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Biorefineries and new technology for production of polylactic acid

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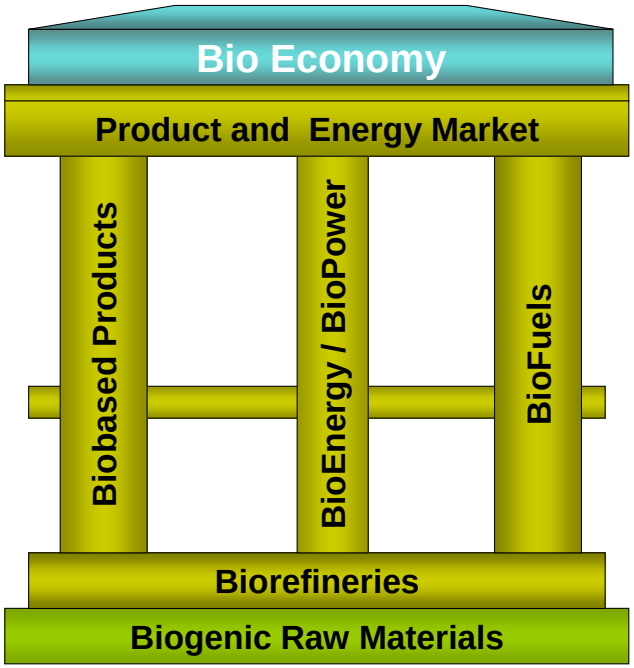
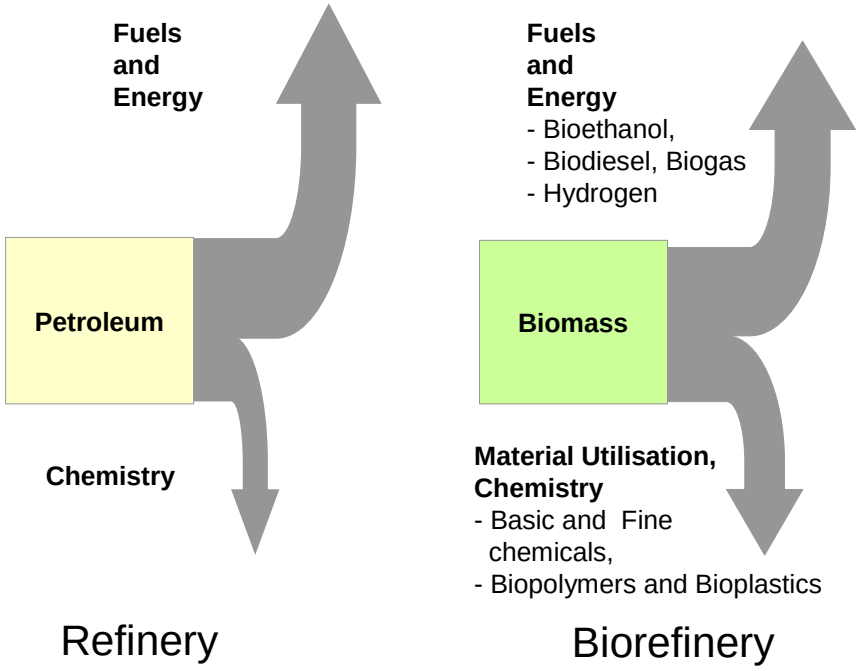


3-pillar model of a future biobased economy

It is absolutely necessary to develop solutions in three sustainable and biobased sectors:

- **Biopower/Bioenergy (electricity and heat)**
- **Biofuels (transportation fuels)**
- **Biobased Products (chemicals/materials) in context of a biobased economy.**



Biobased industrial products can only compete with petro-chemically based products if the raw materials are optimally exploited and a variety of value-creating chains are developed and established.

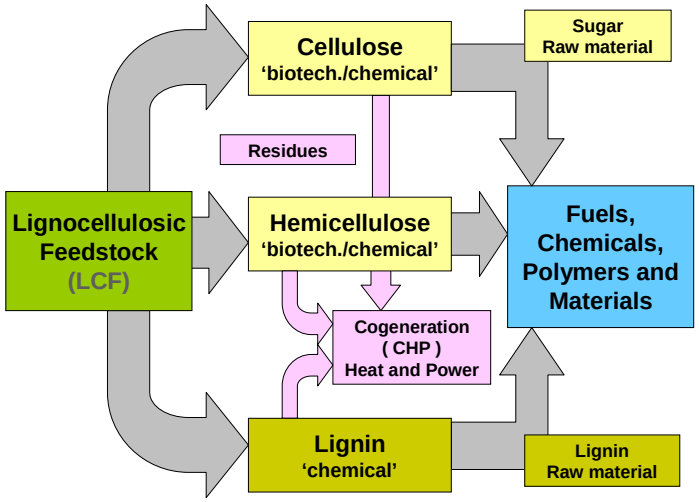
→ development of substance-converting basic product systems and multi product systems, especially biorefineries.

Currently four Biorefinery Systems are forced within research, development and practice:

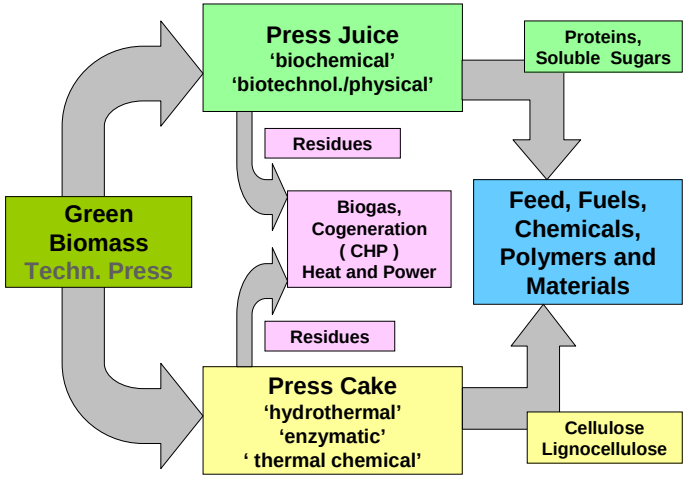
- **The Whole Crop Biorefinery (WC-BR)**
  raw material: cereals, maize etc..
- **The Green Biorefinery (G-BR)**
  raw material: 'nature-wet' biomasses, green grass, lucerne, clover, immature cereals a.o..
- **The Lignocellulose Feedstock Biorefinery (LCF-BR)**
  raw material: 'nature-dry' biomasses, wood, straw, corn stover, cellulose-containing biomass and waste.
- **The Two-Platform Concept**
  production of syngas and/or sugar as platforms for biobased products and fuels.

📖 **Kamm, B.; Kamm, M.**; Principles of Biorefineries. *Appl. Microbiol, Biotechnol., (AMB)*, **64** (2004) 137-145

Lignocellulosic Feedstock Biorefinery

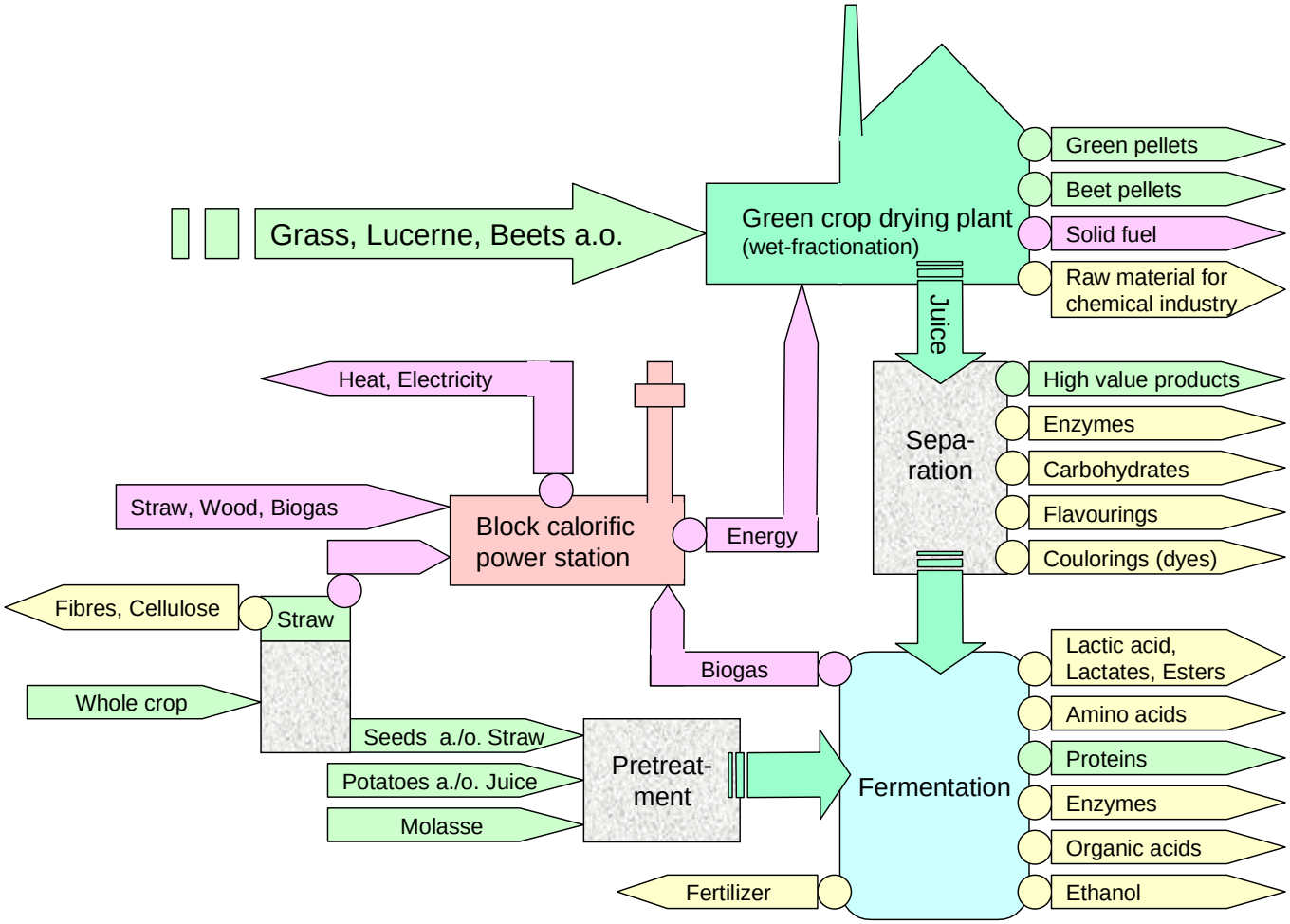


Green Biorefinery



📖**Kamm, B.; Gruber, P.R.; Kamm, M.;** Biorefineries, Industrial Processes and Products, Wiley-VCH, 2006

First green biorefinery: Selbelang, Brandenburg

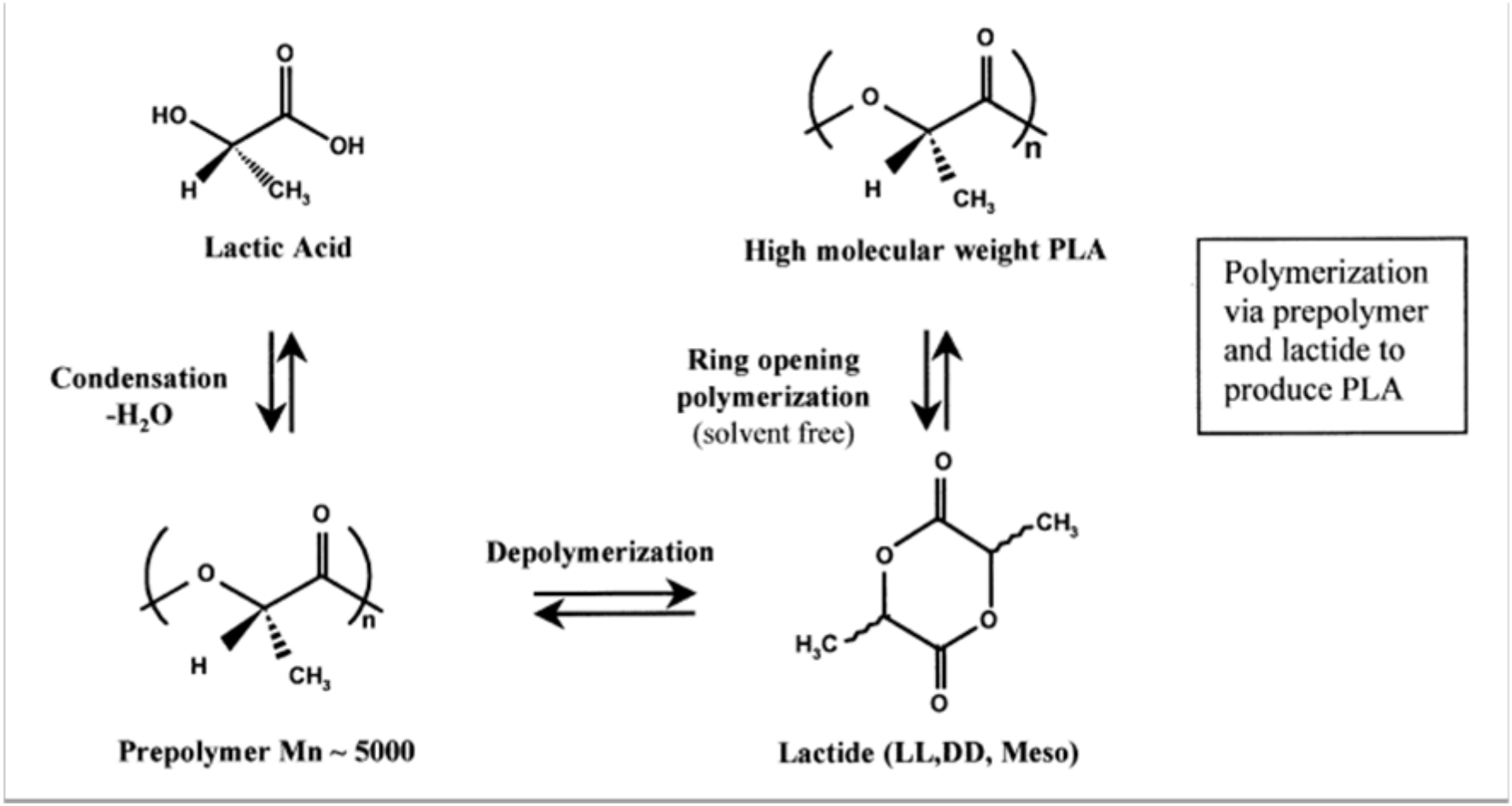


Start of construction 2009, Primary Biorefinery Selbelang‘
Tier 1: 8.000 t DM (8 mo/y); Primary products: pellet, chlorophyll, Prenacell® fibre, Lactic acid, Proteins, biogas-energy; Construction cost: 6,2 Mio EURO (Basic enginering)

Lactic acid and sequence products

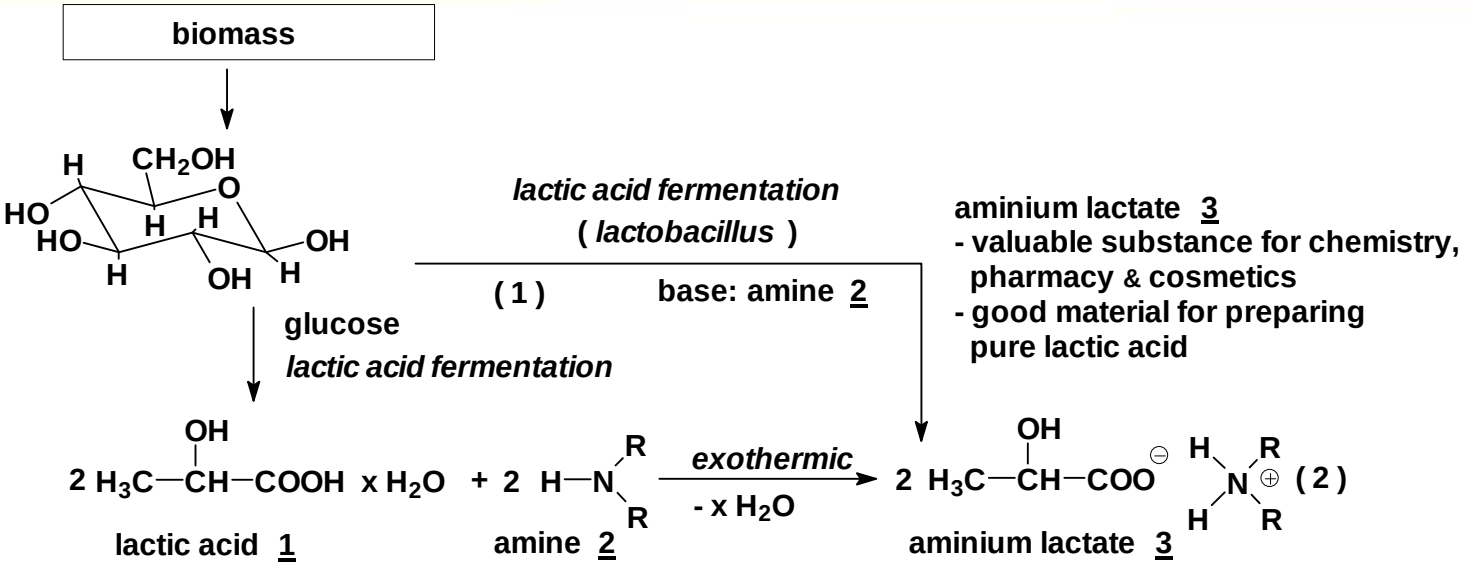
New Technology for Production of Poly(lactic acid)

NatureWorks LLC – classic process for PLA- synthesis



📖 **Vink, E. T.H et al.;** "Applications of life cycle assessment to NatureWorksTM polylactide(PLA) production.," *Polymer Degradation and Stability* 80, no. 3 (2003): 403–419.

New process for manufacturing aminium lactates and dilactide from biomass

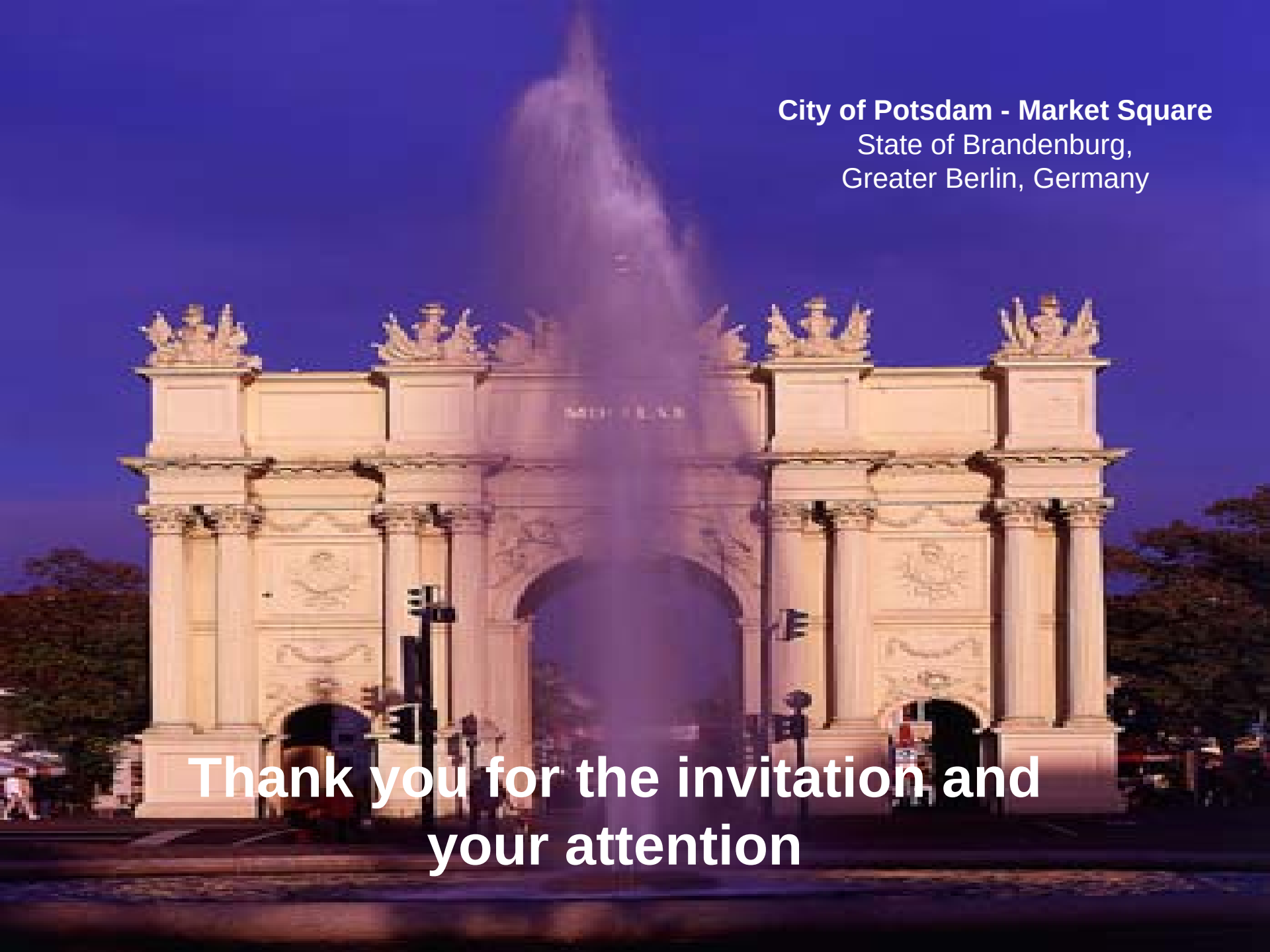


- **Kamm, B.; Kamm, M.; Richter K**.; et al.; EP 0 789 080 (1997); *Industrial Bioprocessing*, **20** (2) 1998; *Acta Biotechn*., **17** (1997), **20** (2000), **21** (2001); *Agro-Food-Industry Hi-Tech,* **12** (3), 2001
- **Kamm, B.; Kamm, M.;** Biorefinery – Systems, CBEQ **18** (1) 1-6 (2004)

Presentation Summary

Several requirements to enter the phase of development of Industrial Biorefinery Technologies and Biobased Products:

- **To increase the production of substances on the base of biogenic raw materials in the ordinary plants of production of cellulose, starch, protein, sugar and oil.**
- **To force the combination of biological and chemical conversion of substances.**



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Thank you for the invitation and your attention

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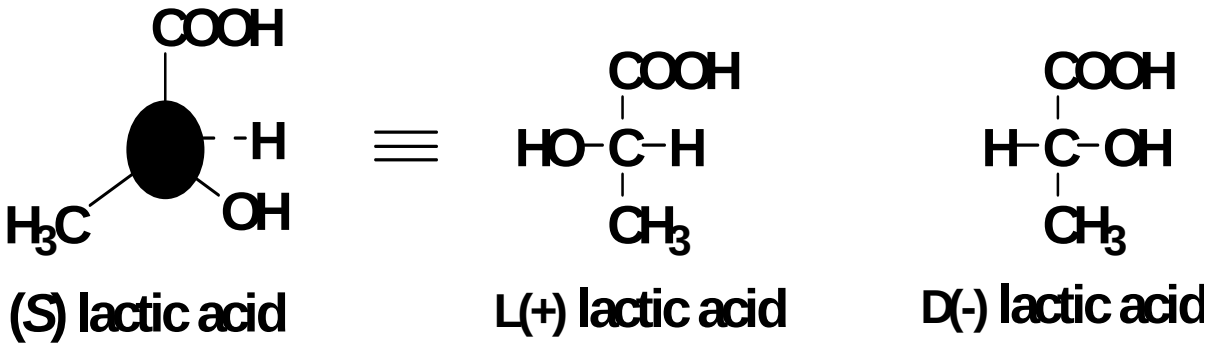
Potsdam and Teltow in the Greater Berlin, Germany

Cellulose-, lignocellulose-, starch – ,sugar (platform) – Lactic acid (building block) - polylactide – intermediate – use

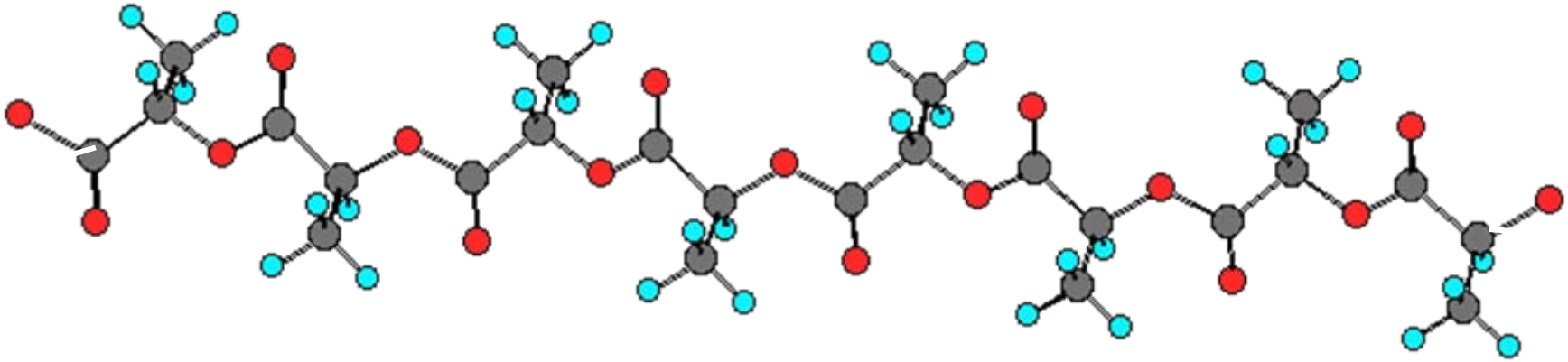


(S) lactic acid **L(+) lactic acid** **D(-) lactic acid**

- Lactic acid - most important metabolical intermediat of living organism
- 1780 Scheele - isolation, firstly as brown oil from acid milk
- 1881 C. E. Avery - first industrial production
- 1895 B. Ingelheim - first successfull industrial production, fermentation *by Lactobacillus*
- today - 250.000 t/ year

📖 **Branduardi, P.; Smeraldi, C; Porro**, **D.**; "Metabolically engineered yeasts: 'potential' industrial applications," *Journal of Molecular Microbiology and Biotechnology* 15, no. 1 (2008): 31-40

What is PLA: Poly(lactic acid) = Polylactide ?

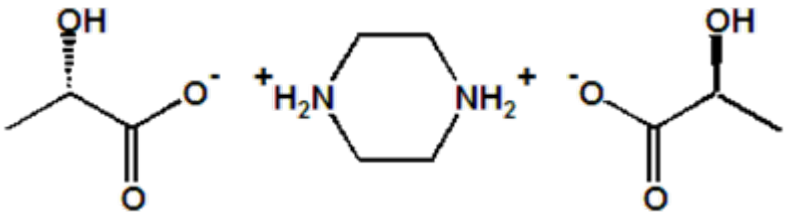


PLA- Polylactide is:

- a material, applicable for packaging and fibres,
- a biodegradable and compostable polymer,

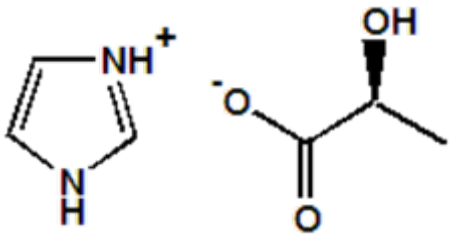
- lactic acid is produced by fermentation of „sugars“,
- „sugars“ are accessible from CO_2 via photosynthesis .

Model substances:



1,4- piperazine-(L,L)- dilactate

Melting point: 114°C



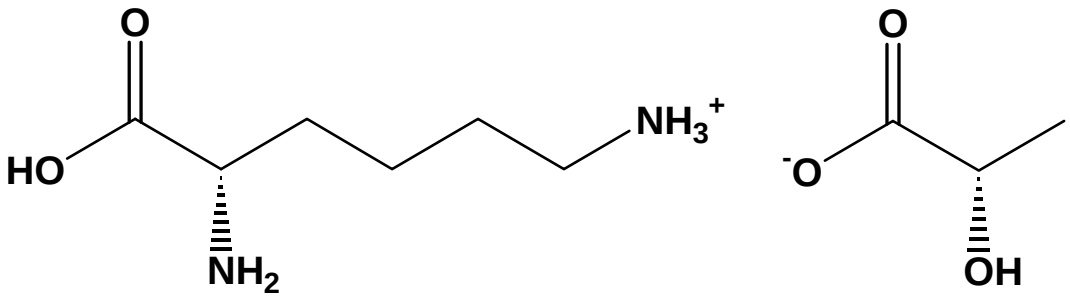
Imidazol-(L)- Lactat

Melting point: 88°C

📖 **Richter, K.; Kose, F.; Kamm, B.; Kamm, M.**; Fermentative Production of Piperazinium Dilactate, Acta Biotechn., 21 (1) 2001, 37-47

📖 **Kamm, B. et al.**; EP 0789080 A2; Process for the preparation of organic aminium lactates and their use in the preparation of dilactide; 13.8.1997

Fermentation of lysine lactate with green juice from alfalfa



CAS: 57061-63-9

mw: 236,27 g/mol

melting point: 146-149 °C

application: lotion for treatment of skin disorders

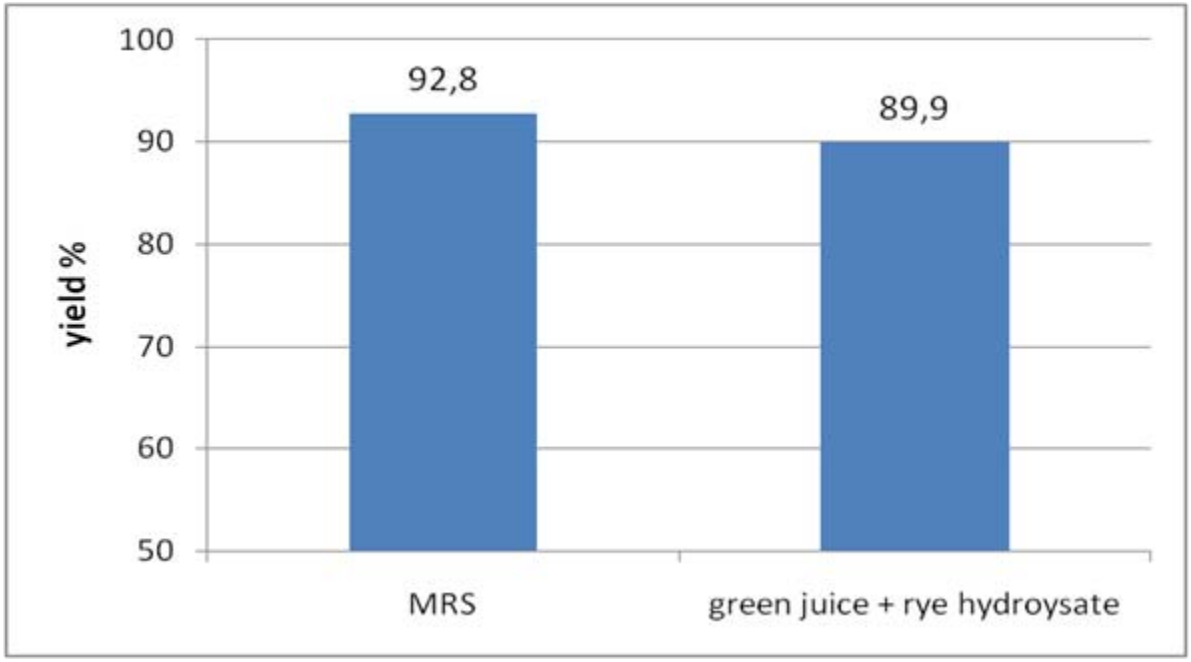
📖 **M.Pfeil; diploma thesis, 2006**
📖 **Parab 1995; Patent Nr. 94-215984;** Topical preparations having alpha -hydroxy carboxylic acids for treatment of skin disorders

Classic approach

MRS- medium*

New approach

Green juice + rye hydrolysate



📖 **De Man, J.C.; Rogosa, M.;Sharpe, M.E**. A medium for the cultivation of lactobacilli. *J. Appl. Microbiol* **23**, 130–135 (1960).