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Journal of Radiation Research and Applied Sciences
journal homepage: http://www.elsevier.com/locate/jrras

Recent trends in lactic acid biotechnology: A brief review on production to purification

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ARTICLE INFO

Article history:
Received 8 February 2014
Received in revised form
11 March 2014
Accepted 15 March 2014
Available online 13 April 2014

Keywords:
Green biotechnology
Lactic acid
Fermentation
Product optimization
Purification

ABSTRACT

Lactic acid is one of the most important organic acid which is being extensively used around the globe in a range of industrial and biotechnological applications. From its very old history to date, many methods have been introduced to improve the optimization of lactic acid to get highest yields of the product of industrial interests. In serious consideration of the worldwide economic and lactic acid consumption issues there has been increasing research interest in the value of materials with natural origin, which are cheap, abundant and easily available all around the year. Recent trends showed that lactic acid production through fermentation is advantageous over chemical due to the environmental concerns of the modern world. The eco-friendly processing and fermentable capability of many of the agricultural and agro-industrial based raw materials or by-products respectively makes them attractive candidates in fermentation biotechnology to produce a value-added product with multiple applications. In fact, major advances have already been achieved in recent years in order to get pure lactic acid with optimal yield. The present review work is summarized on the multi-step processing technologies to produce lactic acid from different substances as a starting material potentially from various agro-industrial based biomasses. The information is also given on a purification through schematic representation of the product of quality interests.

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Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.jrras.2014.03.002

1. Background introduction

From the histological point of view lactic acid has a long history of uses for fermentation and was first discovered in 1780 by Swedish chemist, Carl Wilhelm Scheele, who isolated the lactic acid from sour milk as an impure brown syrup and gave it a name based on its origins: 'Mjölksyra'. After nine years around in 1789, *Lavoisier* named this milk component "acide lactique", which became the core origin of the current terminology for lactic acid. For a very long time until 1857 it was being considered a milk component while later on that year *Pasteur* discovered another phenomenon and postulated lactic acid as a fermentation metabolite generated because of the involvement of certain microorganisms. In support with *Pasteur*'s discovery a French scientist Frémy produced lactic acid by fermentation and this gave rise to first industrial production of lactic acid in the United States by a microbial process in 1881. From that time it has Wide applications in food, pharmaceutical, cosmetic and chemical industries etc (Narayanan, Roychoudhury, & Srivastava, 2004). The worldwide demand for lactic acid is estimated roughly to be 130 000 to 150 000 tons per year (Randhawa, ahmed, & akram, 2012). However, the global consumption of lactic acid is expected to increase rapidly in the near future (Wee, Kim, & Ryu, 2006).

2. Common aspects in the synthesis of lactic acid

Lactic acid can be synthesized industrially by two means either through chemically or by microbial fermentation. However, the least one (fermentation through microbes) has some potential advantages e.g. pure lactic acid can be attained whereas, chemical synthesis of lactic acid always give a raceme mixture (Randhawa et al., 2012). The existence of L(+)-lactic acid which have high optical purity provides polylactic acids with high crystallinity and high melting point (Oh et al., 2005). One of the most expanding uses of lactic acid is its use in polymerization of lactic acid to form polylactic acid (PLA), a polymer of great interest because it can be produced from renewable means which is biodegradable in nature. Fig. 1 illustrates the production of PLA using starch as a potential starting substrate. Many PLA-based products are already available in the market, where they are used to replace the petroleum-based consumables (Ilmén, Koivuranta, Ruohonen, Suominen, & Penttilä, 2007). Lactic acid is the simplest hydroxy acid which has an asymmetric carbon atom and is present in two optically active forms. In humans and other mammals only the L(+)- isomer is present, whereas the D(−)- and L(+)-both enantiomers can synthesized using an appropriate bacterial strains. Therefore, most of the world's commercial lactic acid is prepared by fermentation of carbohydrates by bacteria, using homolactic microbes such as a variety of modified or optimized strains the genus *Lactobacilli*, which especially produce lactic acid. Commercially pure lactic acid can be synthesized by microbial fermentation of the following carbohydrates such as glucose, sucrose, lactose, and starch/maltose derived from feed-stocks such as beet sugar, molasses, whey, and barley malt. The preference of feedstock entirely depends on its price, availability, and on the respective costs of lactic acid recovery and purification. Biomass of lignocelluloses is a low-cost and extensively available renewable carbon source as an alternative to these conventional feed-stocks that has no challenging food value (Pang, Zhuang, Tang, & Chen, 2010). Other biological agents capable of producing lactic acid are also used such as strains of *Rhizopus*, *Escherichia*, *Bacillus*, *Kluyveromyces* and *Saccharomyces* (Maas et al., 2008).

Widely used method for the production of lactic acid is Batch fermentation. Conditions for Fermentation are different for each industrial method but are usually in the range of 45–60 °C having a pH of 5.0–6.5 for *Lactobacillus delbrueckii* and

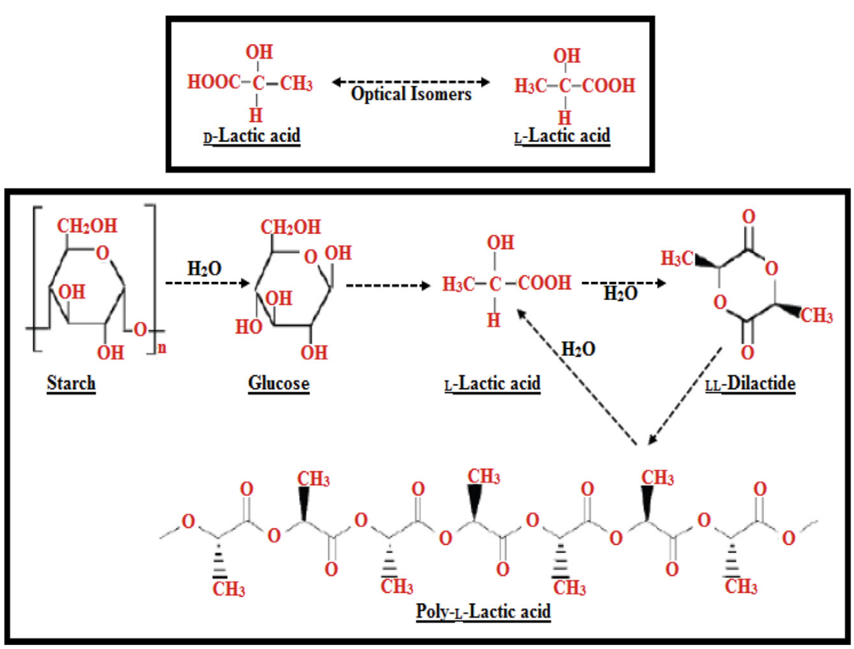

Fig. 1 – Production of Poly-L-lactic acid using starch as a substrate.