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HOW GREEN MANUFACTURING TRANSFORM TRADITIONAL MANUFACTURING METHODS?

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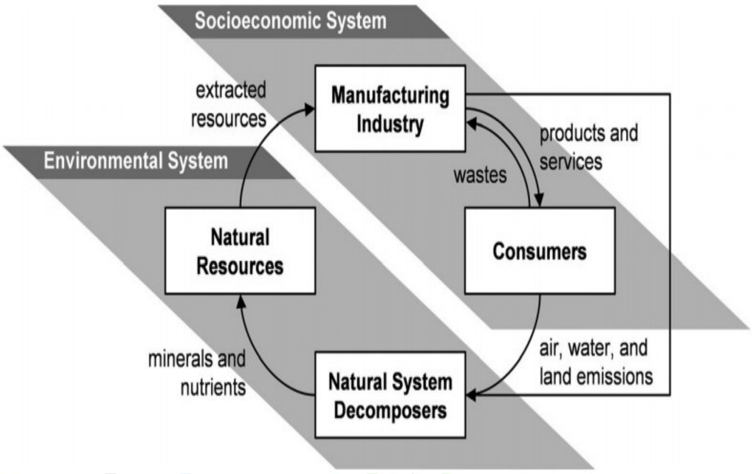
INTRODUCTION

Green manufacturing

Green Manufacturing is a philosophy rather than a standard or a process. It is a method for manufacturing that minimizes waste and pollution through product and process design. The main goal of Green Manufacturing is sustainability. Every manufacturing sector should conserve the resources for future generation. They should also know where their responsibility ends and what is the acceptable level of toxic emission to the environment.

Green manufacturing creates a reputation to public, saves useless cost and promotes research and design. The process of Green Manufacturing involves investing in production process improvements rather than control technology, substitute renewable sources for finite ones, employee recycling and the companies must decide whether to make or buy the product.



TECHNIQUES TO ACHIEVE GREEN MANUFACTURING

- Reduction of emissions
- Lean manufacturing tools
- Clean production process
- Green technologies
- Use of alternative or sustainable energies
- Green practices in productive processes

BENEFITS

Operational	Commercial	Economic
• Increase the quality • Product design improvement • Greater competitiveness, productivity, and efficiency • Optimization in the use of available resources	• Local market expansion • Better customer service • Increase the green products • Greater environmental certifications	• Increase in economic gains • Reduction of marketing costs, material waste, production costs

Selected emerging green technologies: Carbon capture and storage (CCS) and renewables

- Carbon capture and storage CCS
- Focuses on removing CO_2 from fossil fuel uses

What aspects of manufacturing does green chemistry address?

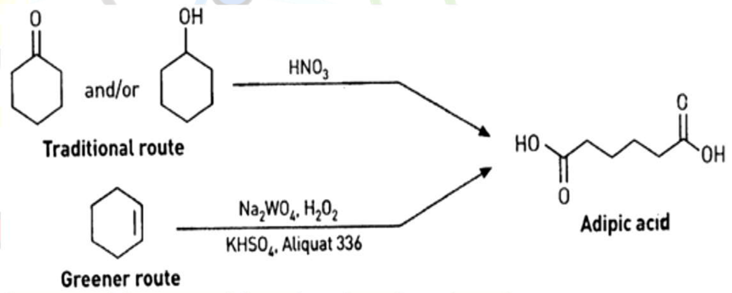
1. Renewable feedstocks
2. Effective ways of converting the whole plant into useful products
3. Reactions involved in making chemical products
4. Traditional catalysts – enzymes
5. Industrial processes and reactors
6. Improved analytical techniques
7. Finding replacements

FOCUS AREAS

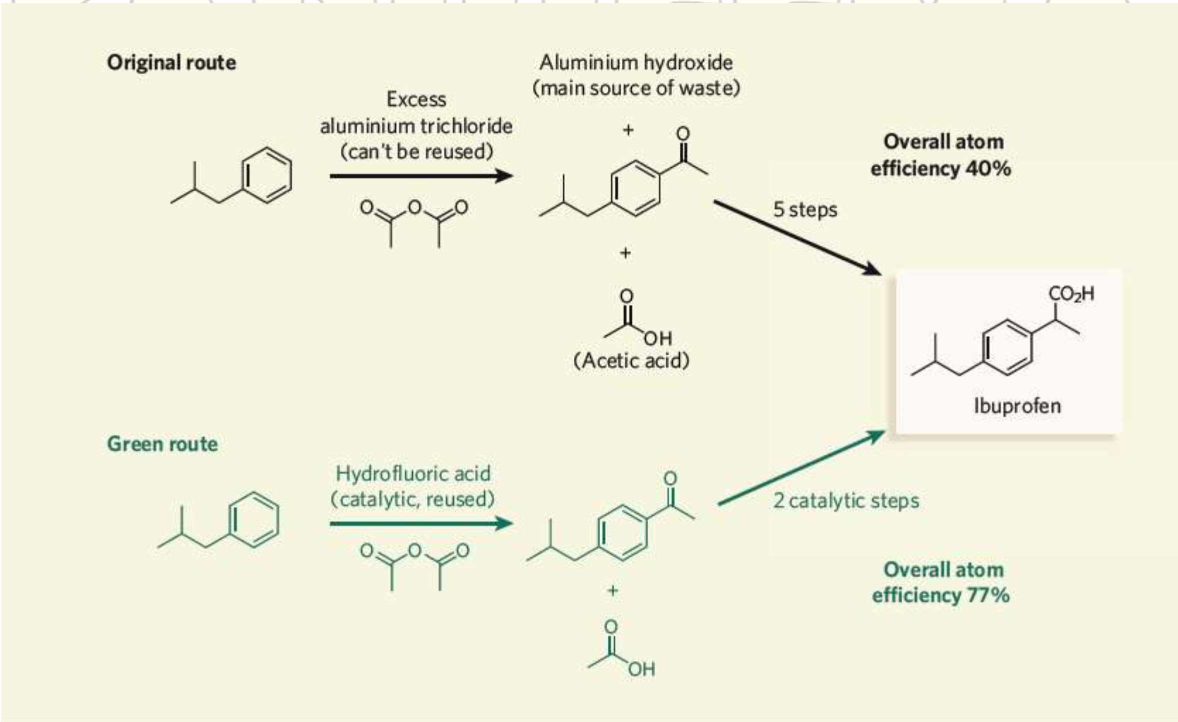
- Alternative synthesis routes
- Alternative reaction conditions
- Alternative chemicals - safer, less toxic or less accident prone.

Synthesis of Adipic acid

- The "greener" method of manufacturing of adipic acid starting chemical as cyclohexene and its oxidation is performed by 30% hydrogen peroxide (H_2O_2). The catalyst is dissolved in a special organic solvent (Aliquat 336). The catalyst is a salt of the metal Volfram or Tungsten (W) (Tungsten catalysts (Na_2WO_4 /$KHSO_4$/ Aliquat 336).
- The biocatalytic method of synthetic adipic acid from D-glucose - achieved with genetically transgenic bacteria *Klebsiella pneumoniae.* The scientist was awarded the "Presidential Green Chemistry Challenge Awards Program" in 1998, USA.



Green ibuprofen



Synthesis of Maleic Anhydrite

- The "old" Method for Synthesis of maleic anhydrite used benzene (C_6H_6) as a starting material and a catalyst which was composed of oxides of Vanadium and Molybdenum, V_2O_5 and MoO_3 (fixed bed reactor).

$$2C_6H_6 + 9O_2\,(air) \rightarrow catalysts \rightarrow 2C_4H_2O_3 + H_2O + 4CO_2$$

- The "new greener" method with starting material n-butane and catalyst $(VO)_2P_2O_5$ (fixed bed reactor).

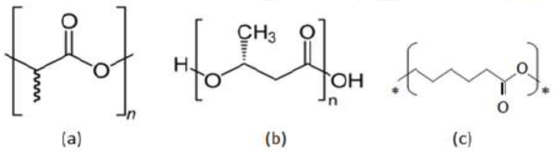
$$C_4H_{10} + 3.5\,O_2\,(air) \rightarrow catalyst \rightarrow C_4H_2O_3 + 4H_2O$$

Textile industry and sustainability

The textile industry is considered as ecologically one of the most polluting industries in the world. Recently a number of steps have been taken to make textile processing greener. These include use of greener fiber, greener dyes and auxiliaries, greener solvents, eco-friendly, optimized and efficient processing, bio-processing, recycling of textile, water and chemicals and elimination of hazardous chemicals.

Bio-polymers

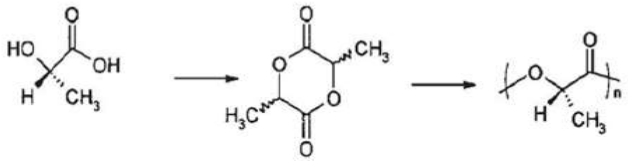
- Bio-based or/and biodegradable
- Produced by living organisms – e.g plastics made from corn, sugar, starch and other renewable raw materials



(a) polylactic acid (PLA)
(b) Poly- (R)-3-hydroxybutyrate (P3HB)
(c) polycaprolactone.

Cargill Dow's technology

- Corn starch (in the united states), tapioca products (roots, chips or starch mostly in asia) or sugarcanes (in the rest of world)
- Process consumes up to 50% less fossil fuel than the conventional PLA manufacturing processes
- Corn → starch → unrefined dextrose → fermentation → D- and L-lactic acid → monomer production → D-, L- and meso-lactides → polymer (PLA) production → polymer modification → fiber, film, plastic, bottle etc



Polymerization reaction

Greener fibres

- Organic linen – flax fibres – without fertilizers and pesticides
- Some chemicals such as substances with high **AOX (adsorbable organic halogens)** values, bluing agents, chelating agents, chlorine compounds, formaldehyde etc. Are prohibited to use for organic textiles.
- The first choice for dyeing organic fabric, where, applicable, could be plant-based natural vegetable dyes. However, their commercial availability is limited. The best choice could be low-impact dyes made from petrochemicals such as **fibre reactive dyes**.
- Mechanical finishing techniques must be explored instead of chemical finishes wherever possible

Conventional process –

- Regenerated cellulose fibres namely rayons are manufactured by dissolving cellulose in conventional solvents followed by precipitation in suitable solution (mostly mineral acids). Both **carbon disulphide** and **cuprammonium hydroxide** are used for dissolving cellulose, but they cause environmental problems. Hence, attempts have been made to develop an alternate process.

Alternate process -

- Lyocell fibres are produced by regenerating cellulose in an organic solvent, N-methyl morpholine-N-oxide (NMMO) hydrate. Non-toxic, biodegradable NMMO solvent is almost completely recycled. The lifecycle of a lyocell fibre has minimal environmental impact. The fibre is significantly more sustainable than oil-derived synthetic fibres (e.g. Polyester, nylon, and acrylic) and natural fibres such as cotton.
- Lyocell fibres are available in the market in the name of Tencel (Courtaulds, USA), Lyo Cell (Lenzig, Austria), and New Cell (Akzo-Nobel, Germany).

Recycled textiles

The sorting categories of textile recycling by volume is represented by a pyramid structure, the base of which consists of

- Used cloth market (48%),
- Conversion to value added new materials (29%),
- Cut into wiping and polishing cloths (17%)
- Landfill and incineration for energy (<7%)

Polyester fibre:

Polyester fibre is one of the most non-biodegradable polymers which create environmental problems. There are two broad types of recycled polyester in the market namely

- Melted and re-extruded into fibres
- Multi-stage de-polymerization and re-polymerization to produce better quality yarn

Greener preparatory processes

- Textile materials possess a variety of impurities that are to be removed before actual dyeing or printing processes
- Use of **enzymes** in textile processing
- Amylase, pectinase, lipase, protease, catalase or peroxidase, cellulose etc.,
- Amylase – desizing agent – removal of starch from fabrics after weaving (pH 5-7)

Modification of dyeing processes

Dyeing is a process of uniform coloration of textile materials using dyes or pigments in aqueous medium. The process demands the use of a large number of chemicals including acid or alkali. This is generally conducted at high temperature for prolonged time. The following are some of the process modifications for making dyeing processes greener:

Process optimization to reduce process time and energy

1. Reduced consumption of water, electrical power and steam
2. Substitution of hazardous sodium sulphide in sulphur dyeing
3. Dyeing with reactive dyes using low or no salt and alkali addition

Multiple savings - automation in textile dyeing and printing

1. Process control
2. Auto-dispensing
3. Computer-controlled weighing and stock-taking
4. Colour measurement and matching - significant improvement in quality

New greener coloration processes

- Continuous preparatory and dyeing methods instead of batch wise methods
- Sustainable digital printing and heat transfer printing which require less water and produces less waste than the traditional printing methods
- Cold transfer printing process (Cooltrans) of reactive dyes at room temperature on pretreated cotton, viscose, linen and silk thereby saving water and heat
- Supercritical carbon dioxide - dyeing or waterless dyeing

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