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POLYESTER COMPONENTS FOR THE CONSTRUCTION INDUSTRY USING GLYCEROL

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SUMMARY

POLYESTERS

✓Obtained via the Polycondensation process of

- Glycerol
- Aromatic acids

✓To replace conventional polyesters in the construction industry in components such as;

- tiles,
- boards,
- sanitary vases,
- sinks.

✓Could offer a low cost environmentally compatible material

✓This paper discusses life cycle analysis considerations of polyesters with respect to the utilization of glycerol as a substitute to petroleum based materials

INTRODUCTION

BIODIESEL INDUSTRY

- Offers the energy network an alternative fuel from renewable resources
- Large quantities of crude glycerol are generated as a by-product
- For every 100 kg of biodiesel produced, a further 10 kg of crude glycerol is also produced (10-30%)

BIODIESEL PRODUCTION
EU economies 2005-2006
-3694 million tons to 7495 million tons
Brazil 2008
- 1.02 million tons

GLYCEROL PRODUCTION -Brazil 2009
- 120,000 tons
ANNUAL DEMANDS - PURIFIED GLYCEROL
-23000 tons

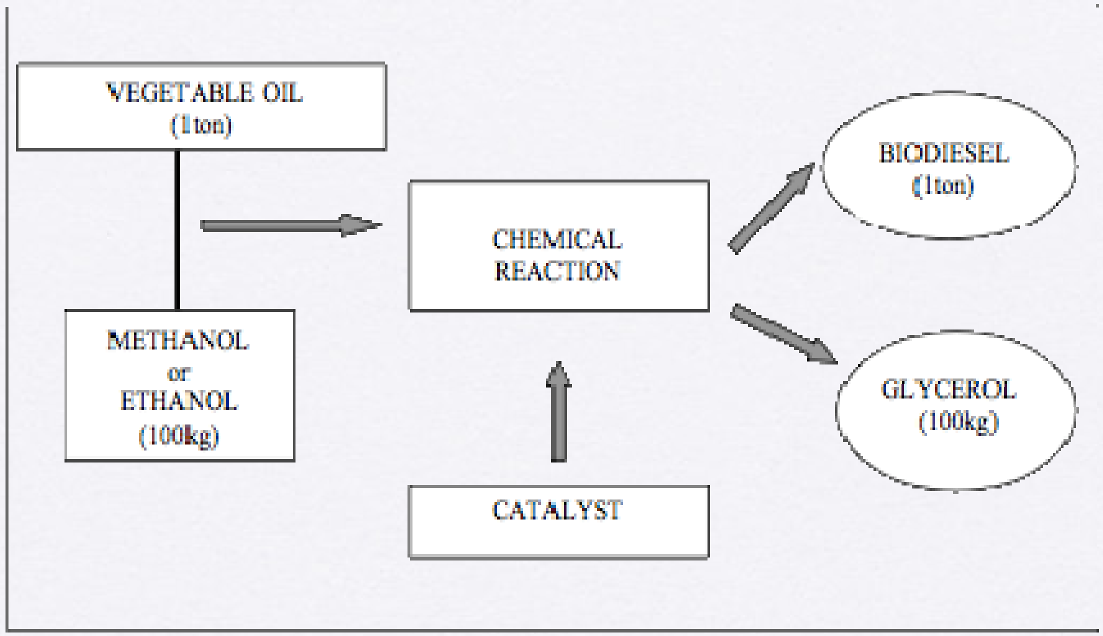


FIGURE I. TRANSESTERIFICATION PROCESS OF BIODIESEL

Large scale applications of glycerol are necessary to accompany its production.

INTRODUCTION

GLYCEROL

- polyalcohol
- oily liquid (at 25°C)
- colorless, odorless, and viscous
- sweet taste and hygroscopic features

APPLICATIONS OF PURIFIED GLYCEROL

- chemical industry
- cosmetics and pharmaceutical industries
- food industry
- esters and resins

- Crude glycerol derived from the biodiesel industry contains many impurities
- fatty acids, methanol, water, soaps
- Requires expensive refining technologies processes
- low annual demands
- low market value
- no economic incentive to refine the crude glycerol into a marketable condition

ENVIRONMENTAL THREATS

- produces acrolein when exposed to temperatures above 290oC
- organic load is greater than that of gross domestic sewage

➡contamination if discarded into natural water systems

- hygroscopic characteristics - causes a rapid consumption of oxygen

SYNTHESIS OF AROMATIC POLYESTERS

Polycondensation process of glycerol and phthalic and terephthalic acids using different molar ratios

METHOD

- Glycerol is introduced into a closed system reactor and heated under constant stirring to 90°C
- Terephthalic or phthalic acids are added.
- The temperature is raised to 120°C
- Two drops of dibutyltin dilaurate catalyst are added in order to initiate the polycondensation reaction.
- The temperature is further raised to 170-200°C in order for the polymerization process to occur.

POLYESTERS DERIVED FROM GLYCEROL

- Crystalline structure can be altered by changing the molar ratio
- Best results obtained with stoichiometric ratio (1,1:5)
- Distinct variations in terms of thermal stability, surface morphology and processing,
  - ➡ partially attributed by their degree of crystalline structure and the linkage between polymeric chains.

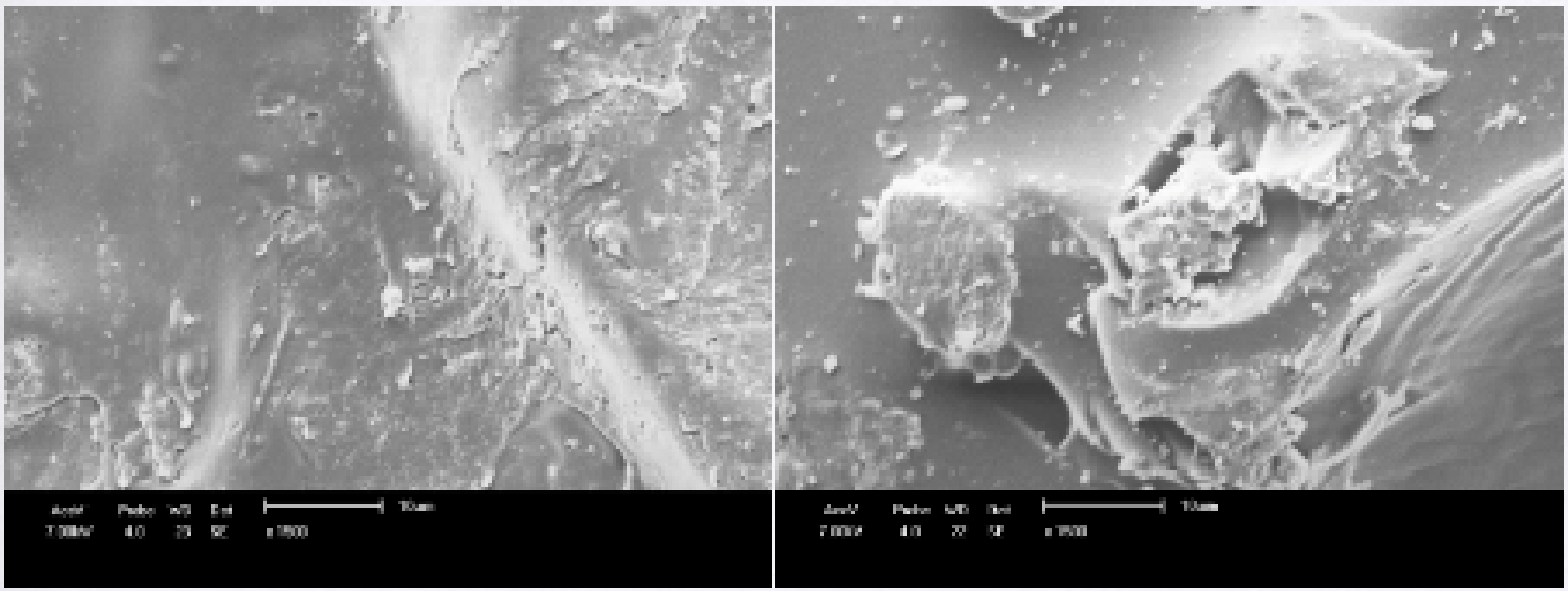
PHTALIC ACIDS- GLYCEROL POLYESTERS

- transparent
- predominantly amorphous in structure
- smooth surface morphology
- thermally stable up to 180°C
- better processing conditions

TEREPHTALIC ACIDS- GLYCEROL POLYESTERS

- translucent
- semi-crystalline material
- rough, angular surfaces
- thermal stability up to 200°C

POLYESTERS DERIVED FROM GLYCEROL



i) ii)

FIGURE 2 -SCANNING ELECTRON MICROGRAPHS x 1500 OF i) POLGE ii) POLGT POLYMERS

POLYESTERS AND THE CONSTRUCTION INDUSTRY

APPLICATIONS

- Cladding and roofing
- Canopy sheets in pre-fabricated buildings,
- Plastic kitchen and bathroom fittings,
- Plastic tanks and reservoirs,
- Window frames, gutters,
- Boards.

POLYESTERS

- Account for 0.29% of all construction materials in the UK
- Polymers in building applications continue to increase
- Versatile
- Durable
- Strong
- Corrosion and resistance characteristics

LIFE CYCLE CONSIDERATIONS

- Construction industry is responsible for;
  - Consumption of 40% of all natural resources,
  - Almost 50% of all CO2 emissions;
  - 50% of all solid waste generated
- In UK, 47.8% of energy consumed and 70.1% of air emissions released within the construction industry are due to mineral extraction and material/product manufacturing stages.
  - Plastics industry is responsible for 5%.
- Non-renewable fossil oil reserves when converted into plastics, are estimated to last a maximum of 27 years

POLYESTERS

- Consume high levels of energy and emit carbon and sulphur dioxides during refining processes.
- Contain additives such as plasticizers, softeners, pigments, stabilizers, preservatives and perfumes, among other toxic chemical substances
- Release heavy metals and other poisonous substances
- Take years to break down into smaller fragments when disposed into environment

LIFE CYCLE CONSIDERATIONS

✓ Utilizing the by-product from biodiesel particularly during the extraction of raw materials, refining and processing stages greatly reduces;

- Inputs - raw materials, fossil fuel energy and water
- Outputs - gas, liquid and solid effluents

✓ Most thermoplastics and some thermosetting polymers can be recycled up to five times before finally being disposed of

➡ Economizing 90% of the primary energy consumption during the processing of the virgin polymer.

➡ Reducing plastic waste designated to landfills.

Further knowledge is required about the recyclability, durability and degradation behavior of these polyesters.

Full cradle to grave Life Cycle Analysis in accordance with the ISO 14000 codes is necessary

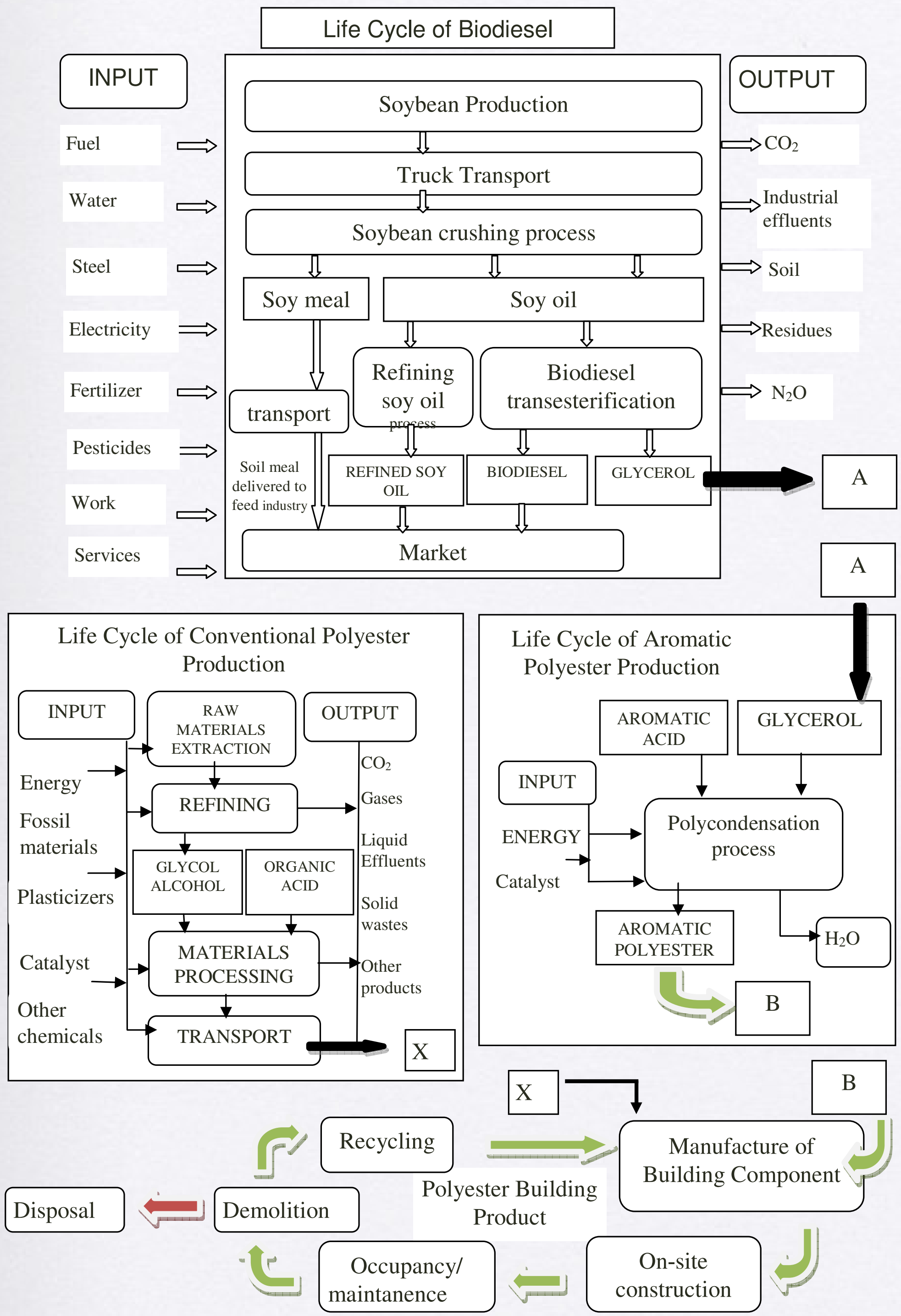


FIGURE 3: LIFE CYCLE DIAGRAM BIODIESEL PRODUCTION AND POLYESTER COMPONENT MANUFACTURE

NEXT STEPS

- Identify the type and degree of cross-linking between polymeric chains
- Determine the changes in crystalline structure, surface morphology and thermal and mechanical behavior when subjected to heat cycles
- Polymer blends - combining aromatic polyesters with recycled plastics
- Natural fiber reinforced composites (sisal, piassava and licuri etc)
- Improve processing and molding techniques and curing times
    - ➡ To optimize environmental performance through reducing energy and overall resource consumption
- Confirm other environmental aspects of these materials so that product service life can be increased, such as:
    - the recyclability, degradability and durability,
    - effects of water absorption, acid rain and salt attacks.

CONCLUSIONS

- ✓ These materials show promising results and could offer a new, environmentally compatible, low-cost material for the construction industry
- ✓ Using industrial wastes such as glycerol, not only is raw material and energy consumption reduced, but the life time of non-renewable resources is increased
- ✓ Economic benefits such as adding value to the productive biodiesel chain and reducing disposal costs.
- ✓ If incorporated with natural fibers; a renewable and abundant material as reinforcements in composite materials, further social and economic advantages would be gained

  ➡ generation of income and employment for rural communities

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