

## COURSE "INTRODUCTION TO GREEN AND SUSTAINABLE CHEMISTRY"

Written exam – January 19, 2018 (part I)

*PLAGIARISM. The Course takes plagiarism very seriously. Cutting and pasting from an article or any another person's work is plagiarism, even if you cite them (the exception to this is "quotations").*

- 1) Which is for you the best definition of Sustainable Development? In this context, frame the importance of the concepts of recycling, reuse, re-fabrication, and recovery.
- 2) Discuss briefly three indicators which evidence that global warming is in place. Report the origin of the variation and the long-term implications for each one.
- 3) \* See next page.
- 4) \* \*\* The chemical CH<sub>3</sub>CHO (acetaldehyde) can be synthesized starting from two different raw materials; acetylene and ethanol, according to the following reactions:  
$$\text{HC}\equiv\text{CH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CHO} \quad (\text{under catalysis of Hg}(\text{OCOCH}_3)_2)$$
$$\text{CH}_3\text{CH}_2\text{OH} + \frac{1}{2} \text{O}_2 \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O} \quad (\text{under catalysis of supported Platinum metal})$$
Keeping in mind the different sources of reagents, the different catalyst and the predictable safety and purification issues, which process do you think is more sustainable, also in terms of cost?
- 5) What problems do European regulations on oil fuel intend to overcome when they impose limits on the content of sulphur and aromatic derivatives?
- 6) Describe the life cycle of a PET plastic bottle. Specify two alternatives that can simplify and reduce life cycle impacts of this package. What means bio-PET and how it is made?
- 7) Explain, with examples, the different recycling strategy industrially adopted for addition polymers, condensation polymers, and composites.
- 8) \*Express your opinion on the following aspects related to the use of biofuels: a) they have a marginal role in the energy needs of modern economies, b) their introduction has contributed to increase the cost of agricultural commodities, c) their use will lead to the destruction of tropical forests, d) bioethanol from lignocellulose biomass is a better biofuel than biodiesel and bio-methane, e) until useable, common sustainability standards or certification for biofuels will be available, the use of biofuels must be restricted.
- 9) In REACH specific attention is posed to substances of concern belonging of these categories: CMRs (cat 1A/1B), Sensitizers, PBT/vPvBs, Endocrine disrupters, and Petroleum/coal stream substances which are CMRs or PBTs. What is the basis of the classification? Make for each category one example of compound and briefly explain the criteria to be consider for their identification.
- 10) What are the differences between Industrial Ecology and Industrial Symbiosis approaches? Discuss briefly, with examples, their scales, their focus, and the circumstances in which they are adopted.
- \*\*11) I) Select and justify the untrue answer for this sentence: Proteins are popularly used in food processing industry because: a) Water binding capacity, b) Oil binding capacity, c) Ability to coagulate on heating, d) None of the mentioned. II) Folding and denaturation of proteins is due to a problem of conformational stability? III) the isoelectric point is a property of amino acids but not of their polymers, the proteins.
- \*\*12) Which are the main differences between the two polyesters a) polylactic acid (PLA) and b) polyhydroxybutyrate (PHB) in term of classification, preparation method, uses and potential, market relevance and costs?
- \*\*13) Polysaccharides are a broad class of natural polymers. Typical representatives are: Cellulose, Pectine, Chitosan, Amylose, Alginate. Provide the name of monosaccharides found in the 4 polysaccharides, the most stable conformation of the monosaccharides, the nature of glycosidic bond, and state whether or not the polysaccharide is a polyelectrolyte at pH 2 and 8, respectively

- 3) Lactic acid (LA) can be prepared by a chemistry process from oil as summarized in Fig 1. A more recent biotechnological approach, which produces lactic acid from starch, is reported schematically in Fig. 2.
- a) Identify the advantages and disadvantages of both methods and the key elements of green metrics, as atom economy, E factor, etc., assuming that the yield is 100% in each stage and all reagents are used in stoichiometric amount.
- b) Is the stages to convert technical grade LA to high purity LA well designed or you can propose a more sustainable approach?

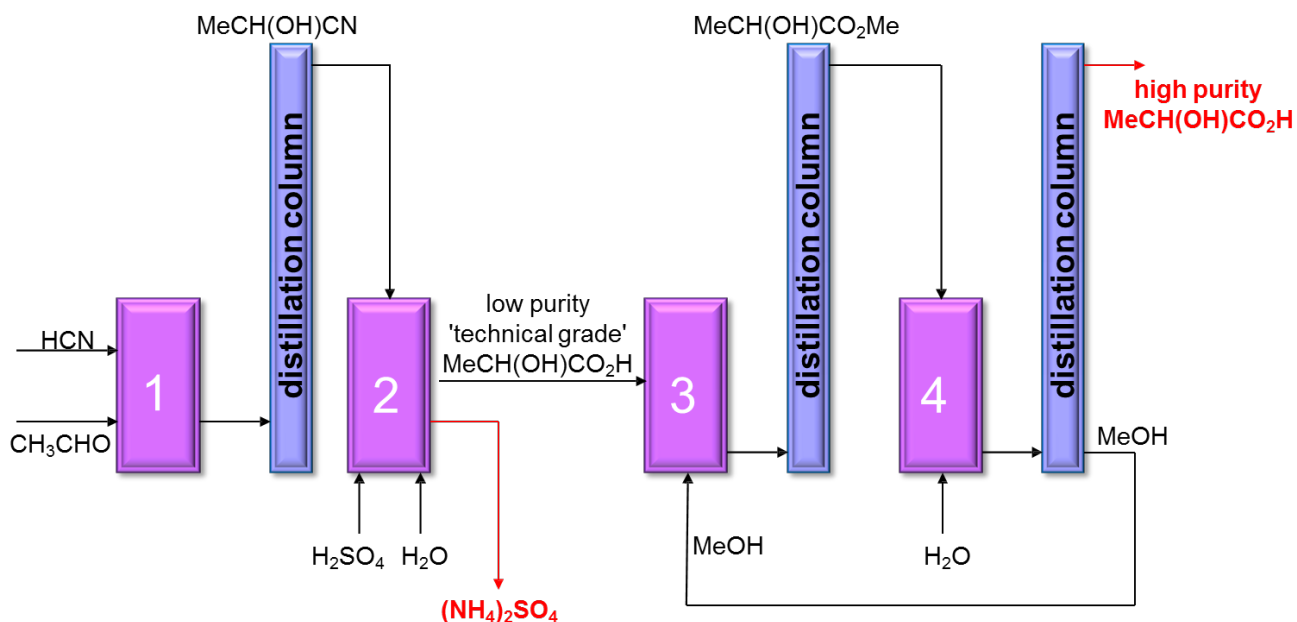


Fig. 1 – Conventional synthesis of lactic acid from acetaldehyde (oil)

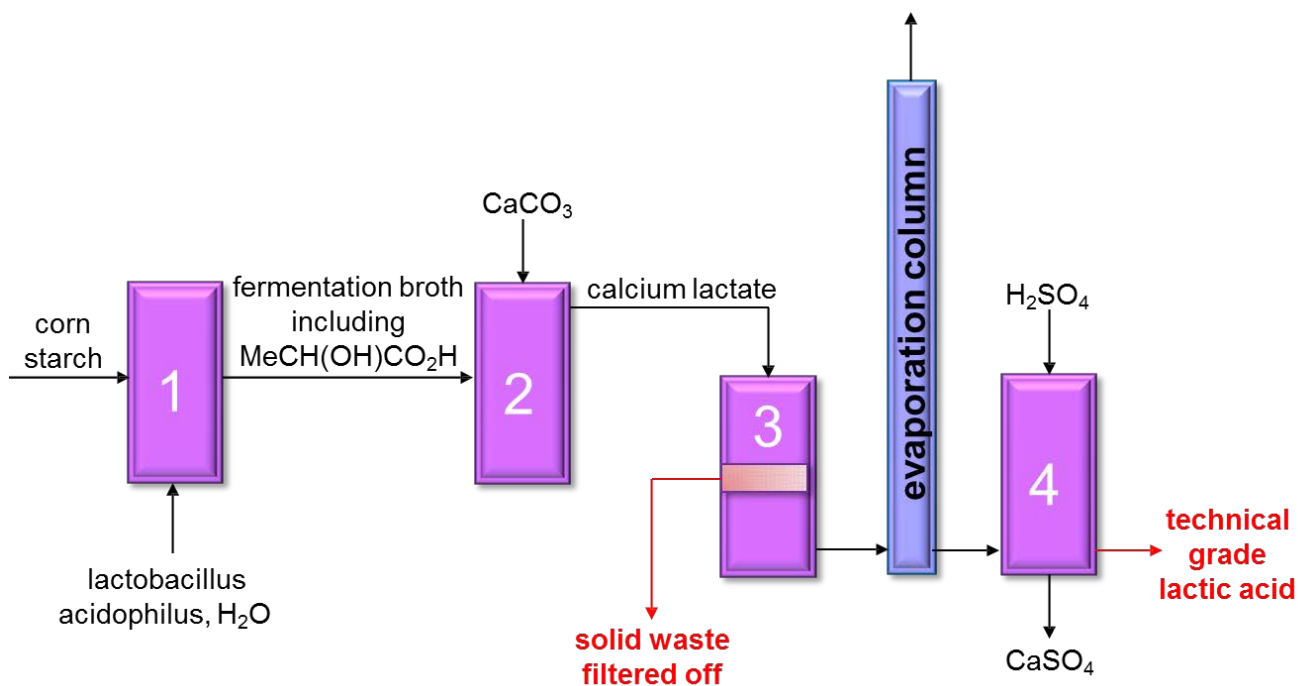


Fig. 2 – Biotechnological synthesis of lactic acid from starch