

Biodiesel Process Intensification Projects at Newcastle University

P.I.N. Meeting,
16th November 2006

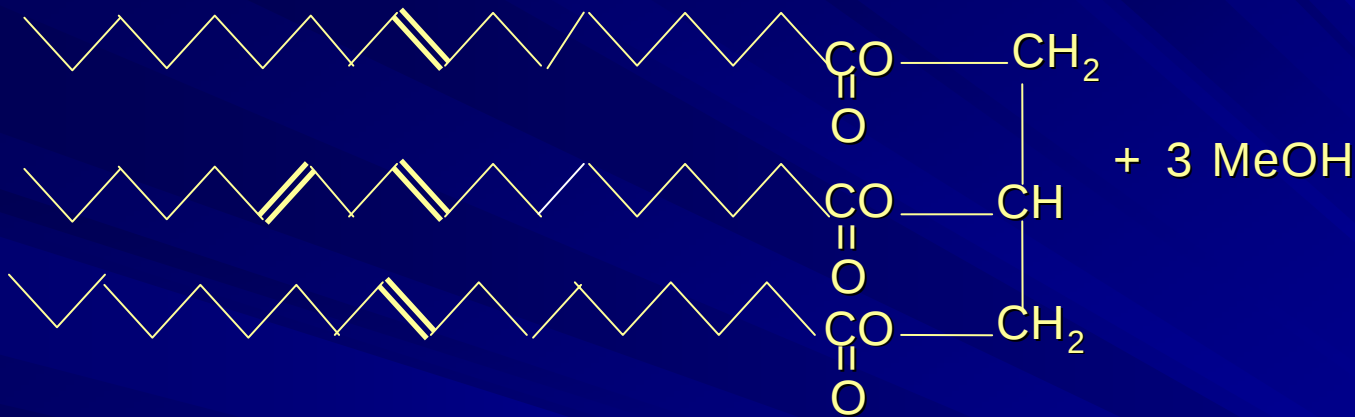
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<http://pig.ncl.ac.uk>

P. I. Group

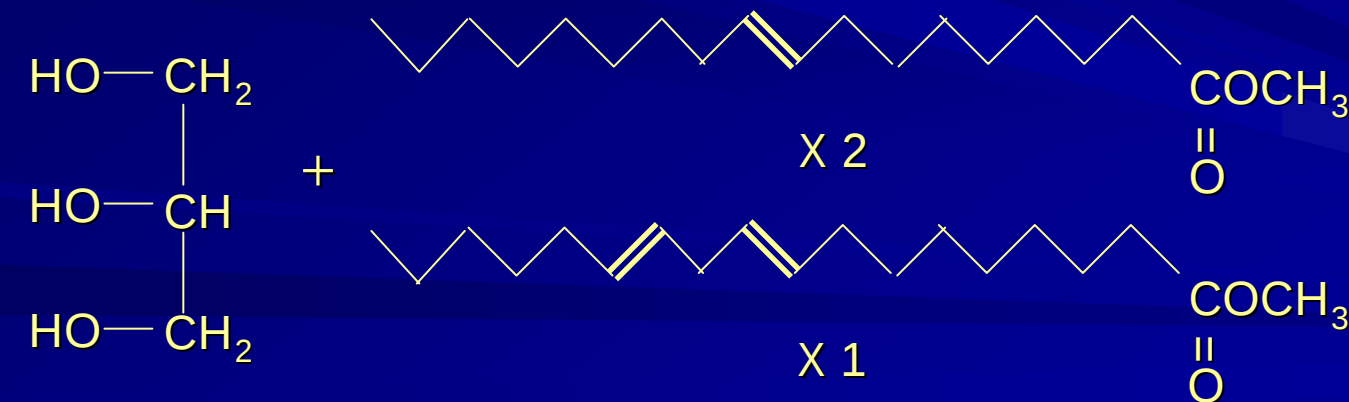
- Currently:
 - 3 lecturers
 - 1 visitor
 - 1 postdoctoral research associate
 - 13 PhD students
- Meetings every 2 weeks (open to all)
- <http://pig.ncl.ac.uk>

The "BIODIESEL REACTION"

Typical Rapeseed Oil Molecule



Catalyst



Glycerol

Typical RME (Rapeseed Methyl Ester)

Lower Viscosity
Cleaner Burning

Why Biodiesel?

1. Renewable
2. Reduced CO₂ emission
3. Reduced pollution

Drivers:

1. Legislation: Renewable Fuels Obligation
2. Tax relief

(Why P.I. of Biodiesel?)

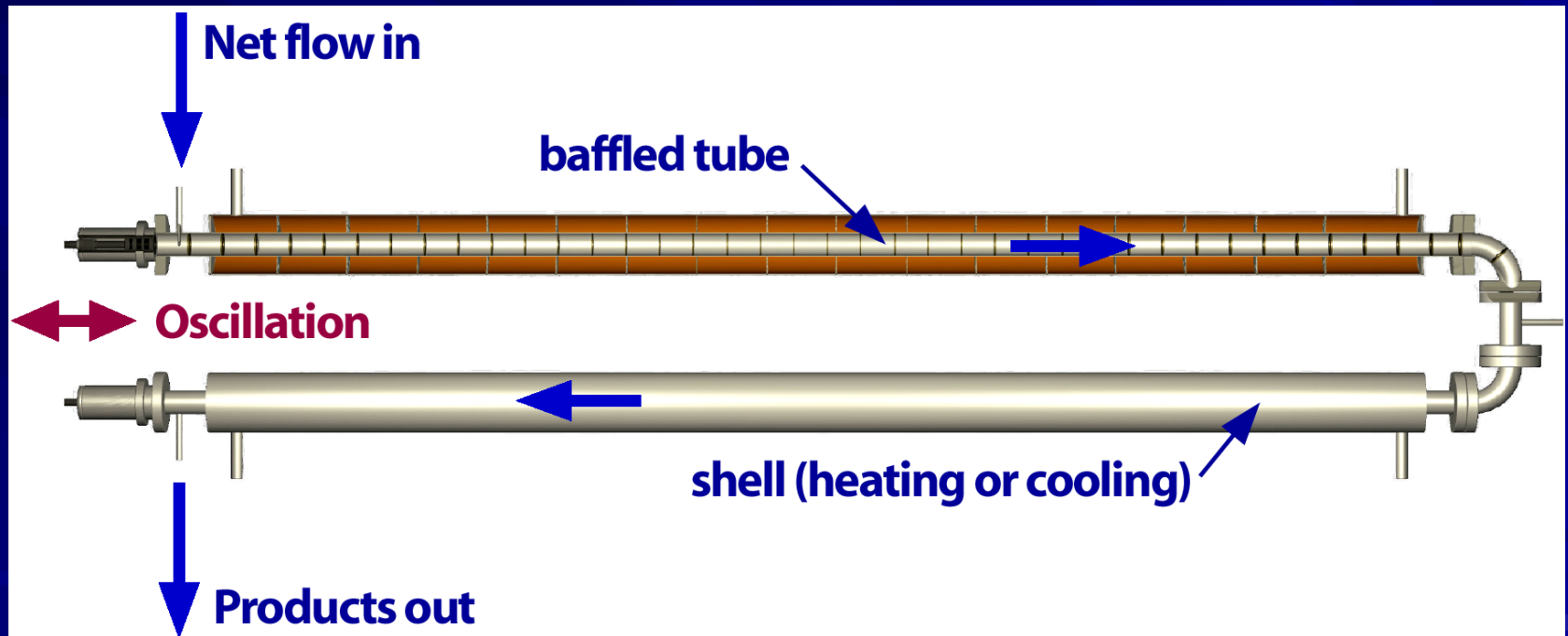
Projects

1. Portable Biodiesel Plant
2. Development of Solid Catalysts for the Biodiesel Reaction
3. Reactive Extraction of Biodiesel

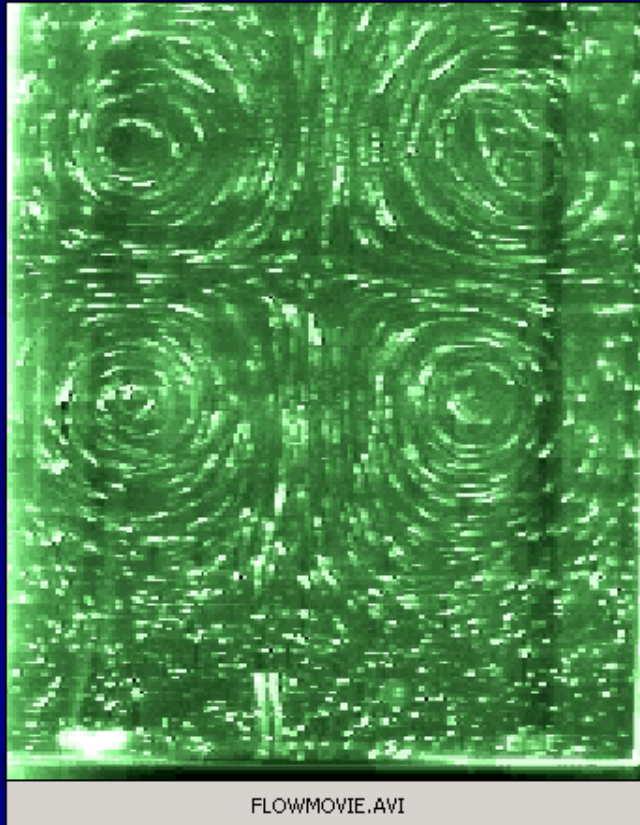
Very briefly:

4. Cold Flow properties of Biodiesels
5. Biodiesel from Algae

1. Portable Plant: An Intensified Biodiesel Plant Based on the “Oscillatory Baffled Reactor”



Oscillatory Flow Mixing



Niche Application of the OFR

Conversion of long residence time batch processes to continuous

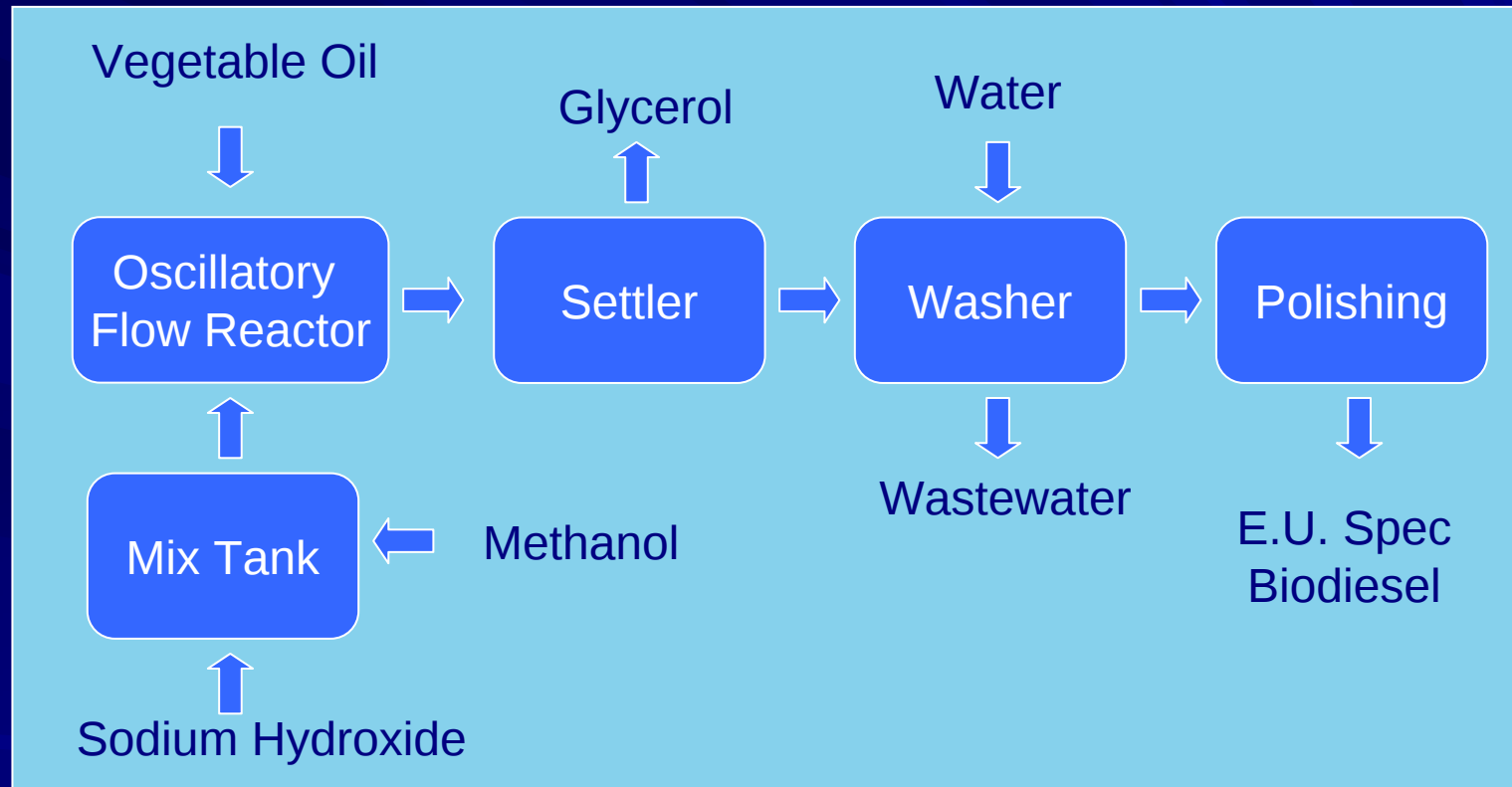
1. Practical, compact design
2. Effective two-phase liquid-liquid mixing
3. Gas-liquid contacting
4. Reduced energy consumption → reduced running costs
5. Smaller reactor due to enhanced (and scaleable) mixing → reduced capital cost

Biodiesel Case Study: Results

Achieved desired conversion in 10 minutes
c.f. industrial processes residence times of
1 – 6h

➔ Considerably smaller reactor, reduced
capital cost, lower energy consumption

Commercial Project: Portable Plant



STANDARD SHIPPING CONTAINER

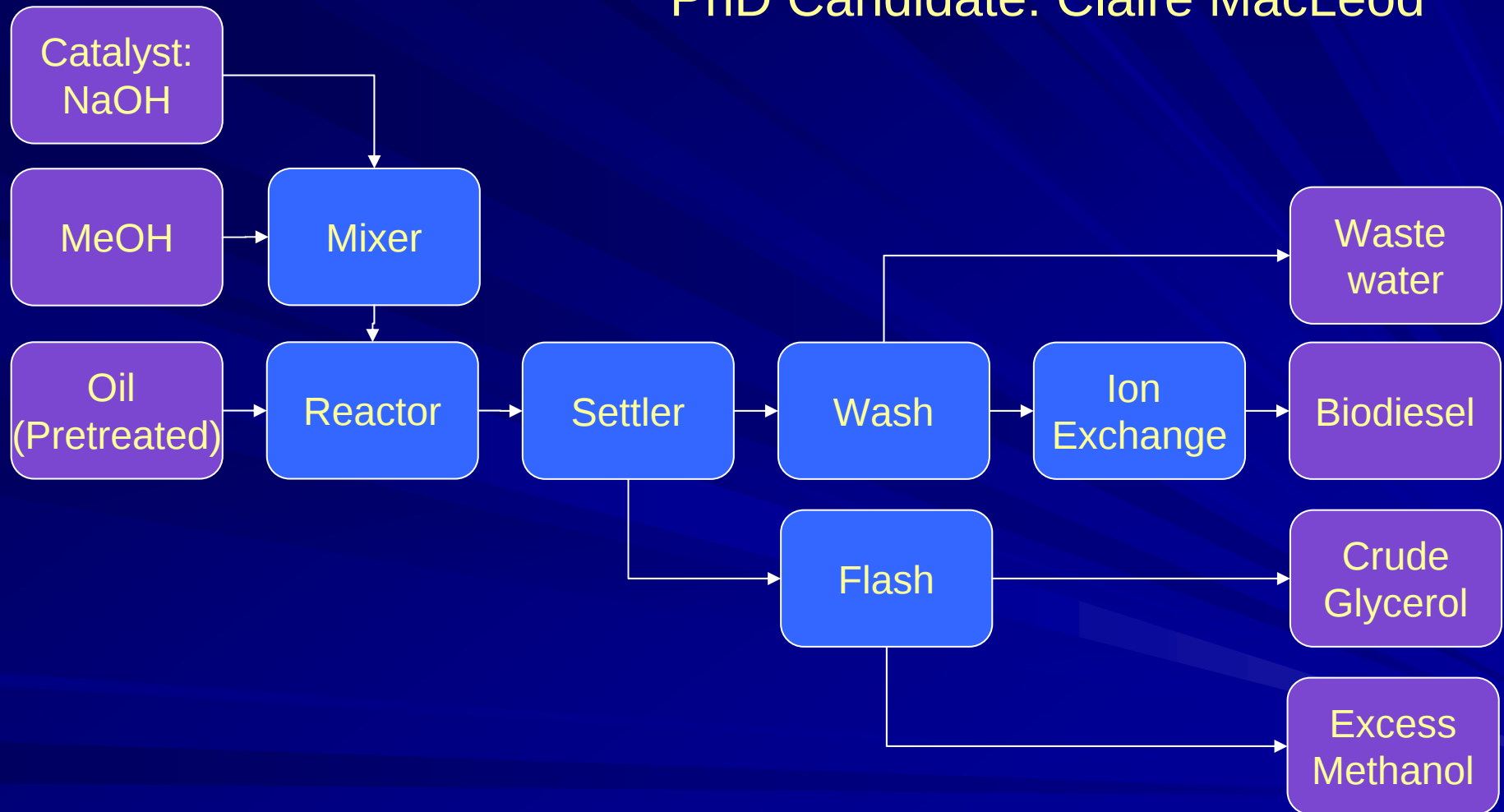
Portable Biodiesel Plant



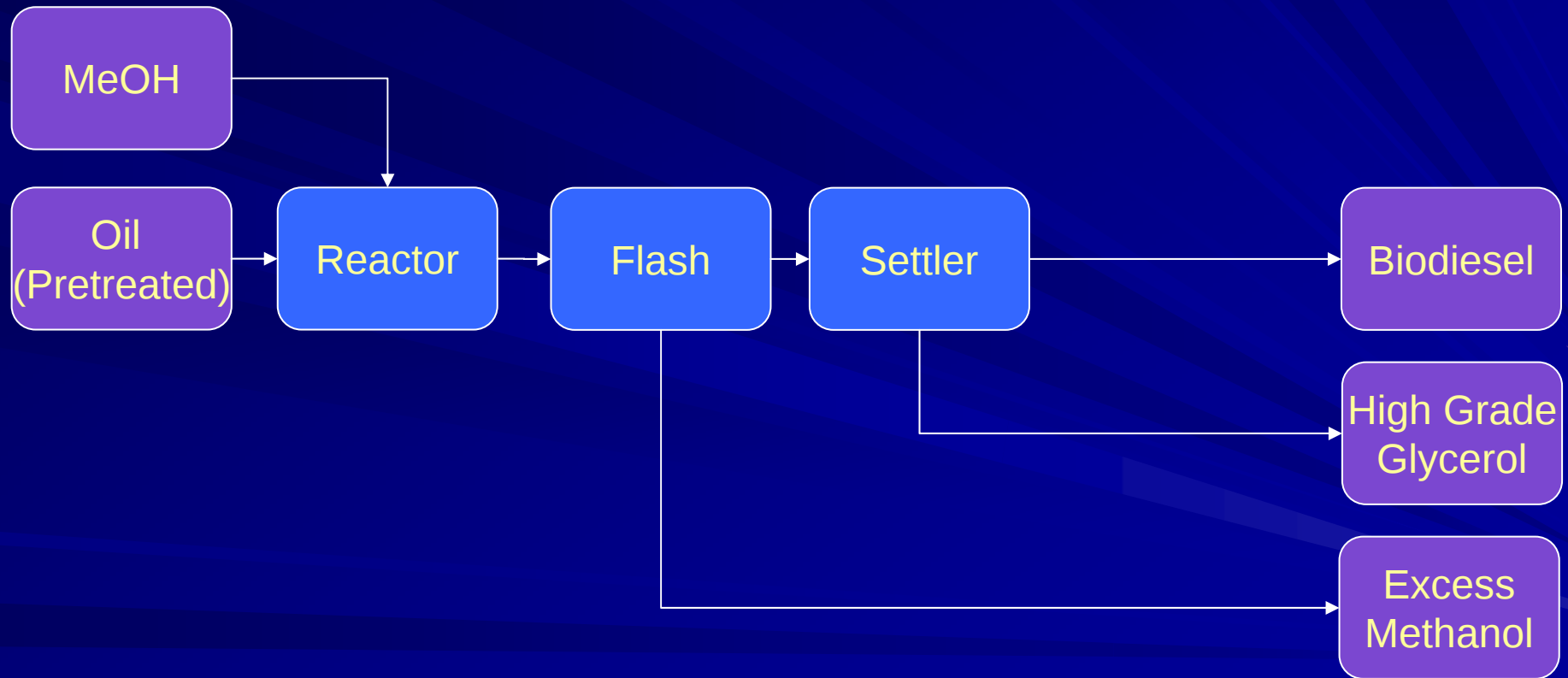
Due next year...

2. Solid Catalysts for Biodiesel Production

PhD Candidate: Claire MacLeod



Conventional Liquid Catalyst Process



Heterogeneous Catalyst Process

Advantages of Solid Catalysts

- Reduce process steps
- Higher quality glycerol/easier glycerol refining
- Greater methanol recovery
- Fewer waste streams

Search for a “Practical” Catalyst

- Solid bases (acids too slow)
- Robust
- Low temperature ($<100^{\circ}\text{C}$) activity
- Inexpensive

Screened:

- Range of alkali metal–doped group II metal oxides
- High voidage polymers with base groups

Results

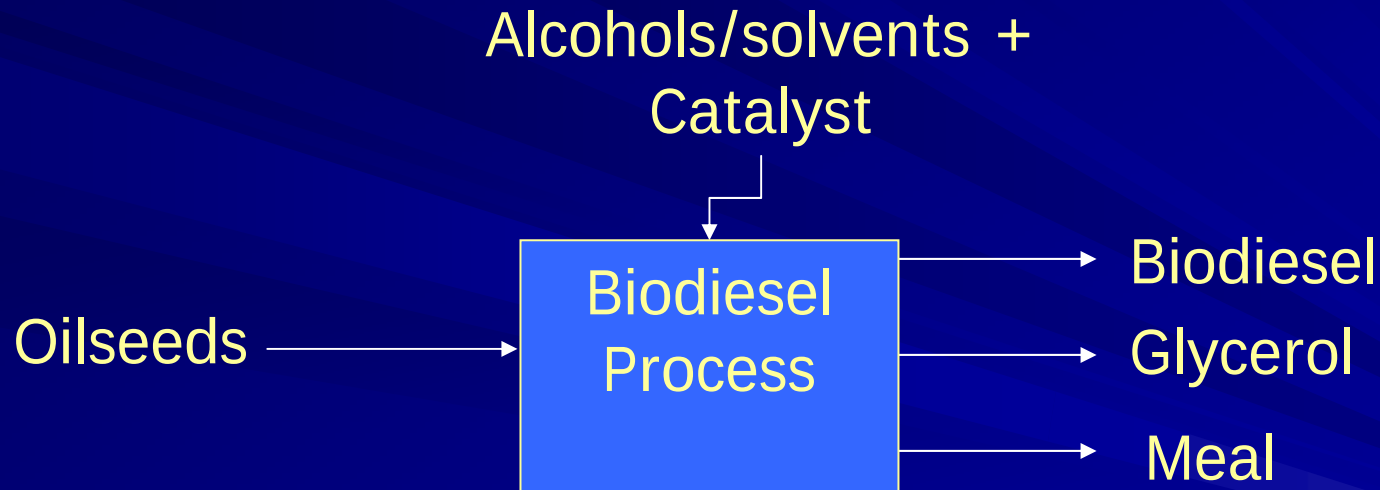
Have identified LiMgO as a good candidate for heterogeneous catalysis:

- Stable
- Inexpensive, and easy to prepare
- Active at 60°C
- Acceptable conversion in 3h

Next step: trials in continuous reactors e.g. monoliths, packed beds etc

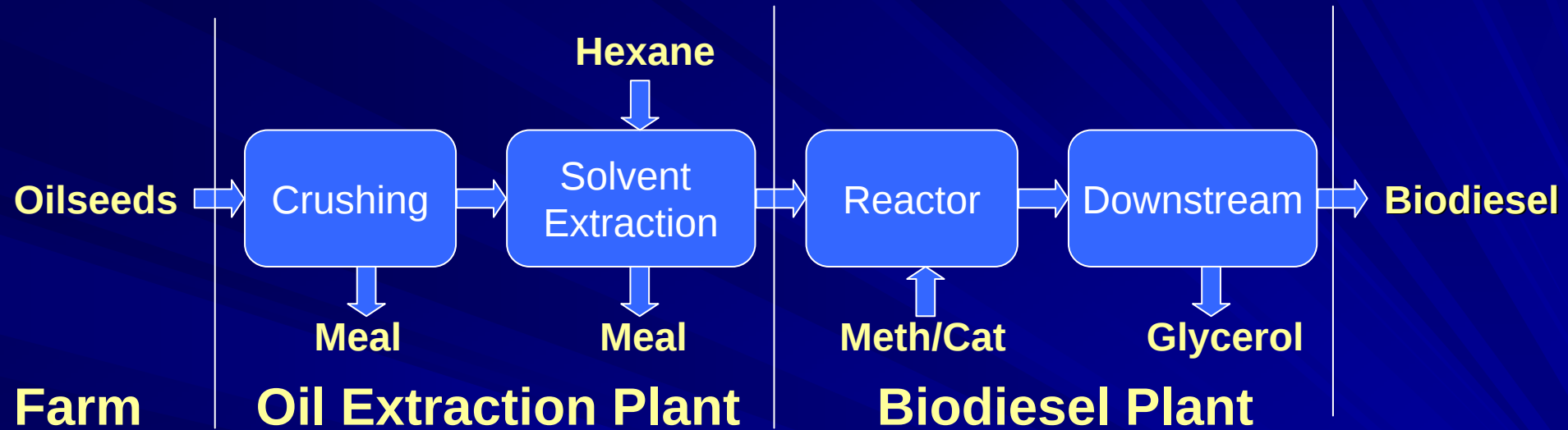
3: Reducing Process Steps: Reactive Extraction

PhD Candidates: Rabitah Zakaria, Khairizal Mahat

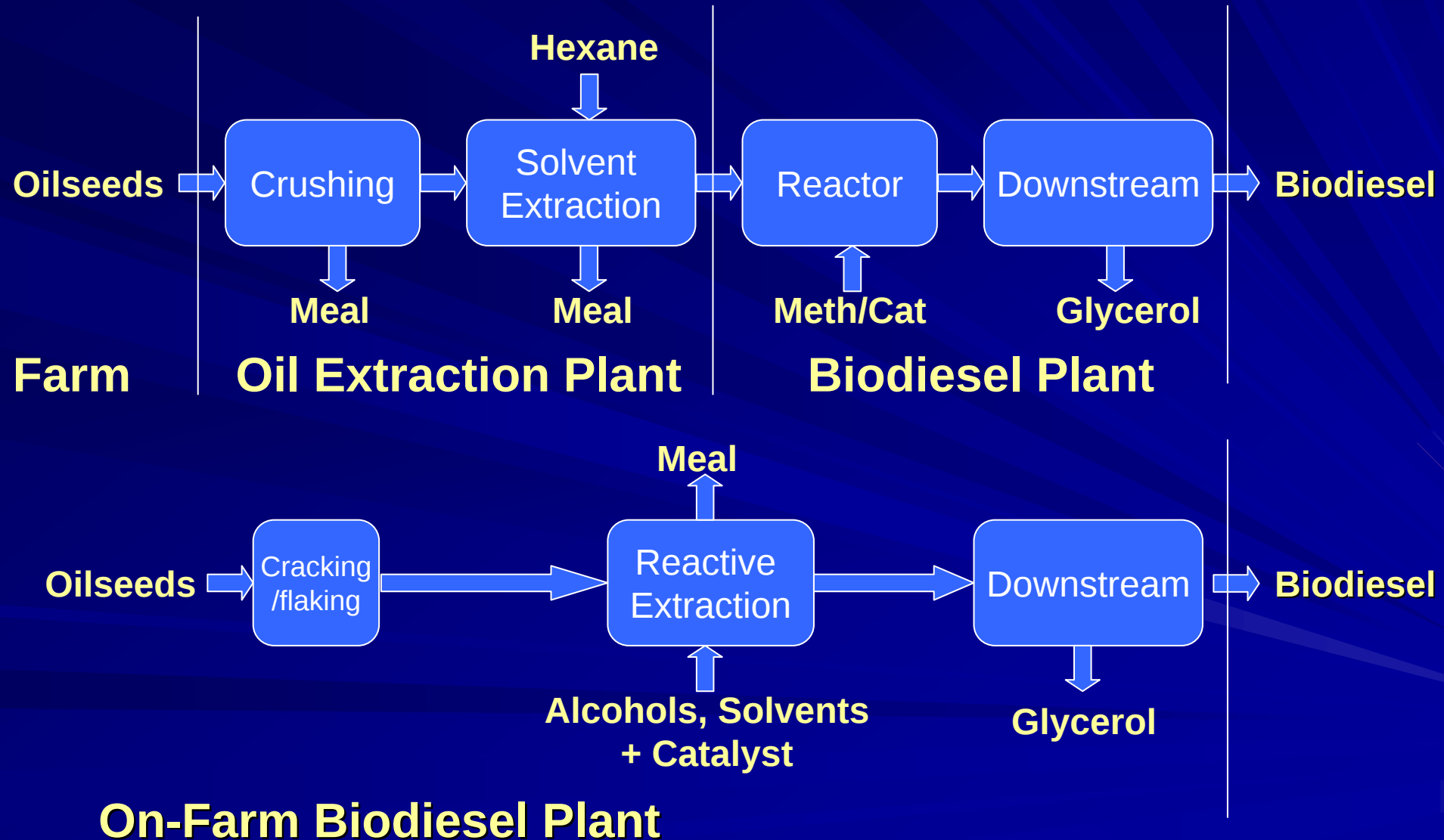


- Would facilitate **distributed production**: e.g. on-farm transport fuel production

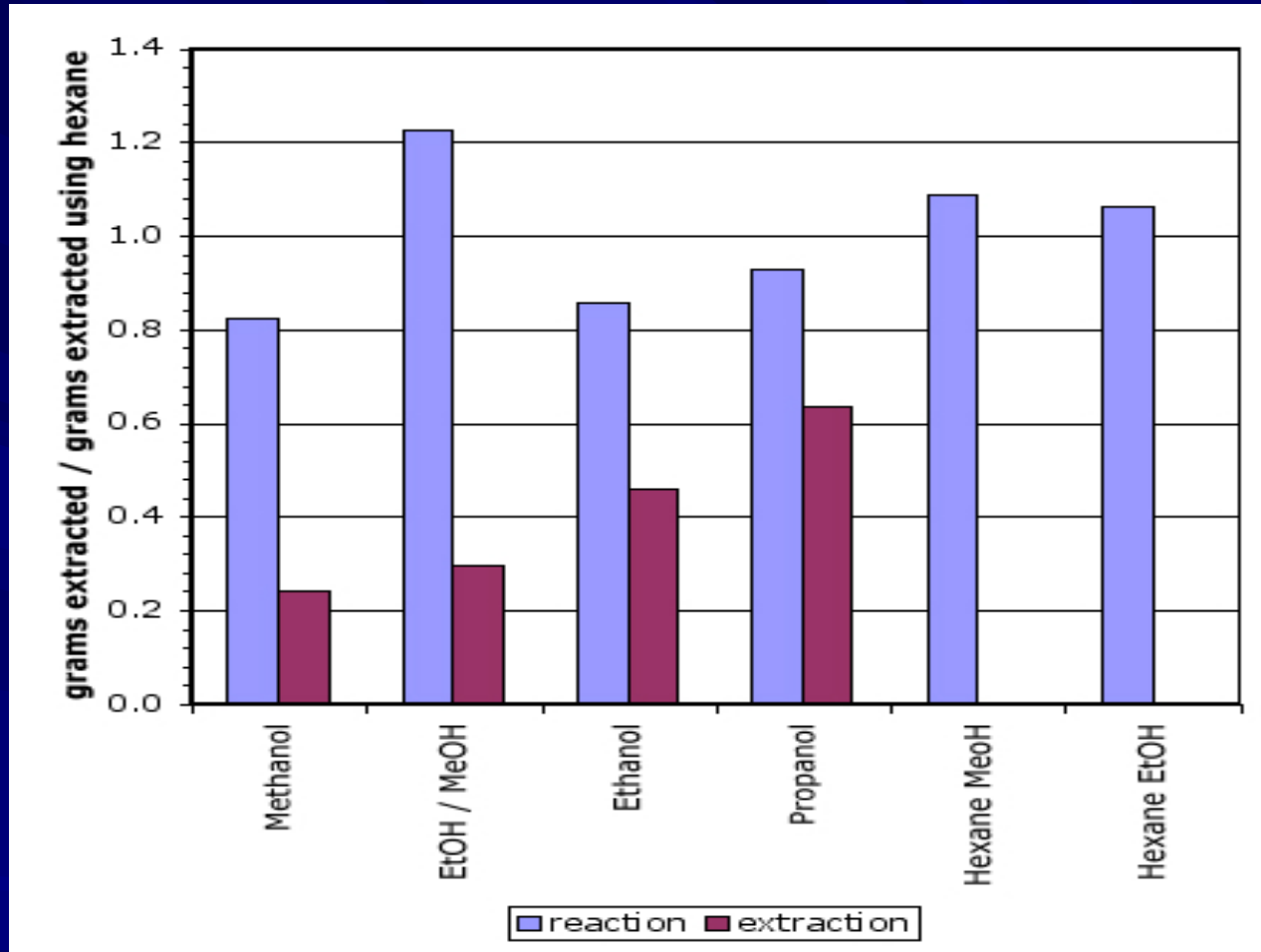
Conventional Biodiesel Production



Conventional vs. Integrated Biodiesel Production



Solvent Extraction vs. Reactive Extraction



1. Enhancement due to reaction
2. Yield increased by using methanol/ethanol mixture

“Mixed Alcohol” Reactive Extraction: Advantages

- Hexane-free
- High yield
- Low temperature (60 °C)
- Distributed production
- Reduced capital cost: fewer and simpler unit operations
- Have also successfully used the solid catalyst

Early Stage Biodiesel Projects

4. Cold Flow Properties of Biodiesels

PhD Candidate: Shahid Rasool

One of the limiting factors for biodiesel is its low temperature performance, as its Cold Filter Plugging Point is higher than that of “petrodiesel”.

A particular problem is producing biodiesel from palm oil for use in Europe.

How can we reduce the CFPP??

Early Stage Biodiesel Projects

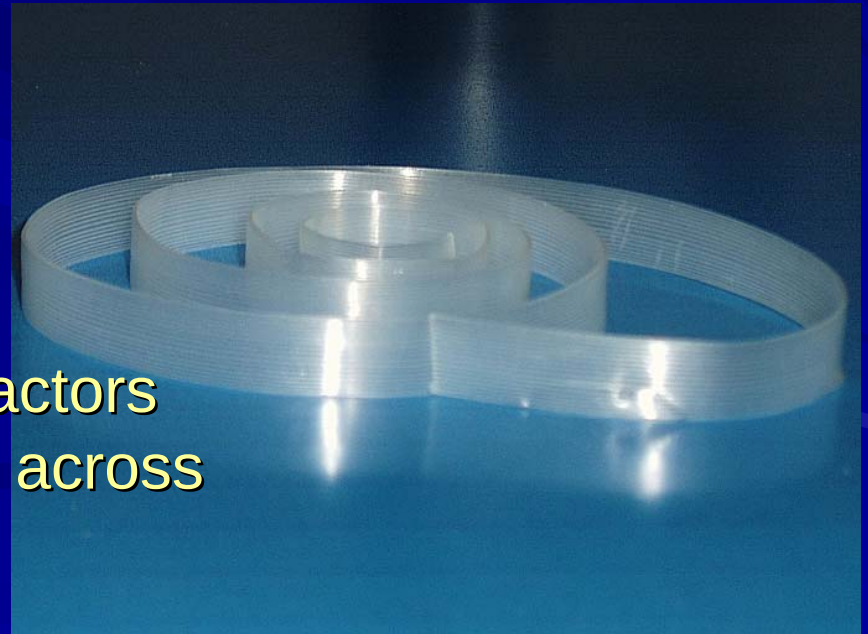
5. Biodiesel from Algae

- Rape seed plants contain 10-20 mass% oil
- Algae contains 30-60 mass% oil

Key factor is **reactor design**:

Evaluating: microcapillary films

Will evaluate: oscillatory flow reactors
(plus any other design we come across
with potential advantages)



Acknowledgments

- Dr Jon Lee
- PhD Students
- Rest of the P.I. Group
- Numerous MEng students & exchange students

Uses for Glycerol

Currently, after refining, cosmetics industry, but that market will soon be saturated (glycerol price already decreasing)

- Burn
- Gasify
- → lactic acid
- → propylene glycol

Opportunity for chemical engineers/chemists: a new, inexpensive, 3 carbon, functionalised feedstock:

“GLYCEROCHEMISTRY”