



Integrated Biorefinery Research Facility (IBRF) - Overview

Advanced Development and Optimization (ADO) Workshop

December 12-13, 2017

Integrated Biorefinery Research Facility (IBRF)

Biochemical Conversion Pilot Facility



North High Bay (1994)

- Integrated 1 ton/d process train
 - Feed handling → Distillation
- Additional bench and pilot equipment
 - Pretreatment
 - Separations and recovery
- Houses plant-wide utilities systems



South High Bay (2010)

- Two new 0.5-1.0 ton/d pretreatment systems
- High solids enzymatic hydrolysis
- Open high-bay space for temporary equipment and future capabilities

Deconstruction – Sugars and Furanic Intermediates

Feedstock Preparation

Milling/dust mitigation

Preprocessing

- Feedstock washing
- Ash/extractives removal
- Lignin/acetyl removal
- Dewatering

Grinder



Paddle reactor



Screw Press



Pretreatment

Pressurized systems

- Up to 220 °C, 15 bar
- Continuous processing
- Acid, alkali, steam

Atmospheric systems

- Lignin solubilization
- Mechanical refining (~50 kg/d)

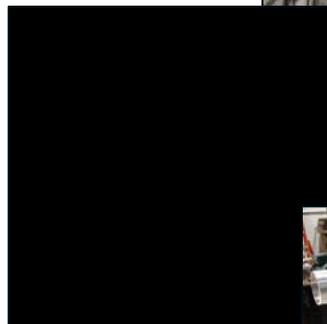
Horizontal screw conveyor



Refiner



Vertical reactors



Enzymatic Hydrolysis

High-solids paddle reactors

- T and pH control

Low solids/fed-batch reactors

- Optional in-line refining

Paddle reactor



Vertical reactors



Biological Conversion of Sugars

Fermentation Systems

Vertical stirred fermentation vessels at several scales

- 20 L (1)
- 160 L (2)
- 1,450 L (2)
- 9,000 L (4)

Anaerobic or aerobic operation

Multiple fermentation process configurations

- Batch
- Fed-batch
- Continuous
- Cascade



Cell Removal/Harvesting

High-speed centrifuges (up to 10,000 x g)

- Batch and continuous
- Effective on yeast and bacteria



Process Separations and Product Recovery

Process Separations

Solid-liquid separations

- Cartridge filtration
- Filtering centrifuges
- Rotary vacuum filter
- Tangential flow filter

Cartridge filters



Filtering centrifuge



Rotary drum filter



Tangential flow filter

Product Recovery

Evaporation

- Sugar concentration and product concentration
- Batch and continuous
 - Atmospheric and vacuum

Distillation

- Single stripping column
- Recovery of alcohols from fermentation broth



Batch evaporator



Continuous evaporator



Stripper column

Process Development and Analytical Laboratories

Process Development Laboratories

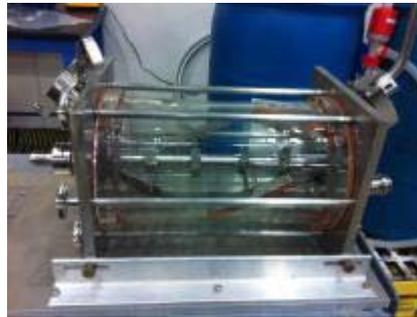
Various bench-scale systems

- Pretreatment
- Hydrolysis
- Fermentation
 - Liquid, solid-liquid, and gas-liquid

Steam explosion



Mini paddle reactor



Bench scale fermenters

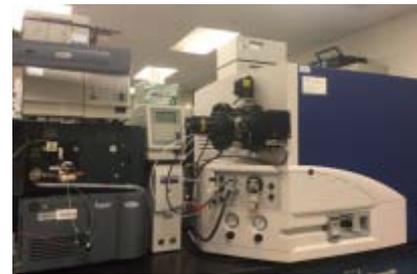


Gas liquid fermenters

Analytical Laboratories

NREL Laboratory Analytical Procedures (LAPs) are a world-wide standard for biomass and conversion intermediates compositional analysis

- Developing new and more efficient methods
- Routinely engage with industrial partners to solve specific analytical challenges



Teaming with Industrial Partners and National Labs

- IBRF pilot plant and lab capabilities are widely applied to solve a variety of process R&D and industrial stakeholder challenges
 - Spanning the entire conversion chain at various scales
 - Supported by compositional, techno-economic, and sustainability analysis

National Lab Consortia Utilizing IBRF Capabilities



Recent Industrial Collaborations Utilizing IBRF Capabilities



Summary

- The IBRF is a unique and versatile resource that provides wide ranging pilot-scale and lab-scale development, integration, and verification capabilities
 - Pretreatment/hydrolysis to generate process-relevant sugars and furanic intermediates for biological/catalytic upgrading to fuels and chemical products
 - Fermentation at several scales and process configurations
 - Process separations and product recovery
- The IBRF has been extensively utilized in many industrial, academic, and federal lab collaborations

