Bio-Ethylene for Chemical Intermediates

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Petron Scientech, Inc.

- **Established in 1988**
- **Headquarter in Princeton, N.J.**
- **Process Technology, R&D, Scale-up, Licensing, Basic and Detailed Engineering.**
- **Core Areas of Business:**
  - **Bio-Ethylene**
  - **Organic Chemicals**

Overview

- Introductory Comments
- Bio-Ethylene Challenges
- Ethanol-to-Ethylene (ETE) Process
- ETE Technology & Economics
- Feedstock Options
- Product Quality
- Investment Requirements
- Concluding Remarks

Ethylene Facts…

- **The most widely produced petrochemical.**
- **Annual Production: 140 x10^6 tons (2010).**
- **Manufactured by 120 Companies in 60 Countries.**
- **Diverse Applications:**
  - **Polymerization: LDPE/HDPE**
  - **Oxidation: EO/Glycols/Antifreeze/PET**
  - **Halogenation: EDC/PCV**
  - **Alkylation: Styrene/Polystyrene/Rubber**
  - **Oligomerization: Lubricants/Motor Oil**
  - **Hydroformulation: Detergents/Fragrants**
  - **Others**

Petroleum Ethylene vs. Bio-Ethylene

Consideration	Petroleum	Bio
Multi-Products Grass-Roots Mega Plants (>10^6 TPA)	X	
$C2^=$- only Small to Mid-Sized Plants (<0.5x10^6 TPA)		X
Debottlenecking Option for $C2^=$- only Product		X
Single Product Make and Marketing		X
Plant Complexity		X
GHG and Other Emissions		X
Raw Materials Options		X
Safety and Environmental		X
Supply and Price Volatility		X
End-Use Flexibility	X	X

Bio-Ethylene Challenges as Chemical Intermediate

- **Production Cost**
- **Product Quality**
- **Potential Risks to Downstream**
  - **Processes,**
  - **Products, and**
  - **Markets**
- **Raw Material Supply and Logistics**

Bio-Ethylene Production Options

- **Catalytic Dehydration of Ethanol**
- **Oxidative Coupling of Methane**
- **Other Routes?**

Raw Material Options

- Sugar Cane
- Corn
- Cellulosic
- Others
- Impurities of Concern:
  - Certain Denaturants such as Methanol, Acetone, Isopropyl Alcohol, Benzene, Sulfur Compounds

Petron Ethanol-to-Ethylene (ETE) Process: 25 Years of R&D and Commercial Experience

- **1991 - SM Dychem, India, 36,000 tons/year for EO/MEG**
- **1994 - Uniglobe Glycol, India, 40,000 tons/year for EO/MEG**
- **1995 - Oswal, India, 58,000 tons/yr for PE**
- **2005 - Reliance, 70,000 tons/yr for EO/MEG**
- **2010 - Henan, China, 90,000 tons/yr for EO/MEG**
- **2011 - Jilin Zhongxon, China, 90,000 tons/yr for EO/MEG**
- **2012 - Greencol (Toyota/CMFC JV) Plant Startup in Taiwan, 100,000 tons/yr for EO/MEG**
- **2012 - Vedanta (Coca Cola/JBF JV) Bio-Glycol Project, 500,000 tons/yr EO/MEG in Sao Paolo, Brazil**

ETE Technology: Main Challenges

$C_2H_5OH \longrightarrow C_2H_4 + H_2O$

- Manage the highly endothermic dehydration reactions.
- Control catalyst temp. profiles and avoid cold spots.
- Reduce mass transfer limitations.
- Achieve high conversion/pass to avoid ethanol recycle.
- Maximize bio-ethylene selectivity and yield.
- Maximize catalyst life and avoid regeneration.
- Reduce by-products formation.
- Obtain product quality at least as good as or better than petroleum ethylene.
- Manage utilities consumption.

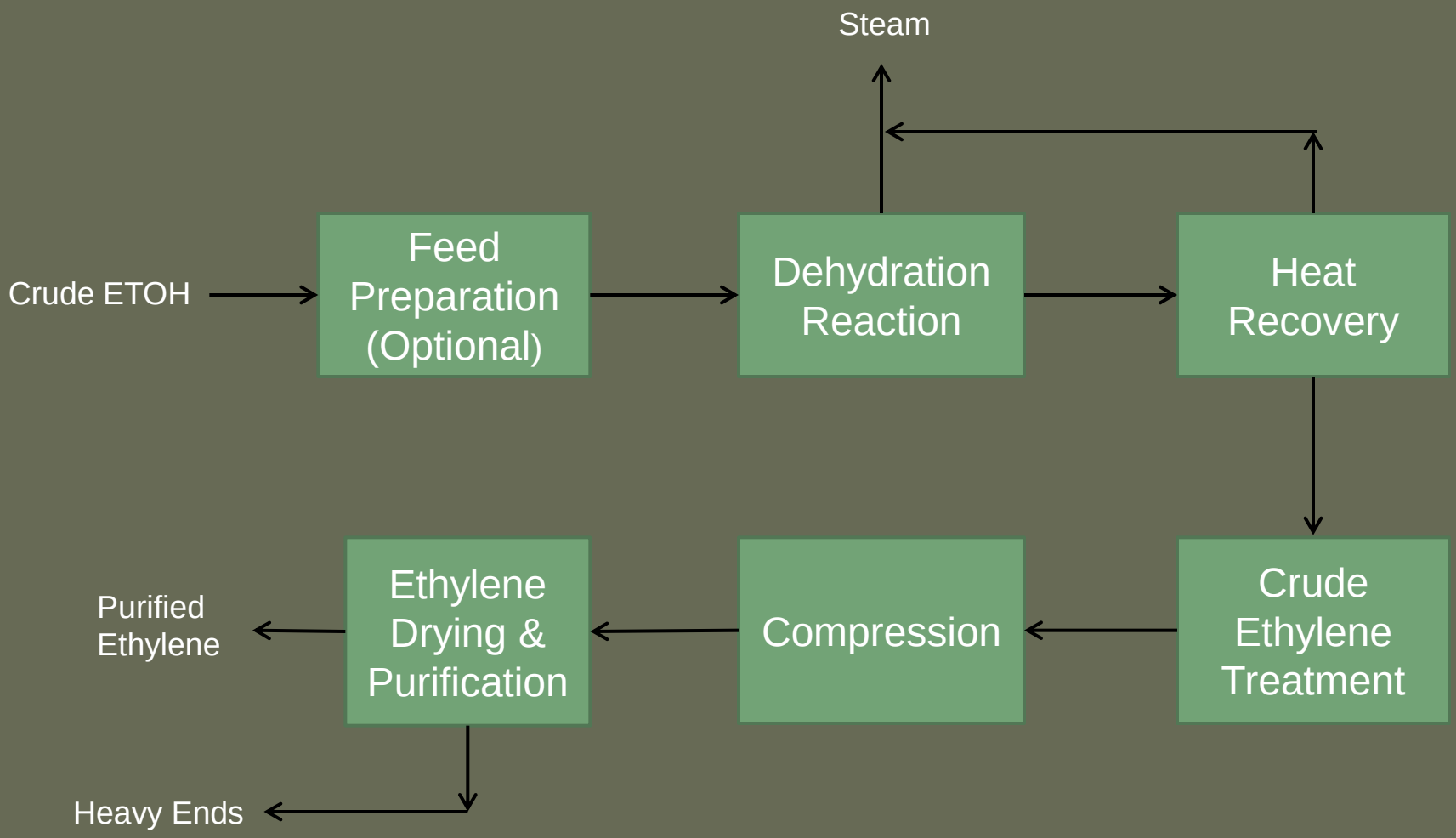
Petron ETE Process Performance

- **Temperature Control: Multi-staging of Catalyst and Reactor Train**
- **Mass Transfer Limitations: Catalyst Properties and Feed Distribution**
- **Ethanol Conversion: ~100%**
- **Ethylene Selectivity: >99%**
- **Ethylene Yield: Almost Stoichiometric**
- **By-Products Formation: minimal**
- **Catalyst Life: 3 years minimum**
- **Catalyst Regeneration: not required**
- **Product Quality: Better than Petroleum-Based**
- **Utilities Consumption: Low Through Extensive Integration**

ETE Process Highlights

- Single-line capacities range from 20,000 to 300,000 tons/year.
- Designed for full integration of utilities with existing units.
- Offers high turn-down from 60% to 120% of design rates.
- Designed for minimization of gaseous, liquid, and solid wastes.
- Capable to process ethanol feedstock from various sources
- Can produce bio-ethylene suitable for chemicals, polymer, etc.
- Developed to have no impact on downstream applications.
- Developed for safe operation.

ETE Schematic Flow Diagram



Bio-Ethylene Variable Cost: Petron vs. Competitor

Estimated Typical Investment

Unit Size, T/Y	ISBL Requirement
30,000	25-30 MM$
30,000	5,000 m^2
100 ,000	50-60 MM$
100,000	10,000 m^2
250,000	90-100 MM$
250,000	15,000 m^2

Typical Bio-Ethylene Quality

Component	Chemical Grade	Polymer Grade
Ethylene, vol. % min.	99.80	99.90
$C3^+$ HC's, vol. % max.	<0.2	<0.1
Oxygenates, vol. % max.	<0.005	<0.004
Sulfur, PPM maximum	0.01	0.01

Bio-Ethylene from Ethanol: Concluding Remarks

- Technology is mature and proven.
- Risks are well understood:
  - technical and operational,
  - product quality and downstream impact,
  - scale-up
  - safety & environmental
- Offers feedstock flexibility and security.
- Provides an attractive option for ethylene-only grass-roots plants or for debottlenecking projects.
- Is readily integrated with existing units.
- Results in over 90% reduction of GHG emissions
- Keys to success:
  - No impact on existing ethylene processes and products
  - Ethanol transfer price

The Coca-Cola Company

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News Release

THE COCA-COLA COMPANY ACCELERATES GLOBAL PRODUCTION OF PLASTIC PACKAGING MADE FROM PLANTS

New Partnership to Deliver World's Largest Facility

ATLANTA, Sept. 27, 2012 –The Coca-Cola Company today announced a partnership with JBF Industries Ltd. to further expand production of the plant-based material used in the Company's PlantBottle™ packaging. The supply partnership will help Coca-Cola continue its leadership in bringing renewable, lower-carbon plastics to the marketplace and move the Company closer to its target of using PlantBottle™ packaging technology in all of its plastic bottles by 2020.

Ronald J. Lewis, Vice President, Procurement & Chief Procurement Officer at The Coca-Cola Company said, "The benefits of sustainable innovation are only fully realized when commercialized and put in the hands of consumers. In 2009, we introduced the world to our PlantBottle ™ package – the first recyclable PET plastic bottle made partially from plants. Today, Coca-Cola has sold more than 10 billion PlantBottle™ packages around the world that are less dependent on petroleum and have a lower carbon impact. We are pleased that our partnership with JBF Industries Ltd. will help us further expand global production."

To support this partnership, JBF Industries Ltd. will build the world's largest facility to produce bio-glycol - the key ingredient used to make PlantBottle™ packaging. The facility, which will be located in Araraquara, Sao Paulo, Brazil, will produce the ingredient using locally sourced sugarcane and sugarcane processing waste. Both materials meet The Coca-Cola Company's established sustainability criteria used to identify plant-based ingredients for PlantBottle™ packaging. These guiding principles include demonstrating improved environmental and social performance as well as avoiding negative impacts on food security.

Construction on the new facility is expected to begin at the end of this year and last for 24 months. At full capacity, it is estimated the facility will produce 500,000 metric tons of material per year. By using plant-based materials instead of non-renewable materials, the facility will remove the equivalent of 690,000 metric tons of carbon dioxide or the equivalent of consuming more than 1.5 million barrels of oil each year.