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# Lactic acid applications in pharmaceutical and cosmeceutical industries

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**ABSTRACT**

*Lactic acid is low molecular weight organic acid which produced mainly by fermentation using lactic acid bacteria or synthetically. For many years this acid is used in many food and chemical industries with wide range of applications. Nowadays, lactic acid is also used in pharmaceutical and cosmetic industries based on its functional properties as. This alpha hydroxyl acid plays also several and major roles in many biochemical pathways. In addition, in recent years more attention was given to lactic acid based on its use for the production of polylactic acid (PLA) which nowadays finds many industrial and medical applications as safe, biocompatible, and biodegradable polymer. In this review is designed to give more focus on market growth of this important organic acid and to provide an overview on the recent applications of lactic acid in both medical and pharmaceutical industries.*

**Key words:** Lactic acid, organic acid, lactic acid market, cosmetics, pharmaceuticals, PLA.

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## INTRODUCTION

Lactic acid is considered as one of the main well-known organic acids with wide range of industrial applications. This C3 low molecular weight alpha hydroxyl acid was first discovered in 1780 by the Swedish chemist Carl Wilhelm Scheele. The name of lactic acid was derived from the Latin name (lact) which means milk. However, the role of lactic acid bacteria on the production of lactic acid was first reported by the famous French scientist Louis Pasteur. This organic acid was firstly produced in industrial scale in 1895 by the famous chemical/pharmaceutical company Boehringer Ingelheim. Since that time this organic acid is considered as one of the key organic acid with many industrial uses. The four main applications of lactic acid are mainly in food, chemicals, cosmetic and pharmaceutical industries. Figure (1) provides overview about the potential applications of this important organic acid [1]. For many years, lactic acid is usually considered as one of the main chemicals in food and chemical industries [2]. The wide application of lactic acid in food industries is based its safety class as it is classified as GRAS (Generally Regarded as Safe) according to FDA (Food and Drug Administration) in USA. Lactic acid is mainly produced lactic acid bacteria which refer to a large group of beneficial bacteria of probiotic properties [3].This bacteria is common in nature and found in the gastrointestinal tract (GIT) for both human and animals with many potential health benefits [4-7]. In addition, this acid plays big role in the preparation of fermented dairy products and in the preparation of pickling, wine making, vegetables baking, sausages, meats and curing fish.

The application of lactic acid in the meat, poultry, and fish industries is mainly to enhance flavors and to increase shelf life through controlling the growth of pathogenic microorganisms in food as reported by many authors [8, 9]. In chemical industries, lactic acid is considered the generality possibility feedstock monomer for chemical conversions, because it includes two interactive practical collections, hydroxyl and carboxylic groups. Lactic acid sometimes undergo to deferent of chemical conversions into potentially useful chemicals. For example, propylene oxide (via hydrogenation), propionic acid (via reduction), acrylic acid (via dehydration), 2, 3-pentanedione (via condensation), Acetaldehyde (via decarboxylation), and dilative (via self-esterification) [10].The consequent polymer poly lactic acid has many involved in a wide range of applications. For example, food packaging, trash bags, preventive clothing, short shelf-life trays, sawdust film, shrink-wrap and rigid containers [11, 12]. The modern large growth of the PLA market maybe will catalyze future request on lactic acid frequently. Lactic acid has received a considerable deal of attentiveness as a feedstock monomer to produce of poly lactic acid that serve as a biodegradable merchandise plastic. The optically lactic acid was polymerized PLA (high molecular mass) through the serial sequent of ring-opening polymerization, and depolymerization[13].

Lactic acid offers natural constituent for cosmetic implementations. At first, it have been used as pH good regulators. In addition, it had other features such as skin hydration, antimicrobial activity, and skin lightening. The moisturizing efficiency was connected directly to lactate is moisture-detained capability, and the skin-lightening action of lactic acid was produced by the repression of the formation of tyrosine. Since they were normal constituent of the human body, following lactic acid and its salt fit completely into the renewed direction towards natural and safe formularization, and they produced such effects as renewal and skin illumination [14].

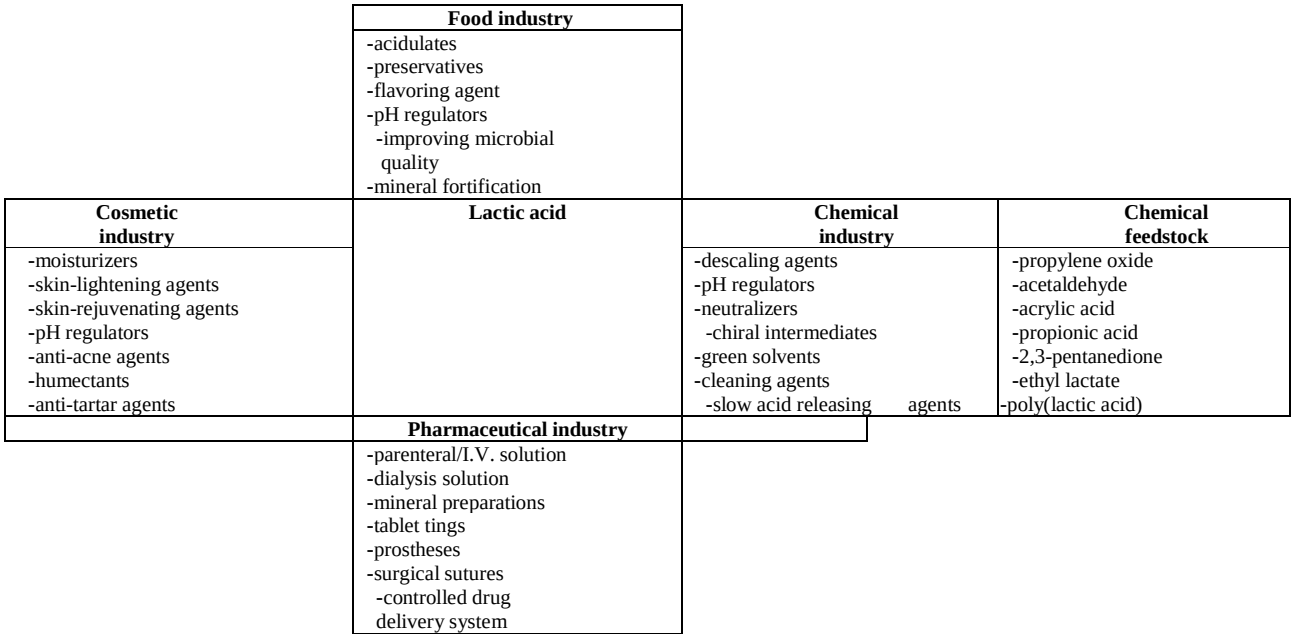


**Figure. 1.The range of commercial applications of lactic acid and its salt.(Modified from Wee *et al.*, 2006)[1]**

In addition, lactic acid have many applications in the drugs manufacture as an electrolyte in numerous, parenteral/I.V. (intravenous) solutions that are prepared to, supplement the bodily fluids or electrolytes. For Example, CAPD solution (continuous ambulatory peritoneal dialysis), and dialysis solution for classical synthetic renal machine [15]. The primary functions for the pharmaceutical applications are pH-regulation, chiral intermediate and metal sequestration, as a natural body constituent in pharmaceutical products. Furthermore, lactic acid is applied in a wide diversity of metal preparations that involve, surgical sutures, tablets, and controlled systems of drug deliver [16].Lactic acid is a valuable component in biomaterials such as resorbs able screws, sutures and medical devices [17].

The moderate acidic taste of lactic acid leaded to apply lactic acid as acidulate in salads, baked goods, beverages, and pickled vegetables. Lactic acid is applied in sweetmeats, not only for taste, but also to adjust pH of the cooked

mix. Lactic acid and its salt are used in different kind of chemical procedure and products. In this group of applications, the functions lactic acid are pH regulator, descaling factor, neutralizer, cleaning agent, metal composition agent, slow acid-release agent, solvent, humectant, antimicrobial agent, and chiral intermediate. Lactic acid has an emergent use as a good and safe natural solvent that is alternate; in numerous fine mechanical cleaning applications. Natural lactic acid is a good remover for polymer resins.it can get it with a large isomeric purity of 98% and is not appropriate as the raw material in the production of medicines or herbs [18]. Natural Lactic acid offers the best characteristics of descaling classic organic done, and it is often used in many products such as decalcifying agent in for coffee makers, and the bottom of the large ships because of its high descaling ability[11].

**Lactic acid Market (A huge market of high growth potential)**

In early 1963 the United States to produce lactic acid simply by fermentation, when Sterling Chemicals, Inc., started producing lactic acid by a chemical process using petroleum by products, equipping almost half the American request for lactic acid. During early 1990s, Ecological Chemical Products (EcoChem), a joint venture of E.I du Pont Nemours & Co., and Con Agra produced about 1,000,000 – 2,000,000 million pounds of lactic acid by fermentation using whey permeate [19]. In 1993, Archer Daniels Midland (ADM), joined the lactic acid business and designed a facility for 40 million pound production per year 10 million Pounds of lactic acid from corn starch. However, with the introduction of polylactic acid, the lactic acid market increased accordingly. Therefore, the global consumption of lactic acid grows continuously, and rapidly since 2008, has reached the market's capacity to 800,000 tons in 2013. The United States remains the largest consumer market in the world, accounting for 31% of the total consumption of lactic acid in 2013. China became the second largest market for lactic acid, with the situation in consumption already benefit from increased demand in the beverage and food industrial as well as an active and strong demand [20].There are many manufacturers of major companies to lactic acid in the world and in the lead, the three largest companies are Purac (Netherlands), Cargill (USA), Galaxy (Belgium), and Henan Jindan Lactic Acid Technology Co., Ltd. card total of 500,000 tons in 2013 While Cargill provides mainly lactic acid products to its subsidiary – Nature Works to produce polylactic acid. Since achieving smoother industrial production in the 1990s, polylactic acid witnessed the gradual increase in its application in the automotive, electronics, biomedical and many other areas. At present, the leading industrial PLA producers are mainly in the United States, China, Germany, and the Netherlands. On an industrial domain the assembling expense of lactic acid monomer will be focused to under 0.8 US$/kg, in light of the fact that the offering cost of PLA ought to lessening generally considerably from its available cost of 2 US$/kg. In 2013, the world market of poly lactic acid reached about 320,000 tons, of which 90% came from six major manufacturers. Among them, Nature Works LLC is currently the largest producer with annual capacity of about 150,000 tons which represent market share between 40 % and 45%. Polylactic acid manufacture started relatively late in China because of seeing the gradual transition from the laboratory to production units materials after pilot production only after the 1990s [21].While later in 2015 China produced nearly 13,700 tons, an increase of about 4,800 tons compared to those produced in 2008. However still have a long way and many of the issues that needed to be studied in this process in order to offer a suitable industrial model for lactic acid production process using inexpensive a non-food feedstocks.

**1. Pharmaceutical Applications of lactic acid**

Lactic acid is used in pharmaceutical manufacture as a very important factor. Pharmaceutical show presence for the L(+) lactic acid because the D(-) isomer is not metabolized by the human body. Lactic acid and its salts have been reported in many literatures for different medical applications. They are able to supply the energy and volume for blood besides regulation of pH. Calcium, iron, sodium, and other salts of lactic acid are used in pharmaceutical industry in several formulations as they exhibited anti-tumor activity. Lactic acid and its salts act also as an intermediate for pharmaceutical manufacture, for adjusting the pH of preparations and in tropical verruca medications [22-24]. Therefore, the current applications of lactic acid in the pharmaceutical industry are under the following categories:

**1.1. Parenteral/I.V**

Lactic acid is used in the pharmaceutical manufacture as an electrolyte in many parenteral/I.V. (intravenous) solutions that are intended to replenish the bodily fluids or electrolytes [25]. Lactic acid became one of the major components of in many medicinally used solutions such as Lactated Ringer’s or Hartmann’s solutions, and dialysis solutions for conventional artificial kidney machines.

**1.2. Dialysis solution**

A second option for kidney failure, continuous ambulant peritoneal dialysis CAPD (Continuous Ambulatory Peritoneal Dialysis), uses the lining of and organs residing in the peritoneal cavity as the "dialysis membrane." CAPD works quite well for patients who can tolerate it. Recently, sodium acetate was used as the dialysate fluid. It was infused into the patient through a permanent catheter inserted through the navel; waste material emptied into a drainage bag. Many researchers well documented that L(+) lactate, a normal constituent of the blood, is used instead of acetate due to a lower incidence of side effects [26].

**1.3. Controlled drug delivery system**

For implantable drug delivery, the materials of choice are lactide-glycolide copolymers, which dissolve in the skin and are absorbed into the body.In addition, polylactic acid (PLA) has been reported as a potential candidate as drug releasing matrix in different new drug formulations. This polymer characterized considered as one of the most biocompatible biopolymer. When PLA applied in human body it can hydrolyzed to its hydroxyl acid monomer which can be easily metabolized through the tricarboxylic acid cycle (TCA) [27]. In addition, PLA showed many advantages over other known biocompatible polymers such as poly hydroxyl alkanoates (PHAs), Poly ethylene glycol (PEG), poly ε-caprolactone (PCL) based on its better thermal processing ability [28].A new research showed also that the high potential application of PLA nanostructured membrane as drug delivery system for progesterone in animal model [29].

**1.4. Ammonium lactate for dry skin disorders**

Ammonium lactate is prepared by a mixture of lactic acid and ammonium hydroxide. It considered as an important chemical which involves in many pharmaceutical applications. Topically applied lactic acid salts, particularly ammonium lactate, were reported as efficient approach as skin moisturizer lotion for the treatment of severe dry skin or to mitigate the drying or irritating effects of topical corticosteroids [30]. Other research showed also the effective use of ammonium lactate in the prevention of xerosis and callus formation especially when formulated in combination with urea and applied in cream form [31].

**1.5. Mineral lactate formulations for diseases as such as anemia, hypertension, and osteoporosis**

The body accepts Lactic acid and its salts; lactate is an ideal vehicle for introducing therapeutic minerals. In general these preparations have advantages of good tolerance and pleasant or neutral taste (when ingested or applied topically). Some of the more important mineral lactates are ferrous lactate (anemia), calcium lactate (for osteoporosis, hypertension, tooth decay), manganese lactate (glucose intolerance), magnesium lactate (hypertension, muscle weakness), and zinc lactate (skin disorders) [32].

**1.6. Chiral Synthesis**

Chiral chemistry is very important in pharmaceutical processes, will continue to rely on natural product chiral building blocks, among which lactic acid is one of the most important. Both (R) and (S) isomers are now available in optical purities approaching 100%. Pharmaceutical manufacturers love chiral synthase like lactic acid because they are inexpensive, nontoxic, synthetically versatile, and lead to products with any desired stereochemistry [33].

**2. Cosmetic and cosmeceutical Applications of lactic acid**

Lactic acid has many applications in the field of skin care. Lactic acid was used in ancient history where the famous Egyptian queen Cleopatra is by immersing her weekly bath of milk believing that it will renew the skin and restores youthfulness of the skin [34]. At the beginning of this century, reaching the number of researchers at the Medical Center of the University of Maryland that the lactic acid to an important and essential role in the renewal of the skin and skin care in the event of his more than two hours per day [35].Studies also found that lactic acid has an essential role to play in skin brightener and re-genomic arrangement of melanin pigment responsible for the degree of skin color and treatment of brown spots or smudges rate ranging percentage 6-10% can help "directly inhibit the formation of melanin," the creation of a tool "enormous" to alleviate or remove the skin discolorations [36].Lactic acid peels exfoliate your skin's surface and help improve skin cell turnover rates. The removal of skin cells can help encourage the skin's production of natural elastin and collagen. This in turn may help reduce the appearance of wrinkles and fine lines [37, 38].Natural lactic acid and its derivatives are vastly used for pharmaceutical applications such as parenteral and dialyses solutions. Galactic produces natural lactic acid through the fermentation of sugar and guarantees a pharmaceutical degree by means of a very accurate purification process. Galactic pharmaceutical products respond with the highest quality standards required by industry [39]. As with anything, there are a few drawbacks to lactic acid. Even though it is milder than some other compounds, it can still be irritating, particularly

on damaged or allergy-prone skin. And no matter what lactic acid product you use, increased sun sensitivity is often an issue. It's important to limit your time in the sun and use sunscreen if you use a product that contains lactic acid. For the possibility of smoother skin, though, the extra precaution might be worth it. Lactic acid works with salicylate acid on the peeling the old skin and skin cell renewal for this markedly recently used in many skin care products to the speed of impact and results secured[36, 40].

**2.1. Moisturizers**

Ideal skin free of problem areas such as blemishes or wrinkles is not easy to achieve. Lactic acid in some moisturizers is intended to address these and other skin care concerns. Lactic acid is one of those AHA's that provides key benefits for the skin. It acts as an anti-aging tool by reducing the appearance of fine lines and wrinkles. With aging, there may be notable signs of the skin sagging at the cheeks and neck. Lactic acid promotes collagen production, which helps firm the skin. Lactic acid also plays a major role in lightening age spots [41].Lactic acid is mild enough for all skin types, including sensitive skin, acne and rosacea. As with any skin care product, there is always a possibility of allergic reaction. If you experience any burning, itching or redness, be sure to see a doctor as soon as possible. According to SkinCareNews.com, lactic acid makes the skin more sensitive to the sun's rays. Apply a generous amount of sunscreen with an SPF of 15 or higher after applying moisturizer that contains lactic acid [41, 42].

**2.2. Skin treatment**

Lactic acid is a skin moisturizer, but once applied continuously, may cause micro peeling. A lactic acid lotion advantages a type of skin complaints. It’s a large way to exfoliate, especially for dry and sensitive skin types. It can be utilized on the face to lighten hyperpigmentation and decrease age spots and acne scars. On the body, it can soften calluses, get disinfect of dry and bumpy skin, and even help reduce scars and stretch marks [36]. Lactic acid is an alpha hydroxyl acid used in skin care as a chemical exfoliant. A lactic acid lotion benefits skin by dissolving dead skin that accumulates on the surface of functioning skin. These dead cells lead to dry, dull skin and can prevent your skin treatments from working properly because they can’t be absorbed. Removing this accumulation is one of the most important parts of a skin care regimen [43].

A strong lactic acid lotion may even have a mild peeling effect. Peeling removes damaged tissue to expose the skin below that is in better condition. It is a powerful technique to decrease wrinkles, age spots and other discoloration, and acne scars. The peeling effects most lotions give is very mild and gradually take off skin deterioration. There is less risk of side effects, but it takes longer to exhibit good results. Many people use lactic acid lotion for face care to make sure their skin is properly exfoliated, ensuring their other antiaging products are able to work exactly. Most lactic lotions are mild and can be used daily. It’s a good idea to use it every other day in the beginning, especially if you have sensitive skin. Most lactic acid creams and lotions contain less than 10%, making them mild products that aren’t likely to visibly peel the skin. These products are a great way to prepare your skin for a lactic acid peel. Peels are very strong and will often severely irritate new users if they don’t give their skin time to adjust to using alpha hydroxyl acids. Using a mild product for a few weeks leading up to a peel will greatly reduce your chance of experiencing complications [44].

A lactic acid lotion benefits all kinds of skin and typically ideal for dry and sensitive skin as it is more moderate compared to glycolic acid. Sensitive skin needs exfoliation like everyone else, but often has problem with the attrition associated with manual methods like a facial scrub or microdermabrasion. Mild concentrations of lactic acid in a moisturizing base can be very beneficial for dry skin in which the outer layer is often composed of dead cells that have accumulated on the skin’s surface. Chemical exfoliation removes this dead skin build up more effectively than scrubbing. Lactic acid also has hydrating properties. People with dark skin are less likely to experience excessive skin lightening, which is a common side effect of glycolic acid. Lactic acid has been also used in combination with salicylic acid in acne formulations. A lactic acid lotion acts to reduce acne by removing dead skin that can clog pores. This dead skin can also keep salicylic acid from getting to pores, where it breaks up clogs. Lactic acid body lotion is a great way to treat dry body skin, calluses, and chicken skin (keratosis pilaris). If the lotion is strong enough to peel, it can reduce stretch marks and scars and also to reduce acne [45]. Lactic acid will enhance the effects of manual exfoliation. If using a body scrub or loofah isn’t giving you the results you’re looking for, try adding an alpha hydroxyl acid lotion to your routine. It will loosen the dead skin up so it will scrub away much easier.

## CONCLUSION

Lactic acid is one of key organic acids, which is being extensively applied around the globe in a range of industrial and biotechnological applications. The involvement of lactic acid in the composition of many agrichemicals and pharmaceuticals in many new applications of optically effective lactic acid or its esters, increased the growth of lactic acid market. A new application of optically effective liquid crystal whereby lactic acid is used as a chiral synthon has been recently reported. In addition, the increased growth of production and applications of PLA in industrial, pharmaceutical, and medical fields lead to extra market demand and interest on lactic acid production. The increased awareness of the need of natural and biodegradable biopolymers in everyday application will support the current industrial research to develop new applications of lactic acid and its derivatives.

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