RAMA UNIVERSITY

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FACULTY OF ENGINEERING & TECHNOLOGY

Production of Lactic Acid

Properties and chemical reactions of lactic acid

(i) Lactic acid is a three carbon organic acid: one terminal carbon atom is part of an acid or carboxyl group; the other terminal carbon atom is part of a methyl or hydrocarbon group; and a central carbon atom having an alcohol carbon group. Lactic acid exists in two optically active isomeric forms.

(ii) Lactic acid is soluble in water and water miscible organic solvents but insoluble in other organic solvents.

(iii) It exhibits low volatility.

(iv) The various reactions characteristic of an alcohol which lactic acid (or it esters or amides) may undergo are xanthation with carbon bisulphide, esterification with organic acids and dehdrogenation or oxygenation to form pyruvic acid or its derivatives.

(v) The acid reactions of lactic acid are those that form salts and undergo esterification with various alcohols.

(vi) Liquid chromatography and its various techniques can be used for quantitative analysis and separation of its optical isomers

- Polymers of lactic acids are biodegradable thermoplastics. These polymers are transparent and their degradation can be controlled by adjusting the composition, and the molecular weight.
- Their properties approach those of petroleum derived plastics. Lactic acid esters like ethyl/butyl lactate can be used as green solvents.
- They are high boiling, non-toxic and degradable components. Poly L-lactic acid with low degree of polymerization can help in controlled release or degradable mulch films for large-scale agricultural applications.
- Lactic acid was among the earliest materials to be produced commercially by fermentation and the first organic acid to be produced by fermentation.
- Chemical processing has offered and continues to offer stiff competition to fermentation lactic acid.
- Very few firms around the world produce it fermentatively, but this could change when the hydrocarbon-based raw material, lactonitrile, used in the chemical preparation becomes too expensive because of the increase in petroleum prices.

Properties and chemical reactions of lactic acid

- Technical grade lactic acid is used as an acidulant in vegetable and leather tanning industries.
- Various textile finishing operations and acid dyeing of food require low cost technical grade lactic acid to compete with cheaper inorganic acid.
- Lactic acid is being used in many small scale applications like pH adjustment, hardening baths for cellophanes used in food packaging, terminating agent for phenol formaldehyde resins, alkyl resin modifier, solder flux, lithographic and textile printing developers, adhesive formulations, electroplating and electro-polishing baths, detergent builders.
- Lactic acid has many pharmaceutical and cosmetic applications and formulations in topical ointments, lotions, anti acne solutions, humectants, parenteral solutions and dialysis applications, and anti carries agents.
- Calcium lactate can be used for calcium deficiency therapy, and as an anti caries agent.
- Its biodegradable polymer has medical applications as sutures, orthopedic implants, controlled drug release, etc.

Physical properties of lactic acid

Appearance	*Yellow to colorless crystals or syrupy 50% liquid*
Melting point	16.8°C
Relative density	1.249 at 15°C
Boiling point	122° @ 15 millimeter
Flash point	110°C
Solubility	Soluble in water, alcohol, furfurol
	Slightly soluble in ether
	Insoluble in chloroform, petroleum ether, and carbon disulfide

Uses of lactic acid

(i) It is used in the baking industry. Originally fermentation lactic acid was produced to replace tartarates in baking powder with calcium lactate. Later it was used to produce calcium stearyl 2- lactylate, a bread additive.

(ii) In medicine it is sometimes used to introduce calcium in to the body in the form of calcium lactate, in diseases of calcium deficiency.

(iii) Esters of lactic acid are also used in the food industry as emulsifiers.

(iv) Lactic acid is used in the manufacture of rye bread.

(v) It is used in the manufacture of plastics.

(vi) Lactic acid is used as acidulant/ flavoring/ pH buffering agent or inhibitor of bacterial spoilage in a wide variety of processed foods. It has the advantage, in contrast to other food acids in having a mild acidic taste.

(vii) It is non-volatile odorless and is classified as GRAS (generally regarded as safe) by the FDA.

(viii) It is a very good preservative and pickling agent. Addition of lactic acid aqueous solution to the packaging of poultry and fish increases their shelf life.

(ix) The esters of lactic acid are used as emulsifying agents in baking foods (stearoyl-2-lactylate, glyceryl lactostearate, glyceryl lactopalmitate). The manufacture of these emulsifiers requires heat stable lactic acid, hence only the synthetic or the heat stable fermentation grades can be used for this application.

(x) Lactic acid has many pharmaceutical and cosmetic applications and formulations in topical ointments, lotions, anti acne solutions, humectants, parenteral solutions and dialysis applications, for anti carries agent.

(xi) Calcium lactate can be used for calcium deficiency therapy and as anti caries agent.

(xii) Its biodegradable polymer has medical applications as sutures, orthopaedic implants, controlled drug release, etc.

(xiii) Polymers of lactic acids are biodegradable thermoplastics. These polymers are transparent and their degradation can be controlled by adjusting the composition, and the molecular weight. Their properties approach those of petroleum derived plastics.

(xiv) Lactic acid esters like ethyl/butyl lactate can be used as environment-friendly solvents. They are high boiling, non-toxic and degradable components.

(xv) Poly L-lactic acid with low degree of polymerization can help in controlled release or degradable mulch films for large-scale agricultural applications.

Fermentation for lactic acid

•The organisms which produce adequate amounts and are therefore used in industry are the homofermentative lactic acid bacteria, *Lactobacillus spp., especially L. delbruckii.*

•*In recent* times *Rhizopus oryzae has been used. Both organisms produce the L- form of the acid, but Rhizopus fermentation has the advantage of being much shorter in duration; further, the* isolation of the acid is much easier when the fungus is used.

•Lactic acid is very corrosive and the fermentor, which is usually between 25,000 and 110,000 liters in capacity is made of wood. Alternatively special stainless steel (type 316) may be used.

•They are sterilized by steaming before the introduction of the broth as contamination with thermophilic clostridia yielding butanol and butyric acid is common. Such contamination drastically reduces the value of the product

•During the step-wise preparation of the inoculum, which forms about 5% of the total beer, calcium carbonate is added to the medium to maintain the pH at around 5.5-6.5.

•The carbon source used in the broth has varied widely and have included whey, sugars in potato and corn hydrolysates, sulfite liquour, and molasses.

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•However, because of the problems of recovery for high quality lactic acid, purified sugar and a minimum of other nutrients are used.

•*Lactobacillus requires the addition of vitamins and growth factors for growth.*

•*These* requirements along with that of nitrogen are often met with ground vegetable materials such as ground malt sprouts or malt rootlets.

•To aid recovery the initial sugar content of the broth is not more than 12% to enable its exhaustion at the end of 72 hours.

•Fermentation with *Lactobacillus delbruckii is usually for 5 to 10 days whereas with Rhizopus oryzae, it is about two days.*

•Although lactic fermentation is anaerobic, the organisms involved are facultative and while air is excluded as much as possible, complete anaerobiosis is not necessary.

•The temperature of the fermentation is high in comparison with other fermentation, and is around 45°C.

•Contamination is therefore not a problem, except by thermophilic clostridia.

•**Extraction**

•Recovery is the main problem in fermentative lactic acid production.

•Lactic acid is crystallized with great difficulty and in low yield. The purest forms are usually colorless syrups which readily absorb water.

•At the end of the fermentation when the sugar content is about 0.1%, the spent medium is pumped into settling tanks.

•Calcium hydroxide at pH 10 is mixed in and the mixture is allowed to settle. The clear calcium lactate is decanted off and combined with the filtrate from the slurry.

•It is then treated with sodium sulfide, decolorized by adsorption with activated charcoal, acidified to pH 6.2 with lactic acid and filtered.

•The calcium lactate liquor may then be spray-dried

•For technical grade lactic acid the calcium is precipitated as $CaSO_4.2H_2O$ which is filtered off.

•It is 44-45% total acidity. Food grade acid has a total acidity of about 50%.

•It is made from the fermentation of higher grade sugar and bleached with activated carbon.

•Metals especially iron and copper are removed by treatment with ferrocyanide.

• It is then filtered.

•Plastic grade is obtained by esterification with methanol after concentration.

•High-grade lactic acid is made by various methods: steam distillation under high vacuum, solvent extraction etc.