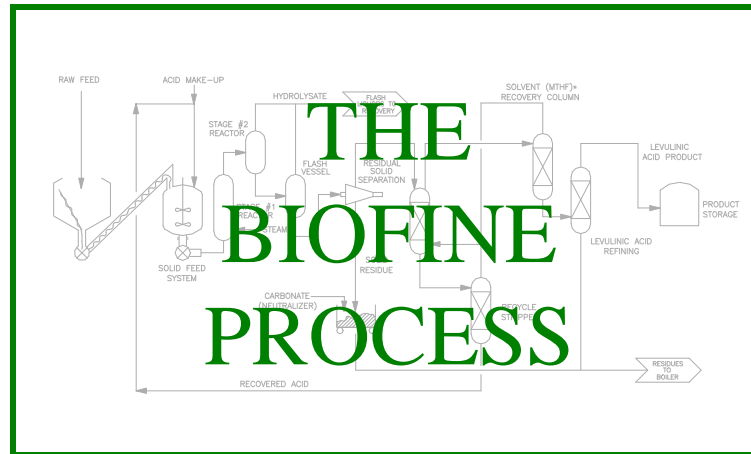


CELLULOSE AND STARCH



ADVANCED BIOFUELS

PRESENTATION TO N.O.R.A.

OUTLINE

- **WHO IS BIOFINE TECHNOLOGY LLC (PAST AND PRESENT)**
- **THE BIOFINE PROCESS TECHNOLOGY (LEVULINIC ACID)**
- **ETHYL LEVULINATE (EL) AS A “GREEN” HEATING OIL COMPONENT**
- **POTENTIAL MARKET AND COMMERCIAL DEVELOPMENT NEEDS**

WHO IS BIOFINE TECHNOLOGY LLC?

- SET UP TO COMMERCIALIZE A PROPRIETARY LIGNOCELLULOSE REFINING PROCESS
- FOUNDED IN 1988 BY DR STEPHEN FITZPATRICK – INVENTOR OF PROCESS
- TECHNOLOGY – A NOVEL THERMOCHEMICAL, FAST, ROBUST PROCESS
- LOWEST COST AND GREENEST ROUTE TO BIOFUELS AND CHEMICALS
- PRIVATELY HELD BY BIOFINE INC. AND AN INVESTOR GROUP
- WINNER OF THE 1999 PRESIDENTIAL GREEN CHEMISTRY AWARD
- CURRENTLY OPERATING A 2 TON/DAY DEMONSTRATION PLANT IN GORHAM, ME
- ACTIVELY SEEKING COMMERCIALIZATION PARTNERS OR OPPORTUNITIES



First Stage
(Seconds)



Second Stage
(Minutes)



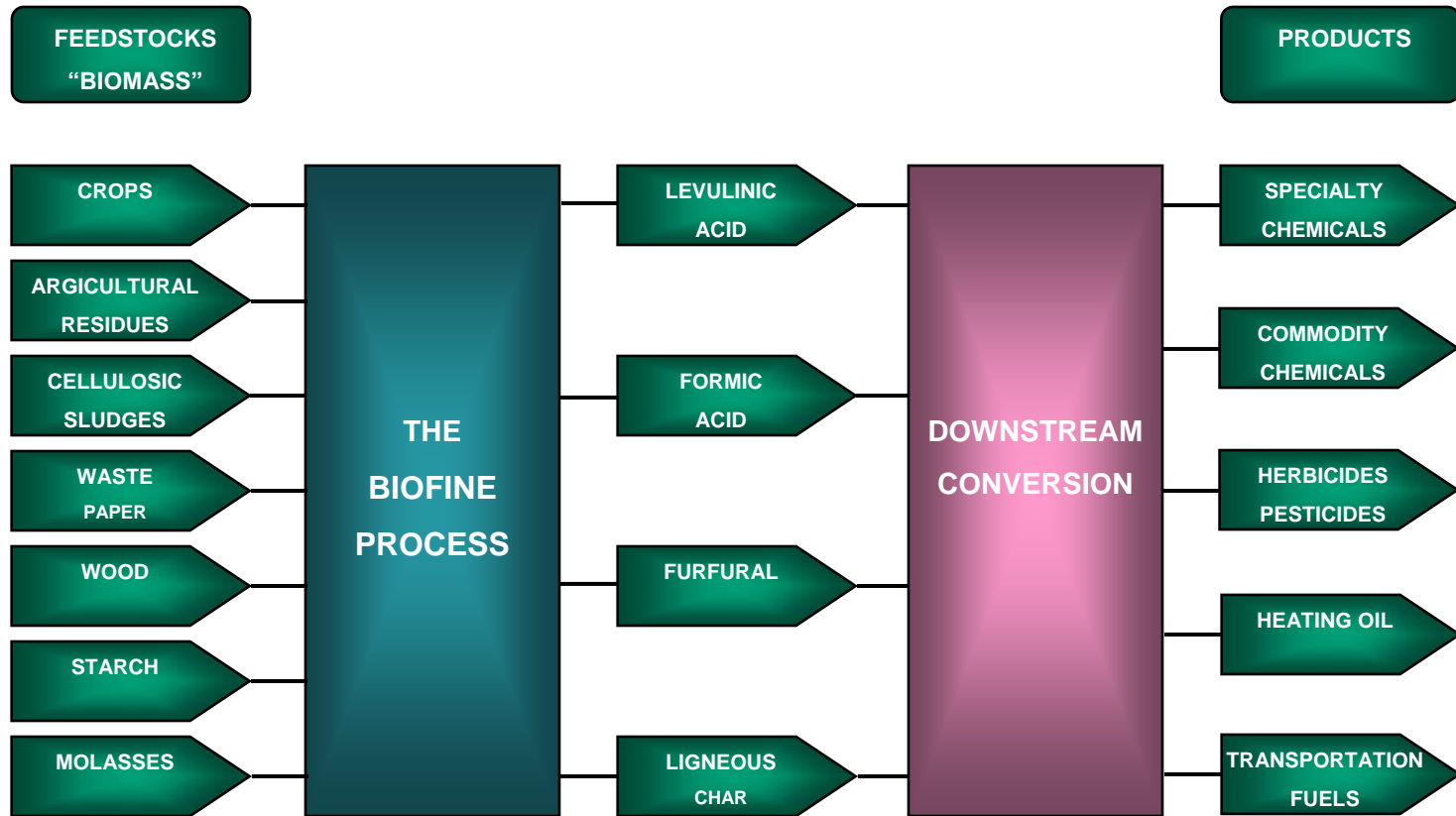
Chemistry of Conversion:

Cellulose
to
Sugars
to
Intermediates
to
Levulinic Acid
(High Yield)



Biofine Gorham, ME pilot plant

THE BIOFINE PROCESS (THE “BIOREFINERY”)



TECHNOLOGY: **HISTORY AND PRESENT STATUS**

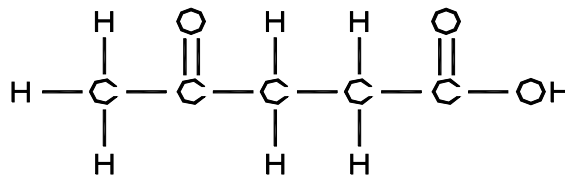
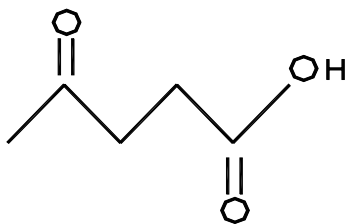
- **INITIAL WORK AT N.R.E.L. CO (1986-1987)**
- **PILOT REACTOR AT DARTMOUTH COLLEGE, NH (1988-1996)**
- **ONE TON/DAY PILOT PLANT S. GLENS FALLS, N.Y. (1996-2000)**
- **50 TON/DAY DEMONSTRATION PLANT CASERTA, ITALY (2000-2005)**
- **TWO TON/DAY DEMONSTRATION PLANT AT GORHAM, ME (2007)**



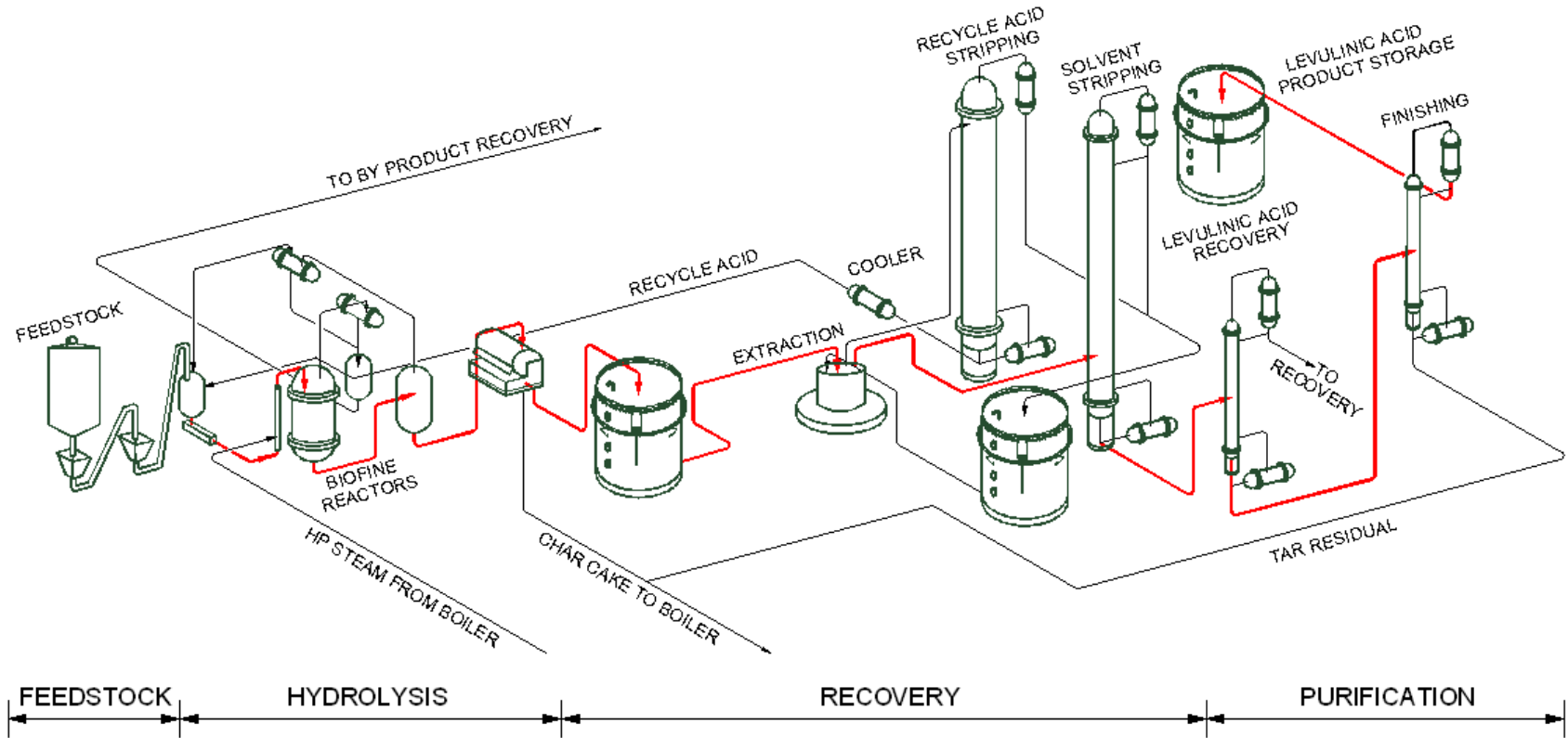
LEVULINIC ACID (LVAC)

**A NEW VERSATILE PLATFORM CHEMICAL
WITH DERIVATIVE PRODUCTS
IN A BROAD RANGE OF MARKETS**

LEVULINIC ACID (LVAC) A VERSATILE PLATFORM CHEMICAL



THE BIOFINE PROCESS



A BETTER PROCESS:

- THERMOCATALYTIC – CHEMICAL, NON-BIOLOGICAL
- COMPACT – FAST REACTIONS (MINUTES)
- ROBUST – WIDE RANGE OF NON-FOOD FEEDSTOCK
- ECONOMIC - VALUABLE BYPRODUCTS - NET POWER PRODUCER
COST EFFECTIVE CO-LOCATION WITH EXISTING PLANTS
- ENVIRONMENTALLY BENIGN - EXCELLENT L.C.A. (90+%)
- FLEXIBLE - BIOMASS TO WELL-DEFINED CHEMICAL PRODUCTS

LIGNOCELLULOSE
BIO REFINERY

LEVULINIC ACID
FORMIC ACID
FURFURAL
LIGNIN

PHARMACEUTICALS
AND
SPECIALTY
CHEMICALS

ANGELICA
LACTONE
LEVULINIC ACID
KETALS
DALA
TELRAPYRROLES
LIGNINS

SOLVENTS
AND
GENERAL
CHEMICALS

FORMIC ACID
NMP
PYRIDINE
FURFURAL
ETHYL FORMATE
GBL
PENTANEDIOL
THF
SUCCINIC ACID

MONOMERS
AND
SPECIALTY
POLYMERS

DIPHENOLIC ACID
POLYCARBONATE
EPOXIES
GVL
BUTANEDIOL
THF
SUCCINIC ACID
FURANS

AGRICULTURAL
PRODUCTS

DALA
HALOGENATED
DIPHENOLIC ACID
FORMIC ACID
LIGNINS

TRANSPORTATION
PRODUCTS

CMA
(ROAD SALT)
DALA
(HERBICIDE)
SODIUM
LEVULINATE
SUCCINIC ACID
(LUBE OIL)
CARBON

FUELS
AND
FUEL
ADDITIVES

MTHF
ETHYL
LEVULINATE
METHYL
LEVULINATE
FUEL ESTERS

ENERGY
PRODUCTS

HEATING FUELS
TURBINE FUELS
GASIFIER FUELS
ELECTRIC POWER

ETHYL LEVULINATE (EL)

A NEW ADVANCED BIOFUEL FOR USE

IN

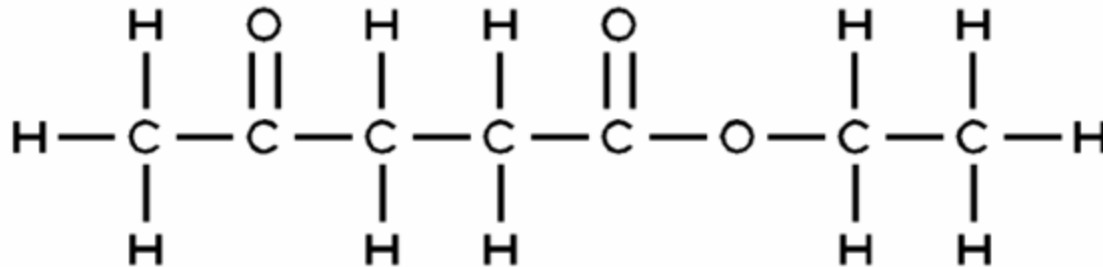
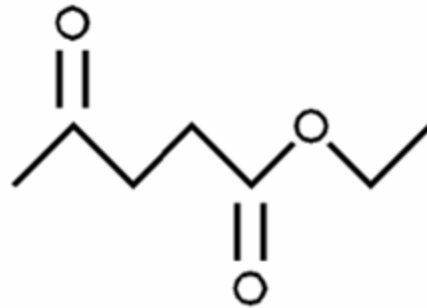
INDUSTRIAL AND DOMESTIC HEATING OIL

ETHYL LEVULINATE
A PRIMARY DERIVATIVE OF LEVULINIC ACID

- **EASILY PRODUCED ETHANOL ESTER OF LA**
- **NON-FOOD FEEDSTOCKS**
- **GREENHOUSE GAS SAVING – OVER 90%**
- **PRESENT MARKET IS IN FLAVORS AND FRAGRANCES**
- **COMPLETELY MISCIBLE WITH BIODIESEL**
- **HIGH FLASH POINT (LOW FLAMMABILITY)**
- **OXYGEN CONTENT - 33%**
- **CLEAN COMBUSTION (HIGH EFFICIENCY)**
- **ROUTE FOR ETHANOL INTO FUEL PRODUCTS**
- **BLENDSTOCK FOR HEATING OIL AND DIESEL**
- **BENEFICIAL CO-ADDITIVE WITH BIODIESEL**

ETHYL LEVULINATE (EL)

CHEMICAL STRUCTURE



ETHYL LEVULINATE **HEATING OIL**

- **HIGH ENERGY CONTENT (100,000 BTU PER GALLON)**
- **EXTREMELY CLEAN BURNING (ELIMINATES SOOT)**
- **PLEASANT ODOR**
- **REDUCES OR ELIMINATES GUM FORMATION**
- **IMPROVES COLD FLOW PROPERTIES (LOWERS CFPP)**
- **REDUCES VISCOSITY AND CFPP IN BIODIESEL BLENDS**
- **REDUCES GREENHOUSE GAS INTENSITY OF H.O.**
- **SUCCESSFULLY TESTED IN H.O. BLENDS**
- **NORA-FUNDED EFFORT UNDER WAY AT B.N.L.**
- **A.S.T.M. CERTIFICATION PROCESS INITIATED**

ETHYL LEVULINATE BIODIESEL (FAME)

- **REDUCES OR ELIMINATES GUM FORMATION**
- **REDUCES VISCOSITY IN FAME BLENDS**
- **IMPROVES COLD FLOW PROPERTIES (LOWERS CFPP)**
- **MUTUAL CO-SOLVENCY IN DIESEL**

MARKET DRIVERS

- **COST EFFECTIVE ROUTE TO ADVANCED BIOFUELS**
- **REDUCE LOCAL AND NATIONAL PETROLEUM DEPENDENCE**
- **DECREASE PARTICULATE POLLUTANTS (SOOT) FROM HEATING OIL**
- **BENEFICIAL FUEL CO-ADDITIVE WITH BIODIESEL (LOWERS CFPP)**
- **UTILIZES WOOD AND WOOD WASTE RATHER THAN FOOD**
- **REDUCES GREENHOUSE GAS INTENSITY OF HEATING OIL PRODUCTS**
- **PRESENTS BENEFICIAL CONFLUENCE IN HEATING OIL STATES OF:**
 - **LOCAL MARKETS (N.E., MID WEST AND MID ATLANTIC)**
 - **LOCAL SITES (PULP AND PAPER MILLS)**
 - **LOCAL FEEDSTOCK (WOOD PRODUCING STATES)**
 - **LOCAL EFFICIENT SUPPLY LOGISTICS**

DISTILLATE FUELS USAGE PROFILE

Millions of Gallons (2007)

Region	Total	Residential and Commercial	Highway
Maine	640	405	180
New England	3,690	2,200	1,120
Mid Atlantic	8,670	3,400	4,230
National	64,330	7,800	39,800

BIOREFINERY CAPITAL & OPERATING COST

Facility type	Large Scale Brown Field
Dry woody biomass (forest residues)	1000 Dry Metric Ton/day
Capacity – (EL Metric Ton /yr)	145,000
ISBL Capital \$MM (incl. power island)	\$175
Feedstock Cost	\$70/dry Metric Ton
Manufacturing cost(\$/MT of EL)	\$606
By Product Credit (\$/MT of EL)	\$180
Return on Equity @20% (\$/MT of EL)	\$72
Total (\$/MT) (\$ per gallon)	\$498 (\$1.90)

FUTURE PLANS AND NEEDS

- **NEED PUBLIC/PRIVATE FUNDING FOR A LARGE SCALE DEMO (DOE APP.)**
- **NEED COMMITMENTS NOW FOR UP TO 80,000 TONS EL PER YEAR**
- **ASTM SPECIFICATION UNDER DEVELOPMENT AT B.N.L.**
- **SHORT TERM (5 YRS) - 40% BLEND WITH BIODIESEL IN “B-5”**
- **THREE COMMERCIAL SCALE PLANTS**
- **LONG TERM - INCREASED USE IN AN “EL-5” HEATING OIL BLEND**
- **TEN COMMERCIAL PLANTS DISTRIBUTED THROUGHOUT MARKET**