



"El saber de mis hijos
hará mi grandeza"

Sustainability of Bio-based Plastics: General Comparative Analysis

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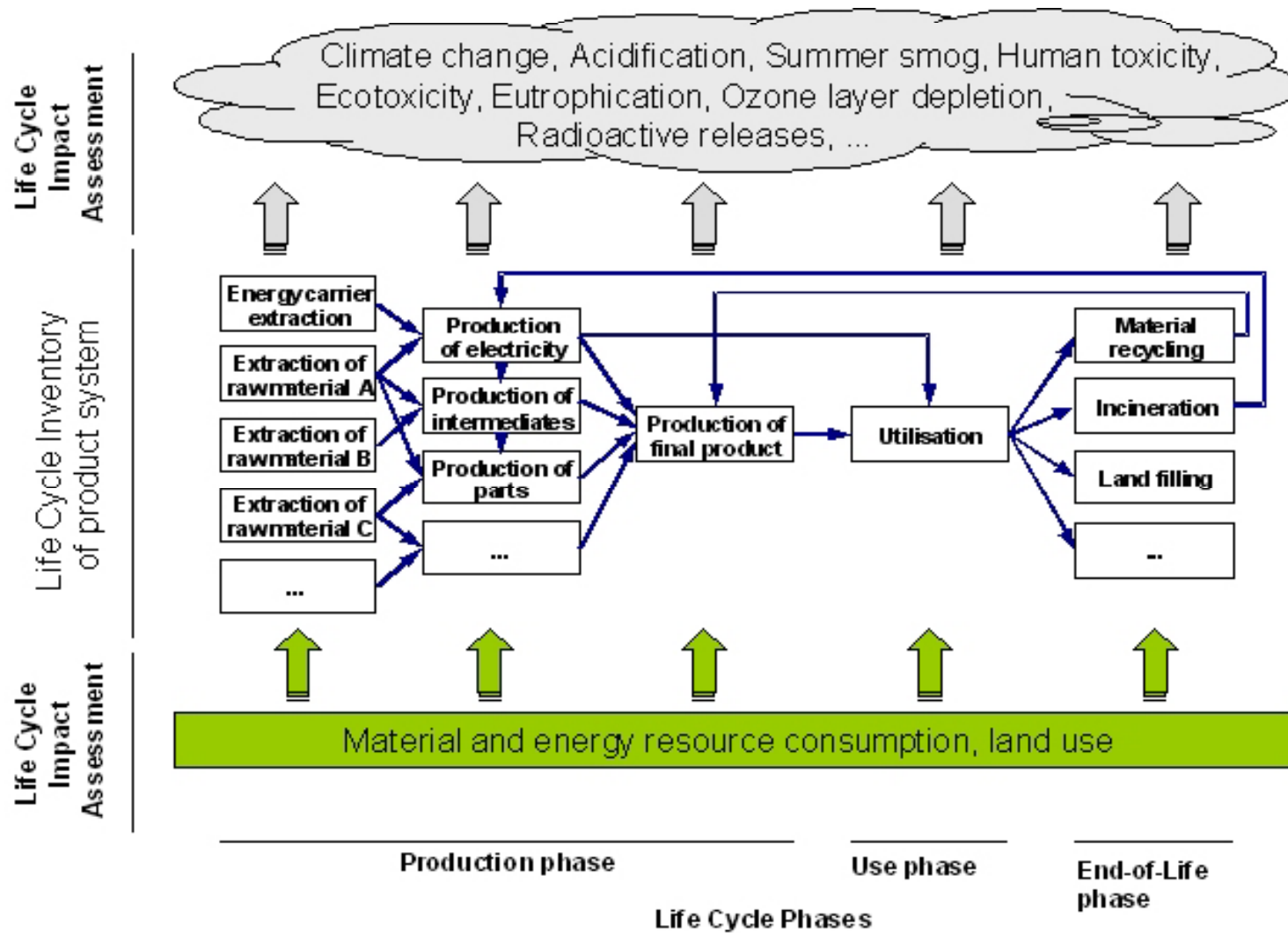
Petroleum-based Plastics (PBP)



- **Plastics: 90% are petroleum-based (PBP)**
- **Exceptional properties and performance**
- **Have brought tremendous benefits and wealth for human being**
- **Have caused serious environmental, health and safety problems**
- **Demand for plastics will continue following the increasing trend in use since the 1950s.**

Life Cycle (LC) of Plastics

Energy and materials are consumed in every stage



(European Commission, 2007; Helmut Kaiser Consultancy, 2008)

<http://lca.jrc.ec.europa.eu/lcainfohub/introduction.vm>

Materials in the World

- **“Materials are a fundamental determinant of sustainability” (Geiser, 2001).**
- **Sustainable materials are those that are high performance, low cost, processing efficiency and during their life cycle reduce impacts to occupational and public health as well as to the environment (Geiser, 2001).**
- **EHS impacts during the life cycle of PBP make these materials commodities that do not positively contribute to sustainability.**

Bio-based Plastics (BBP)

Alternative to improve sustainability of plastics materials



Bio-based Plastics (BBP) Definition:

- Plastics in which 100% of the carbon is derived from renewable agricultural and forestry resources.



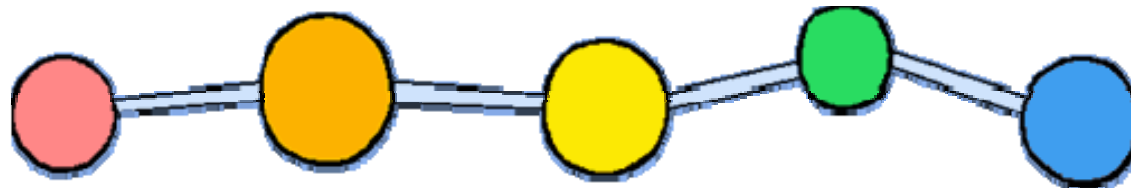
(Group for Safer Chemicals and Sustainable Materials, 2008).

Bio-based Plastics (BBP)

Obtained from cellulose, lignin, starch, proteins, fatty acids and triglycerides.

Bio-based plastics:

- Can be derived directly or from the modification of them. Ex: starch, cellulose.
- After microbial conversion (fermentation) followed by a polymerization process. Ex: polylactide acid (PLA) or polyhydroxyalkanoates (PHAs).





Bio-based Plastics: Promising Alternative

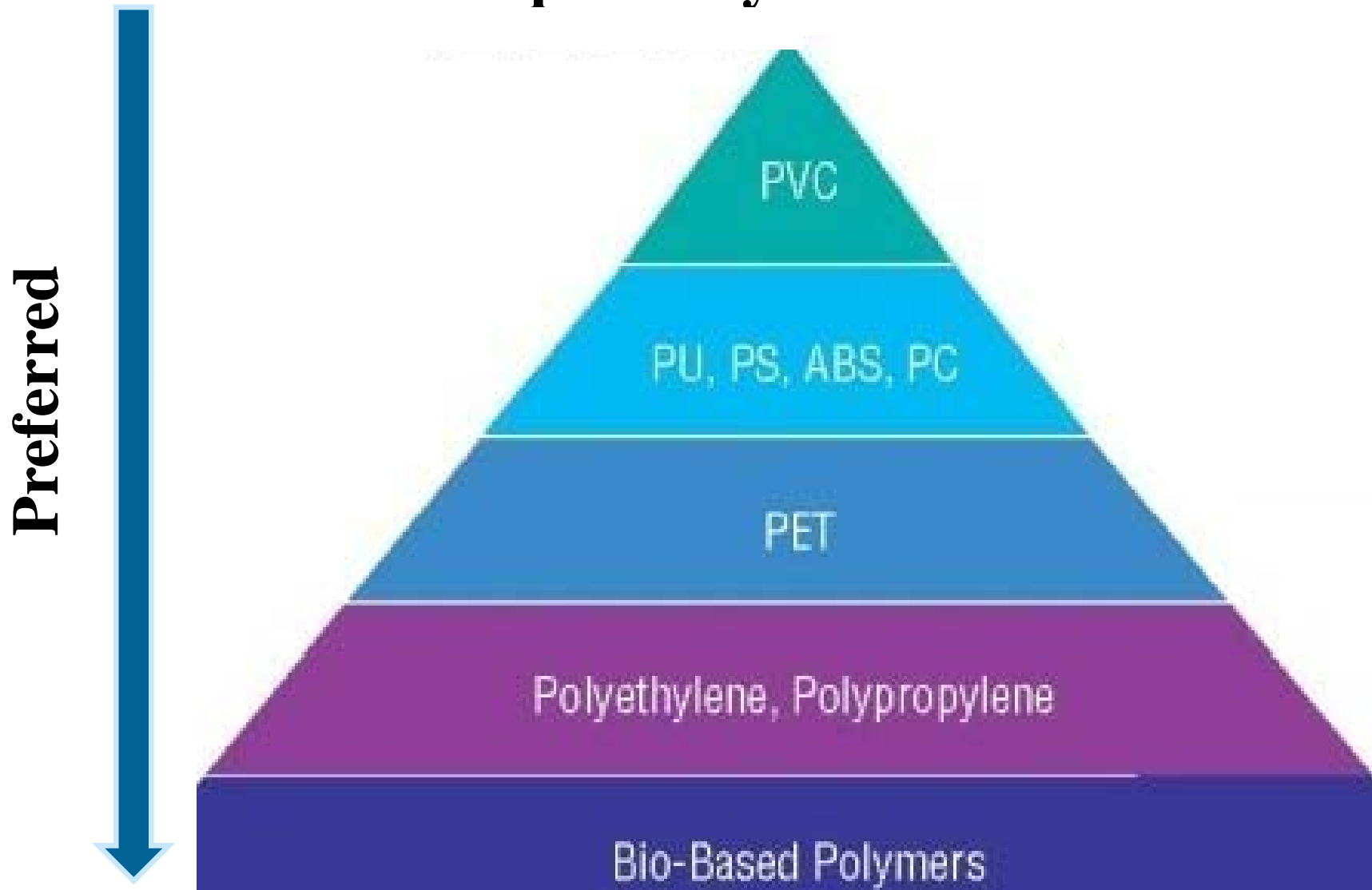
- Reduce the dependency of plastics on fossil fuels
- Feedstocks are renewable
- Production process may be more energy efficient than petroleum-based plastics processing
- Safer and healthier materials
- Reduce pressure on landfills from plastic solid wastes.
- Theoretically they can be composted or recycled



Bio-based plastic (BBP)

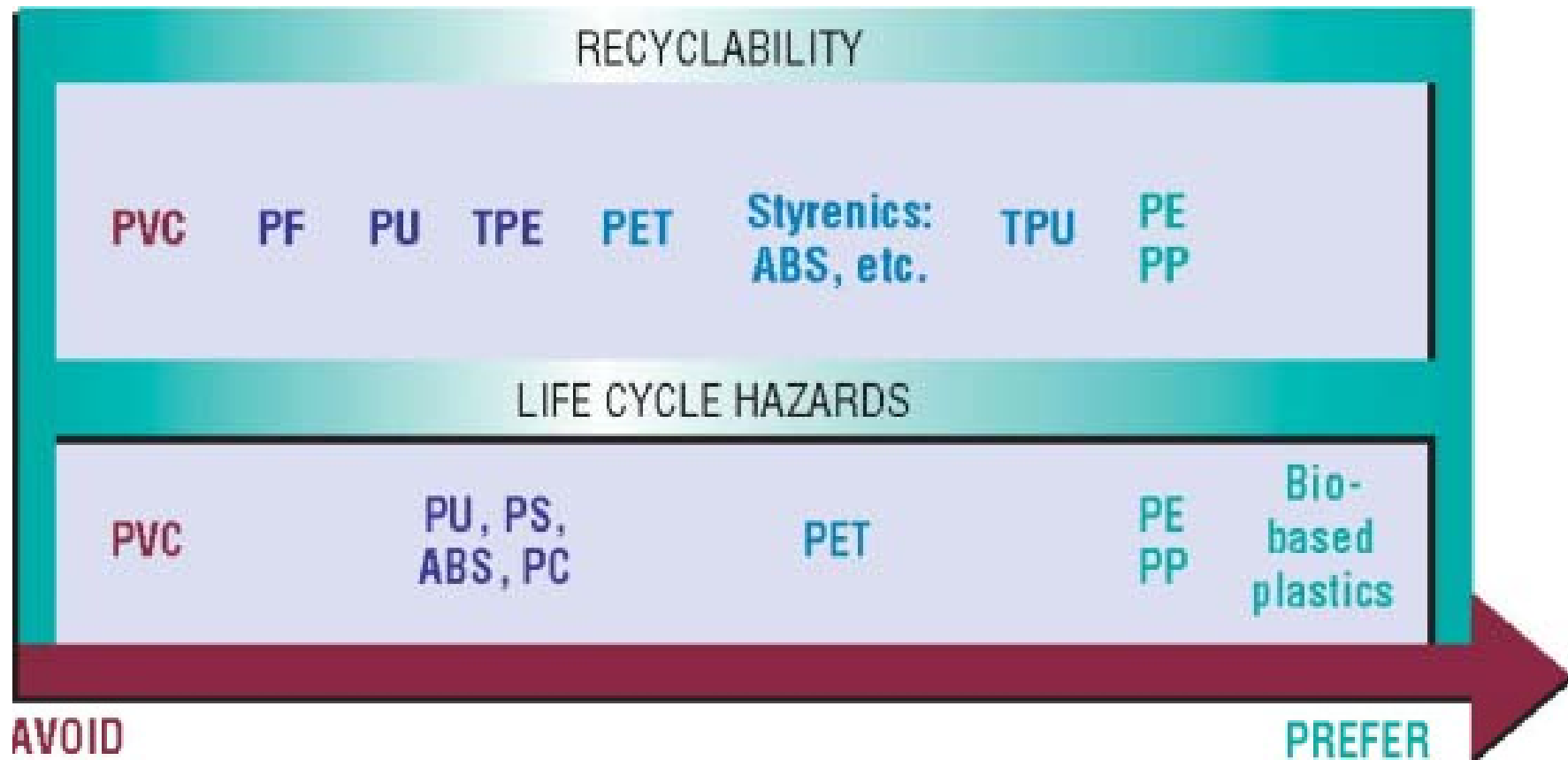
- It is not necessarily a sustainable material
- Depends on the source material, production process, and how the material is managed at the end of its useful life
- Challenging to determine which plastic materials are safest and healthiest for workers, consumers and the environment

Greenpeace Pyramid of Plastics



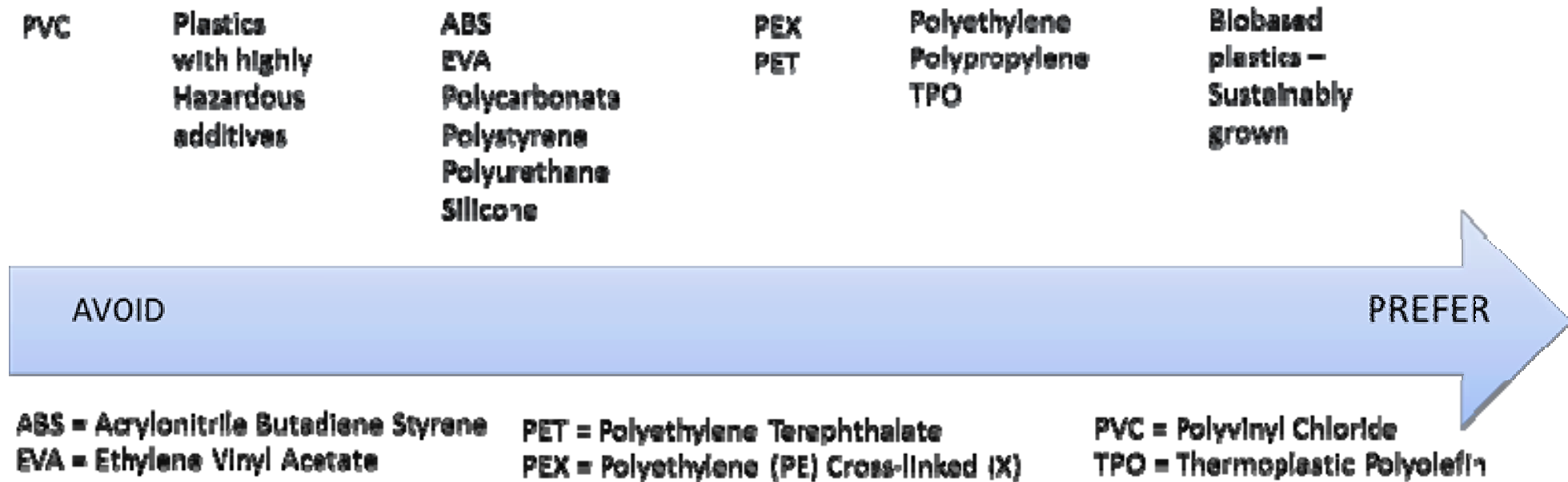
(Source: Van der Naald and Thorpe, 1998)

The Plastics Spectrum



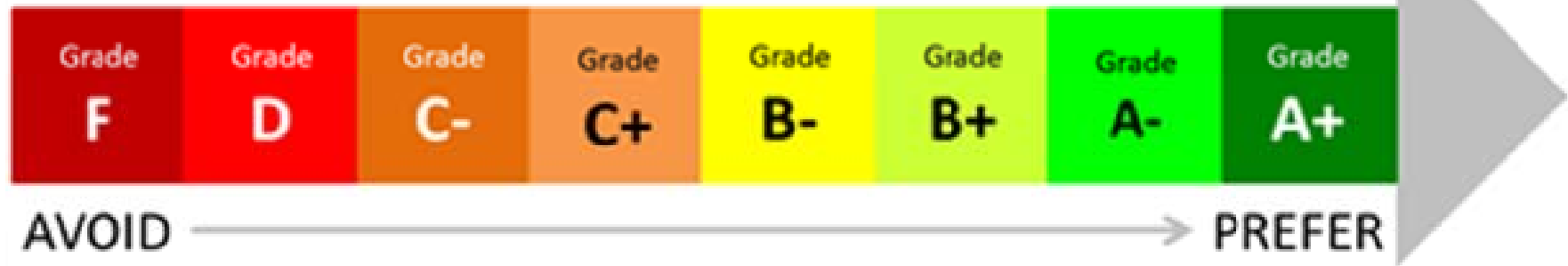
(Source: Rossi et al, 2005)

Environmental Preference Spectrum for the Health-Care Industry



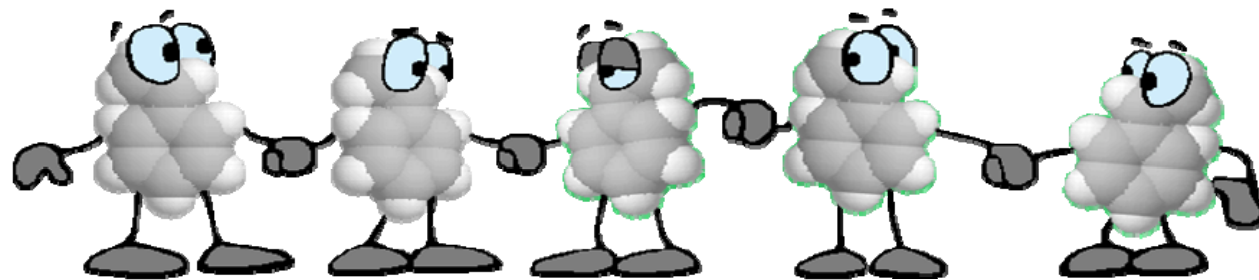
(Source: Rossi and Lent, 2006)

PLASTICS SCORECARD



OBJECTIVE

To evaluate and compare the sustainability of bio-based plastics by studying their environmental, health and safety impacts during their life cycle (cradle to grave).





Methodology

Methodology

- Literature review of polylactide acid (PLA), starch (TPS), polyhydroxyalkanoates (PHAs), Poly(trimethylene terephthalate) (PTT), Ligno-cellulosics, plastics from proteins, BURs, and nano-biomaterials to define and describe their source, production process, environmental, health and safety impacts.
- Information from BBP manufacturers (NatureWorks, LLC; Metabolix; Biosphere, LLC).
- A review of ranking schemes and criteria for plastics that have been developed.

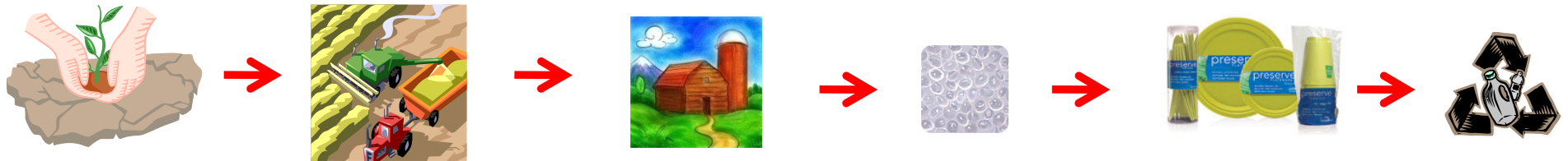
The sustainability criteria included:

- Environmental, health and safety impacts during the life cycle of the plastics
 - GMOs
 - Hazardous pesticides to grow the feedstock
 - Hazardous chemicals or petroleum-based co-polymers during plastic production and processing; hazardous additives or untested nanomaterials
 - Potential hazards in workplaces
 - Disposal options
 - Efficiency in the use of water, energy, and materials, etc.

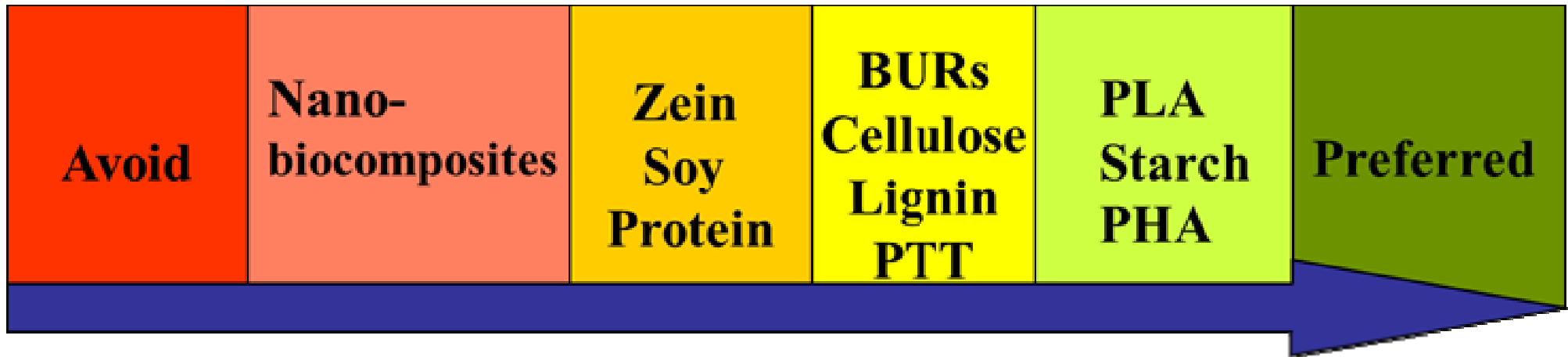
The limitations of this study

- Many developments and innovations in the field are not made publicly available due to the research and commercial interests.
- Development of BBPs is still in its infancy, LCA exist only for some starch polymers; for PLA and PHAs, evaluate only energy use and greenhouse gases.

RESULTS AND DISCUSSION



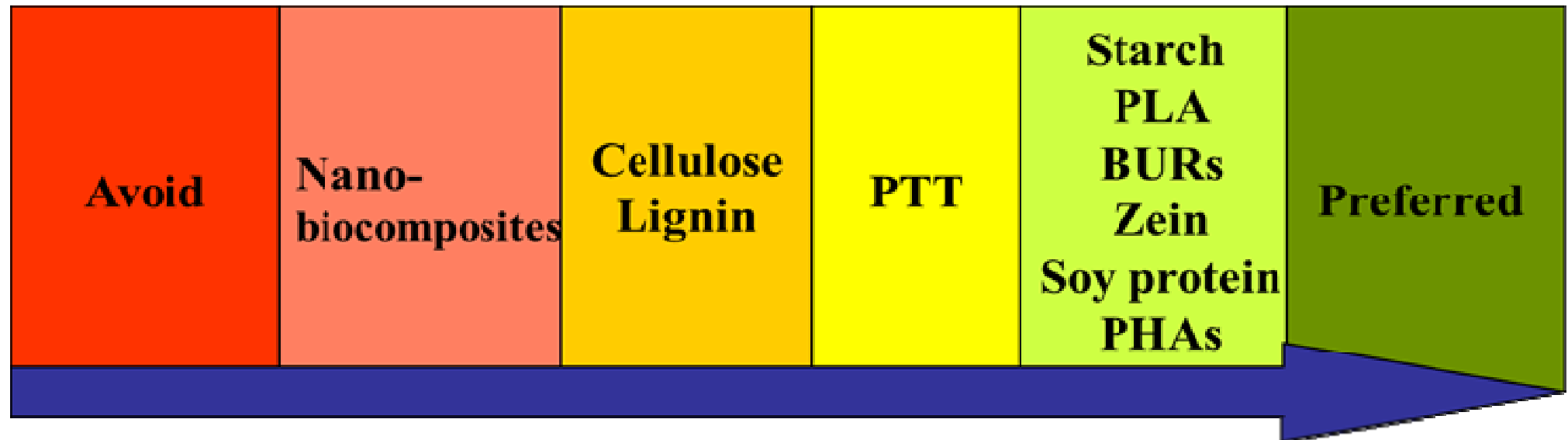
The Bioplastics Spectrum. Comparative occupational health and safety impacts of bioplastics.



Preferred: Feedstock grown sustainably; avoid GMOs, hazardous chemicals, untested materials, or petroleum based co-polymers.

Avoid: Feedstock grown unsustainably; GMOs, hazardous chemicals, untested materials, or petroleum based co-polymers are used.

The Bioplastics Spectrum. Comparative environmental health and safety impacts of bioplastics.



Preferred: Feedstock grown sustainably; avoid GMOs, PBT chemicals, untested materials, or petroleum based co polymers; flexibility in environmentally friendly disposal options; production is energy and water efficient

Avoid: Feedstock grown unsustainably; GMOs, PBT chemicals, untested materials, or petroleum based co-polymers are used; environmentally unfriendly disposal options, production is energy and water inefficient, impact food supply.

CONCLUSIONS

- **None of BBP currently in commercial use or under development are fully sustainable.**
- **Some BBP are preferable from a health and safety perspective and others are preferable from an environmental health perspective.**
- **The placement of the BBP on the Bio-based Plastics Spectrums currently in use may change as additional data becomes available.**
- **Starch (TPS), PLA, PHA score better than other BBP.**

RECOMMENDATIONS

Plastics are considered the most important materials of our era.

- **When impacts are detected, they can be addressed to avoid potential adverse environmental, occupational and public health effects.**
- **The use of a more comprehensive LCA is recommended as an adequate instrument that needs to be part of the decision making about the sustainability of bio-based plastics.**



Gracias! Obrigada! Thank you!

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RECOMMENDATIONS

- **Sustainable agriculture methods should be implemented for growing crops.**
 - **Ensuring crop diversity and soil management**
 - **Development and use of new agrochemicals less hazardous for occupational and public health and environment**
 - **Efficient water use**
 - **Reducing occupational hazards in farming practices**
 - **GMO's should be avoided**
 - **Cleaner and renewable sources of energy**