORS

- BISPHENOL-A - 6% P.A.
- RESINS - 2% P.A.
- OTHERS - 3% P.A.
- OVERALL - 4% P.A.

DEMAND COULD GROW FROM 9.96 MN TPA IN 2012 TO 14.17 MN TPA BY 2020
ACETONE DEMAND SEGMENTWISE

WORLD ACETONE DEMAND - APPLICATIONWISE

- SOLVENT USE, 29%
- BISPHENOL-A, 22%
- ALDOL CHEMICALS AND OTHERS, 25%
- METHYL METHACRYLATE, 24%
ACETONE- GROWTH RATES ACROSS REGIONS

- USA - 2% P.A.
- EUROPE - 1.4% P.A.
- ASIA - 4% P.A.
- OTHERS - 5% P.A.
- OVERALL - 3% P.A.

DEMAND TO GROW FROM 5.97 MN TPA IN 2012 TO 7.78 MN TPA BY 2020
# Acetone - Growth Rates Across Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>P.A.</th>
</tr>
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<tbody>
<tr>
<td>Bisphenol-A</td>
<td>4%</td>
</tr>
<tr>
<td>MMA</td>
<td>1%</td>
</tr>
<tr>
<td>Aldol Chemicals</td>
<td>3%</td>
</tr>
<tr>
<td>Solvents</td>
<td>3%</td>
</tr>
<tr>
<td>Overall</td>
<td>3%</td>
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</tbody>
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Demand to grow from 5.97 MN TPA in 2012 to 7.78 MN TPA by 2020
FEEDSTOCKS FOR CUMENE

BENZENE AND PROPYLENE
BENZENE—MARKET SEGMENTS—GLOBALLY

- **STYRENE** - 51%
- **CUMENE** - 21%
- **CYCLOHEXANE** - 10%
- **NITRO-BENZENE** - 5%
- **OTHERS** - 13%
<table>
<thead>
<tr>
<th>Segment</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene</td>
<td>65%</td>
</tr>
<tr>
<td>Acrilonitrile</td>
<td>6-7%</td>
</tr>
<tr>
<td>Oxo-alcohols</td>
<td>6-7%</td>
</tr>
<tr>
<td>Propylene oxide</td>
<td>6-7%</td>
</tr>
<tr>
<td>Cumene</td>
<td>6.5%</td>
</tr>
<tr>
<td>Acrylic acid</td>
<td>4%</td>
</tr>
<tr>
<td>Others</td>
<td>5%</td>
</tr>
</tbody>
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MAJOR PRODUCERS AND CONSUMERS
MAJOR NORTHEAST ASIA PHENOL PRODUCERS
2013

SOURCE: ICIS Consulting
MAJOR NORTH AMERICAN PHENOL PRODUCERS 2013

SOURCE: ICIS Consulting
MAJOR EUROPEAN PHENOL PRODUCERS

SOURCE: ICIS Consulting
MAJOR NORTHEAST ASIAN PHENOL CONSUMERS

- KUMHO P&B CHEMICALS
- LG CHEMICAL
- NAN YA PLASTICS
- CHANG CHUN PLASTICS
- MITSUBISHI CHEMICAL
- BAYER POLYMERS SHANGHAI
- OTHER (16 Companies)

SOURCE: ICIS Consulting
MAJOR NORTH AMERICAN PHENOL CONSUMERS

SOURCE: ICIS Consulting
MAJOR EUROPEAN PHENOL CONSUMERS

SOURCE: ICIS Consulting
### Major Chinese Existing Phenol Capacities

<table>
<thead>
<tr>
<th>Company</th>
<th>Capacity (TPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinopec Shanghai</td>
<td>360,000</td>
</tr>
<tr>
<td>Sinopec Sabic Tianjin</td>
<td>220,000</td>
</tr>
<tr>
<td>Liuhuiyi Weiyuan</td>
<td>220,000</td>
</tr>
<tr>
<td>Zhuhai Shi You</td>
<td>200,000</td>
</tr>
<tr>
<td>Sinopec Beijing Yanshan</td>
<td>160,000</td>
</tr>
<tr>
<td>Huizhou Zhongxin</td>
<td>120,000</td>
</tr>
<tr>
<td>China Bluestar</td>
<td>120,000</td>
</tr>
</tbody>
</table>
### MAJOR CHINESE PHENOL PROJECTS

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Capacity (TPA)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>INEOS/SINOPEC-</td>
<td>400,000</td>
<td>2015</td>
</tr>
<tr>
<td>JIANGSU HAILI-</td>
<td>360,000</td>
<td>2014</td>
</tr>
<tr>
<td>CHANGCHUN PLASTICS-</td>
<td>400,000</td>
<td>2013</td>
</tr>
<tr>
<td>FORMOSA PLASTICS-</td>
<td>300,000</td>
<td>2014</td>
</tr>
<tr>
<td>CEPSA QUIMICA -</td>
<td>250,000</td>
<td>2014</td>
</tr>
<tr>
<td>SINOPEC MITSUI -</td>
<td>250,000</td>
<td>2013</td>
</tr>
<tr>
<td>CHANGCHUN CUMENE (SIN)-</td>
<td>540,000</td>
<td>2014</td>
</tr>
<tr>
<td>PETROCHINA SICHUAN-</td>
<td>180,000</td>
<td>2013</td>
</tr>
<tr>
<td>SINOPEC BEIJING YANSHAN-</td>
<td>138,000</td>
<td>2014</td>
</tr>
</tbody>
</table>
## MAJOR ASIAN NEW PHENOL PROJECTS

- **KUMHO P & B, S.KOREA:** 300,000 TPA, WITH 900,000 TPA CUMENE (2014)

- **PETRO RABIGH, KSA:** 275,000 TPA (STUDY/2016)

- **PTT PHENOL, THAILAND:** 250,000 TPA (2016)

- **INDIA PROJECT:** 300,000 TPA (STUDY)
CONCLUSIONS

FATE OF CUMENE LINKED TO PHENOL/ACETONE

ZEOLITE BASED TECHNOLOGIES OFFER BETTER ECONOMICS DUE TO SELECTIVITY

SURPLUS CUMENE CAPACITY OVER DEMAND

MAJOR CAPACITY ADDITIONS IN ASIA, MORE PLANNED

ASIA TO SEE LARGEST CUMENE PLANT AND NEW STAND ALONE CAPACITY

CUMENE PRICES DEPEND ON BENZENE/PROPYLENE PRICES

PHENOL/ACETONE PRICES DEPEND ON CUMENE COSTS AND MARKETS

ASIA TO STEER THE GROWTH WITH COMFORT IN BENZENE & PROPYLENE