RAW MATERIALS IN POLYMER TECHNOLOGY

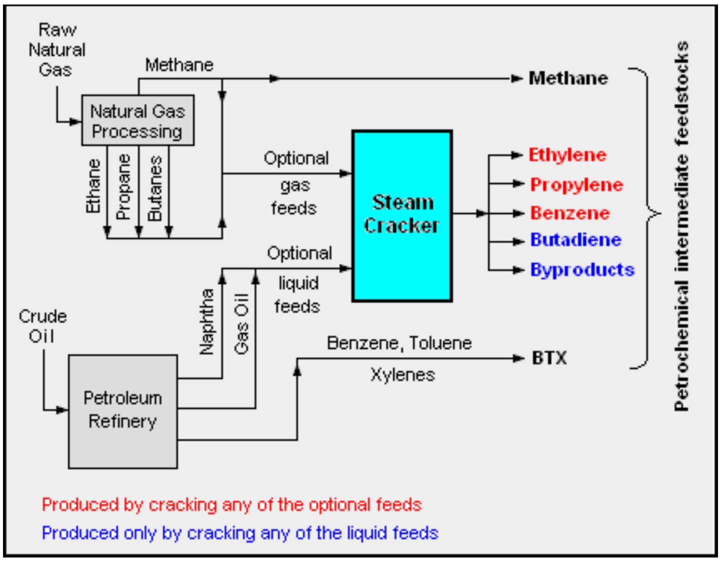
Polymer science and technology I

March 5, 2018

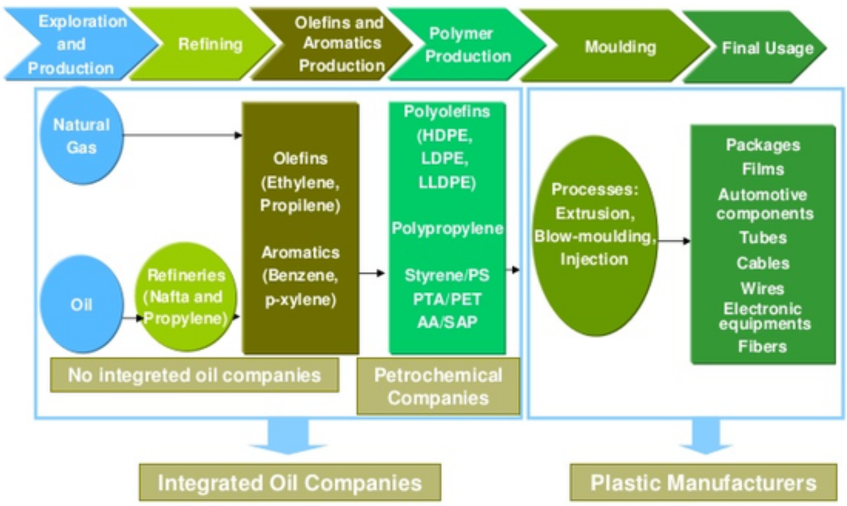
Non-renewable sources

- Petrochemical or fossil plastics are made of fossil feedstocks like petroleum and natural gas which has taken millions of years to be formed.
- Nowadays, about 7% of all petroleum is converted into plastics.
- Examples of fossil-based plastics are polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS) and others.
- Whereas presently these materials are predominantly made from fossil feedstock, they could also be produced from biomass, and would then be bio-based.

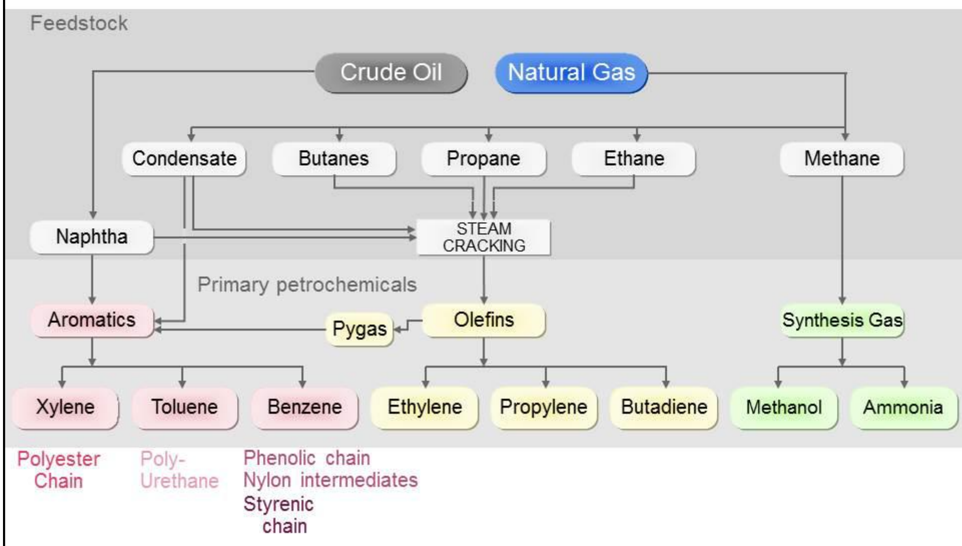
Non-renewable sources



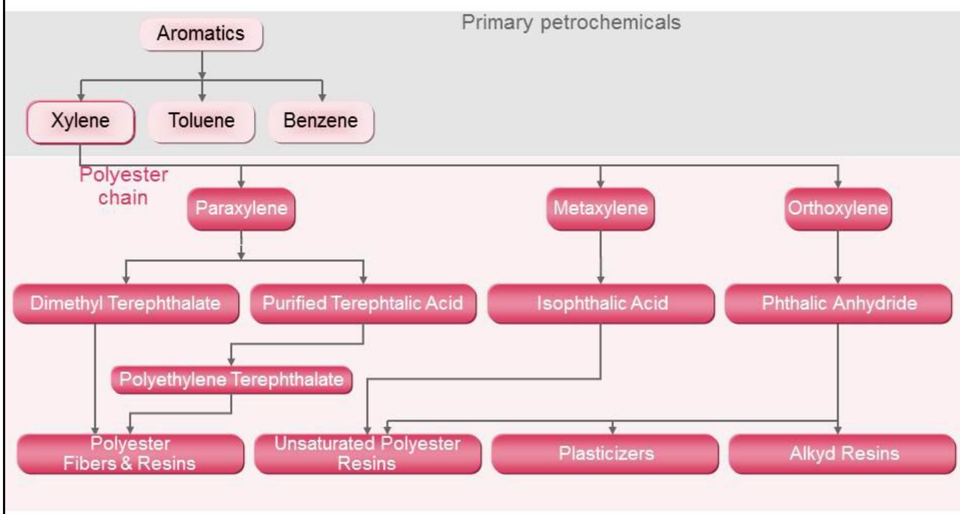
Non-renewable sources



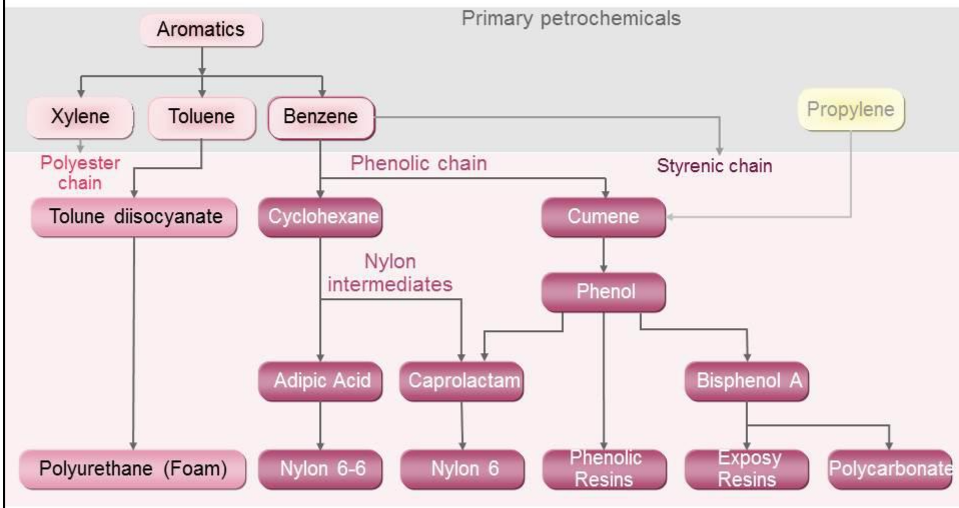
Petrochemical tree
Feedstock and primary petrochemicals



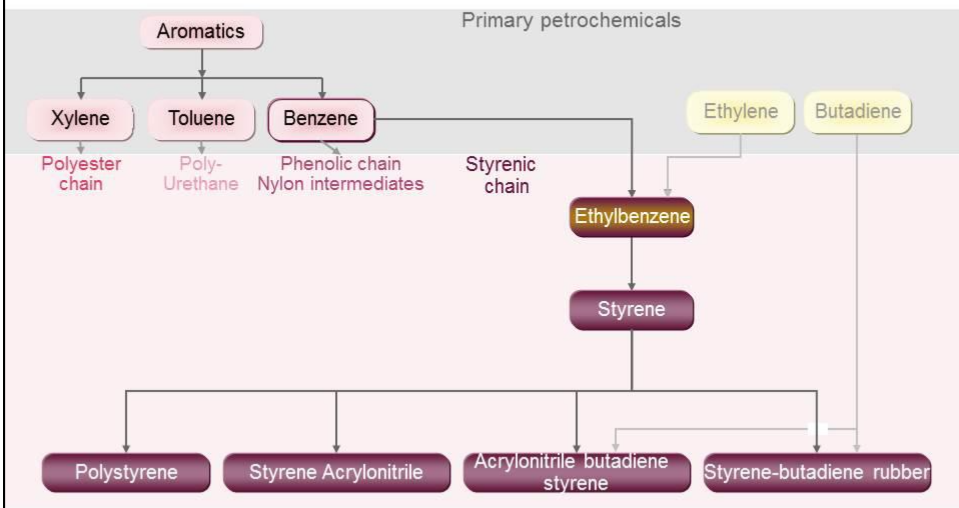
Aromatics – xylene and polyester chain
Derivatives



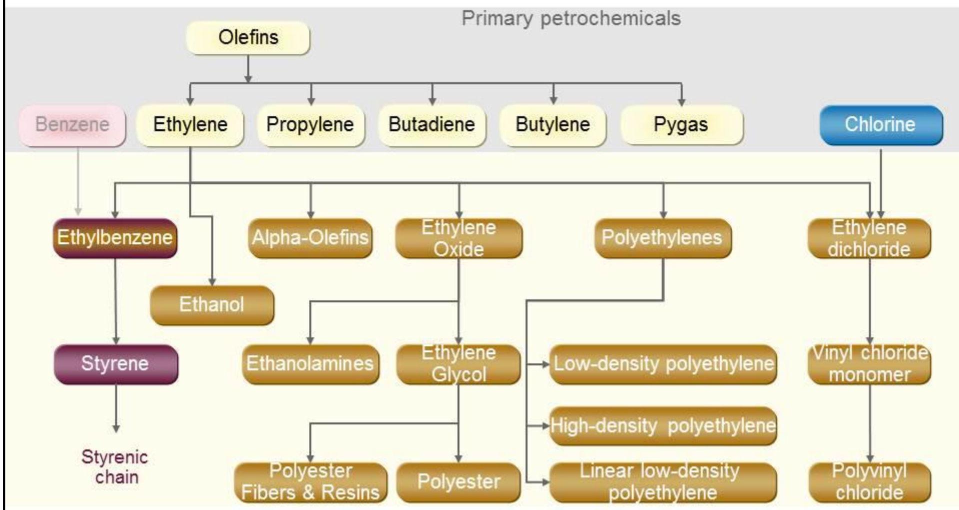
Aromatics – toluene and benzene
Polyurethane and phenolic chain



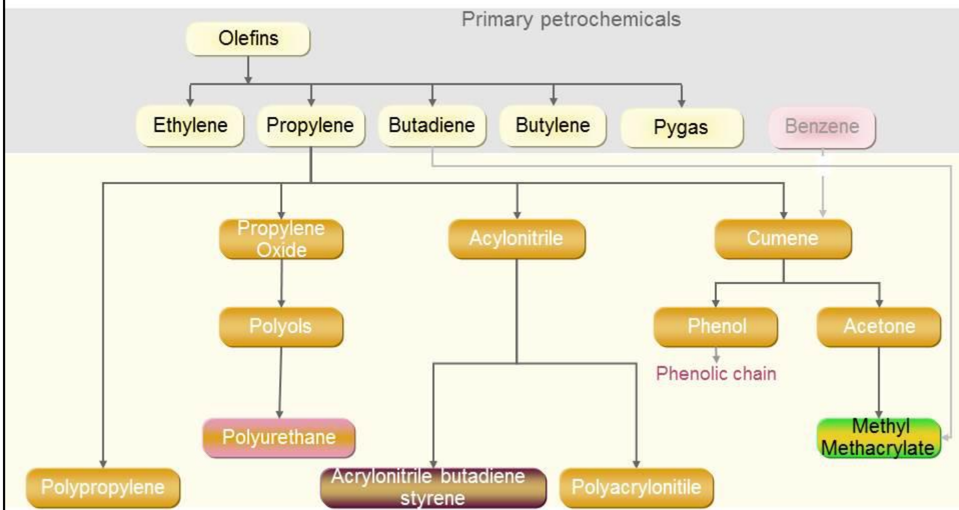
Aromatics - benzene and styrenic chain
Derivatives



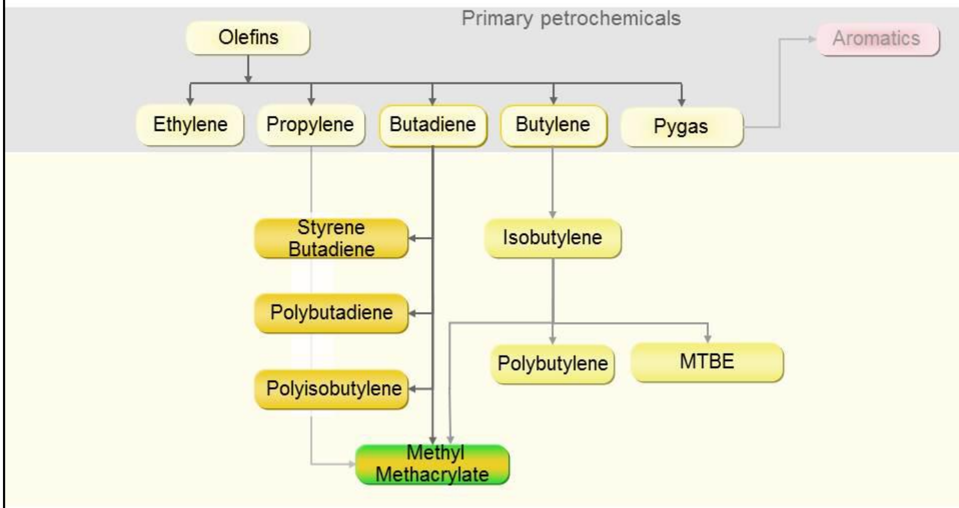
Olefins - ethylene Derivatives



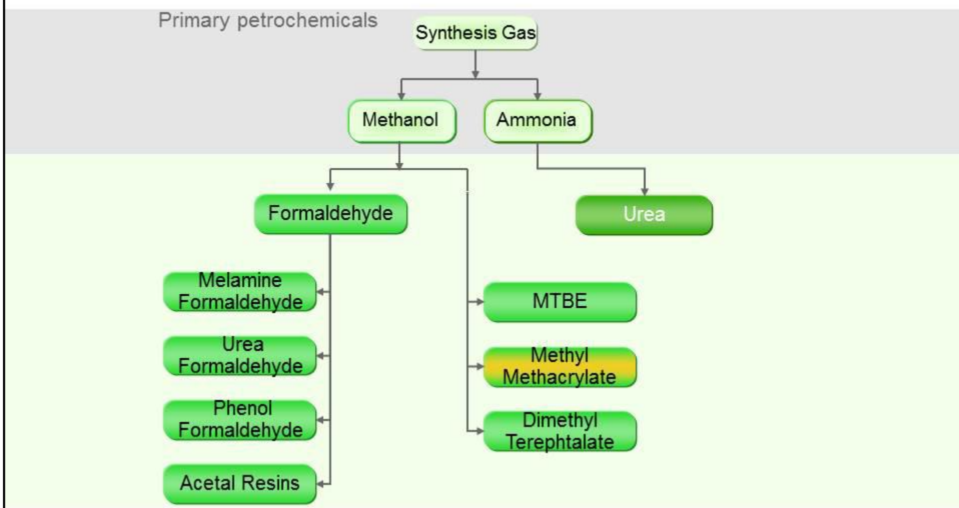
Olefins - propylene Derivatives



Olefins - butadiene, butylenes, and pygas
Derivatives



Syngas - methanol and ammonia
Derivatives



Renewable sources

- Consumed feedstock may be called renewable when it is collected from resources which are naturally replenished on a human timescale, in contrast to fossil oil which takes millions of years to be formed.
- Bio-based feedstock can be called renewable as long as new crop cultivation balances harvesting.
- Wood, some plants (corn, soy, oats), algea, fishes, anilmals
- For instance, peat (turf) is not considered renewable due to slow regeneration rate, and tropical hardwood only is renewable when well managed.
- Consequently, bio-based is not intrinsically ‘renewable’.

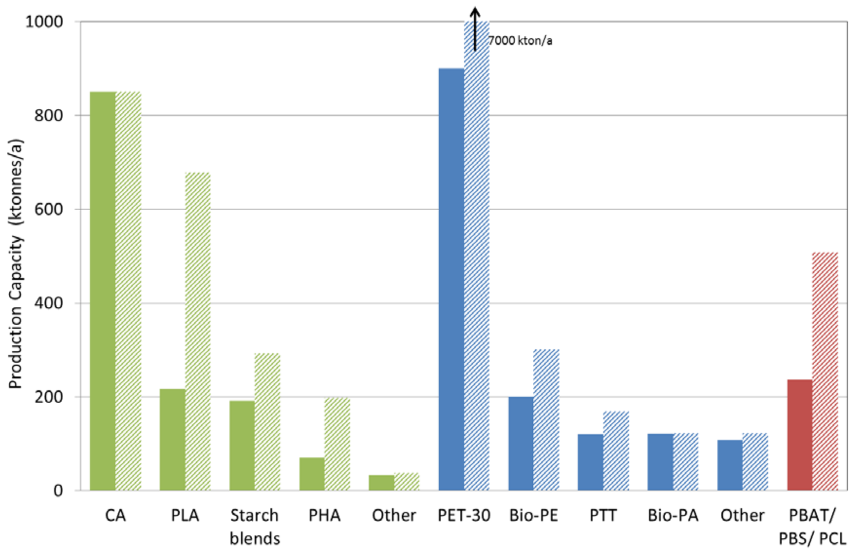
- ‘Bio-based’ is defined in European standard EN 16575 as ‘derived from biomass’.
- Therefore, a bio-based product is a product wholly or partly derived from biomass.
- Biomass is material of biological origin, excluding material embedded in geological formations and/or fossilized (EN 16575, 2014).
- Examples are paper and wood, but also plastics such as PLA whose building blocks are produced from sugars.

Bioplastics

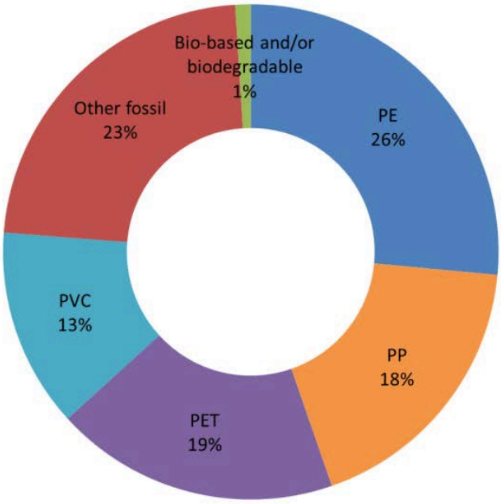
- The term bioplastic refers to either the bio-based origin of a plastic or to the biodegradable character of a plastic.
- Bio-based and biodegradable are not synonymous.

	Petrochemical	Partly bio-based	Bio-based
Non-biodegradable	PE, PP, PET, PS, PVC	Bio-PET, PTT	Bio-PE
Biodegradable	PBAT, PBS(A), PCL	Starch blends	PLA, PHA, Cellophane

- Like fossil-based plastics, bio-based plastics are available in many grades with a wide variety of properties.

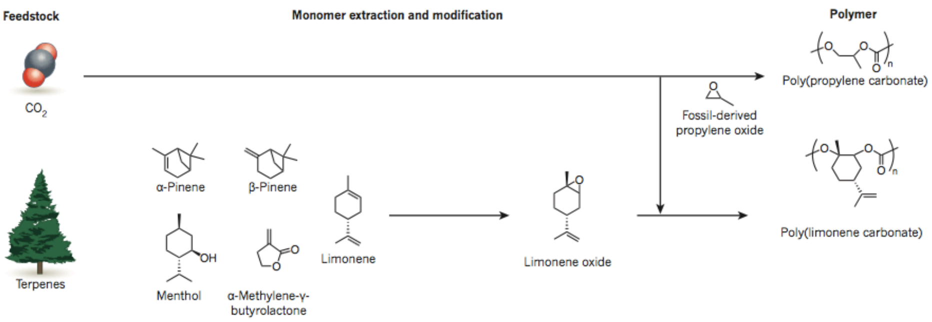


Global production capacity data in 2015/2016 (solid bars) and announced production capacities for 2020 (shaded bars) of bio-based biodegradable polymers (Green), bio-based non-biodegradable (drop in) polymers (Blue) and fossil-based biodegradable polymers (Red).



Global bio-based and biodegradable production capacity data in 2015 and fossil plastic production data at different years in the period 2007-2016: Shares of 302.000 ktonne in total.

Options for replacing petrochemicals as raw materials in the manufacture of polymers



- Carbondioxide is copolymerized with propylene oxide to generate propylene carbonate polyols.
- Terpenes, such as limonene, are chemically transformed to limonene oxide and copolymerized with carbon dioxide to generate poly(limonene carbonate).

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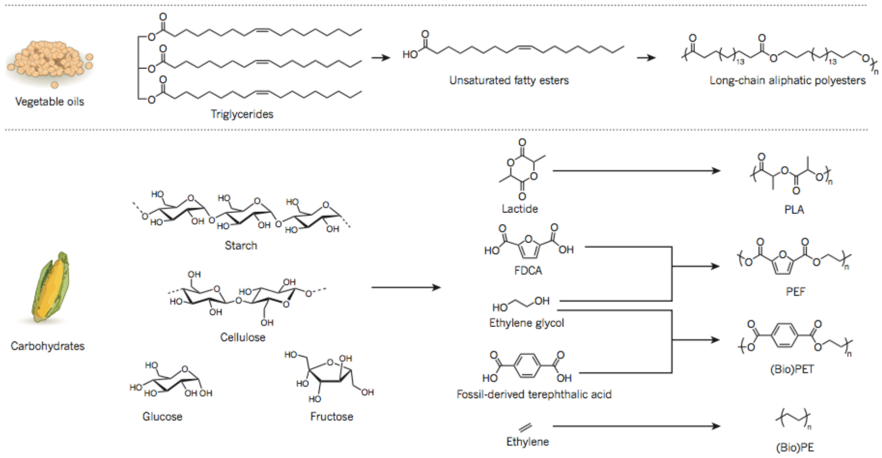
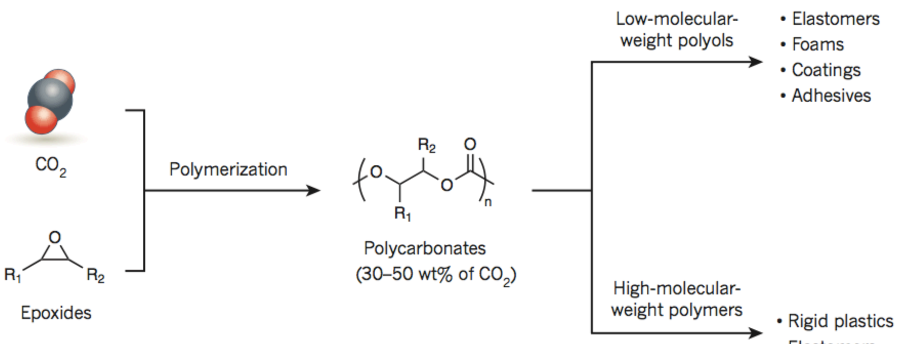


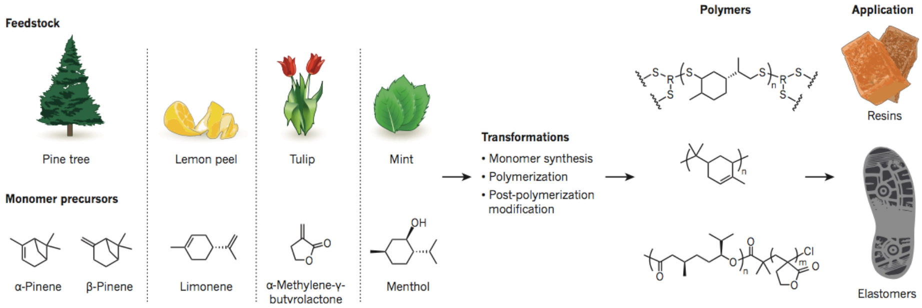
- Vegetable oils, are transformed into long-chain aliphatic polyesters.
- Natural carbohydrate polymers, such as starch, are broken down to glucose, which is subsequently transformed to polymers such as poly(ethylene furanoate) (PEF), polylactide (PLA), bioderived poly(ethylene terephthalate) ((bio)PET) or bioderived polythene ((bio)PE).

Upcycling of carbon dioxide into sustainable polymers of high value



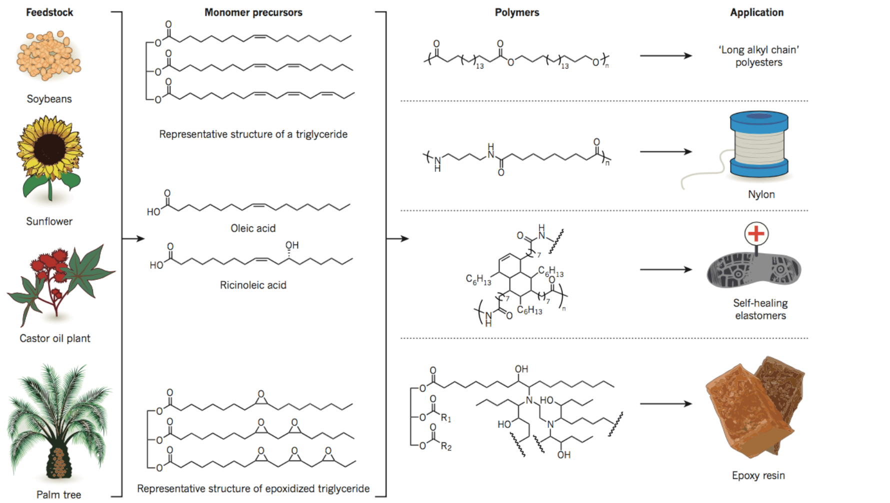
- Carbon dioxide and epoxides can be copolymerized to deliver aliphatic polycarbonates.
- Polycarbonate polyols of low molecular weight may be suitable to prepare foams, coatings and adhesives, whereas high- molecular-weight polycarbonates may be used as rigid plastics or elastomers.

Sustainable polymers produced from terpenes and terpenoids



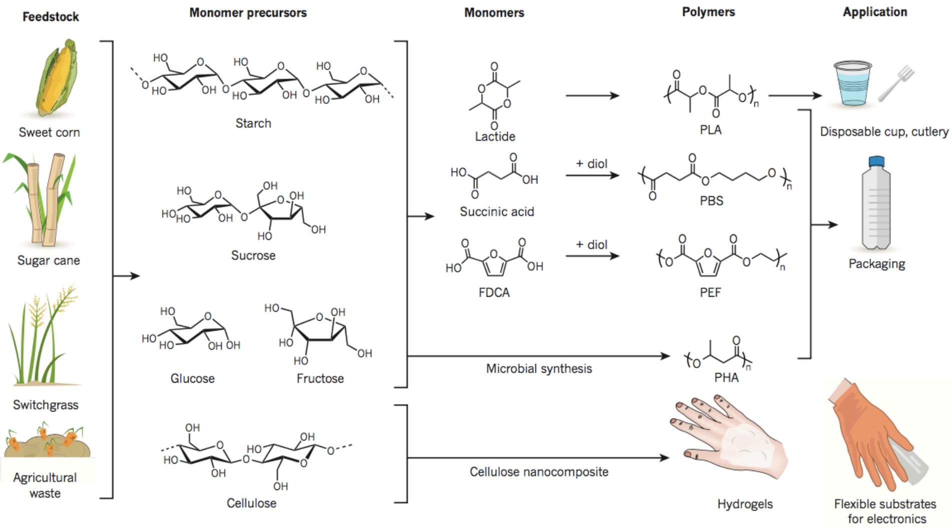
- Terpenes such as pinene and mentholare extracted from plants such as pine or mint.
- They can then be transformed into polymer resins or elastomers before being used.

Sustainable polymers produced from vegetable oils



- Plants such as soy bean, sunflower, castor oil or palm tree are good sources of triglycerides.
- The triglycerides are transformed to polymers such as polyesters or nylons and are subsequently applied as elastomers or resins.

Sustainable polymers produced from polysaccharides



- Plants such as sugar cane and maize are good sources of sucrose or starch, which can be transformed to monomers, including lactide, succinic acid and 2,5-furandicarboxylic acid (FDCA).
- The monomers are polymerized to produce polylactide (PLA), poly(butylene succinate) or poly(ethylene furanoate) (PEF), respectively. Poly(hydroxyalkanoate) (PHA) may be produced directly from glucose by biosynthesis. Cellulose fibres can be used to reinforce composites for use as hydrogels or flexible substrates for electronics.

Prices of polymer depends on

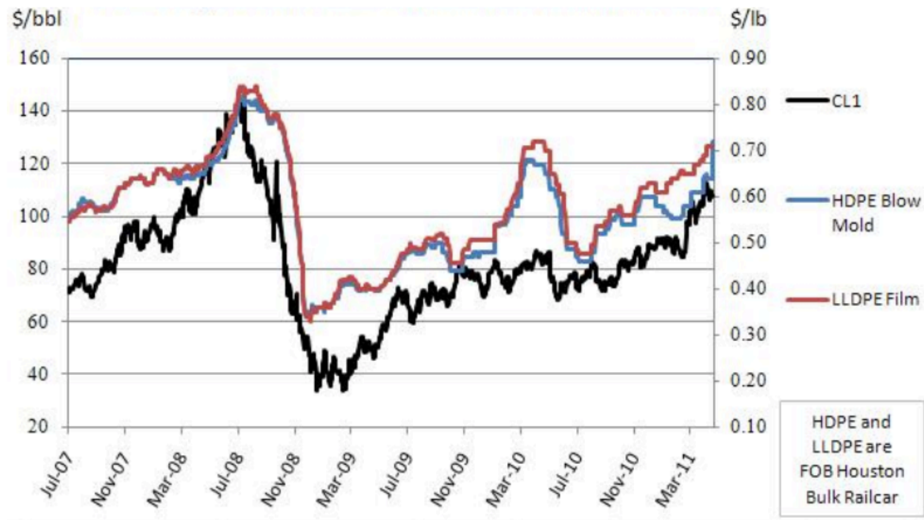
- the price of crude oil
- the production cost
- the production capacity
- the demand

Production cost includes

- the cost of non-petroleum components
- the cost of equipment
- the cost of processing conditions
- the cost of labor
- the cost of environmental protection costs
- the cost of energy consumption

Price level of fossil-based plastics in 2016

Plastic	Price level 2016 (€/tonne)	Density (kg/m^3)
LDPE	1250 – 1450	910 – 940
HDPE	1200 – 1500	930 – 970
HIPS	1350 - 1525	1080
PET	850 – 1050	1370 – 1390
PP	1000 – 1200	900 – 920
PS	1250 – 1430	1040
PVC	800 – 930	1100 – 1450



Comparison daily crude oil prices with the daily prices of HDPE and LLDPE by PetroChemWire