Understanding the Science Behind pH and its Role in Younger, Healthier-Looking Skin

Lawrence E. Samuels, MD

The skin is the first line of defense against the aging process and the body's pH is the thermostat that regulates the speed and progression of this process. Skin care systems can be used to create products with a synergistic effect to regulate the skins pH based on skin type. Creating the right prescription for the skin based on pH and appropriate concentration of active ingredients is the key to improved, younger-looking skin. Good health is not a luxury, it is a necessity. The skin protects a body's internal clock against the aging process and we are the timekeepers.

Although aging is a natural process, as knowledge increases, treatments are being identified that can delay or modify the aging process. This process is controlled by genetic and molecular processes. This process can be modified by the fact that there are DNA repair systems within each cell. Theoretically it is possible for one to stay biologically "younger" and live longer with the aid of agents that are able to assist the repair process and prevent damage. DNA is damaged by environmental insults and internal oxidative metabolism on an ongoing basis, so the DNA repair capacity deteriorates with age.

The body is composed of trillions of cells. The metabolic function of every cell is dependent on the pH of the skin and body. The pH equation of health is the perfect balance between the body's internal pH and the skin's external pH. Outside the pH range compatible with life (pH lower than 2 or higher than 10 for extended periods of time), the skin loses its ability to protect the body from environmental damage, enzymes lose their ability to function, and the body is unable to sustain organ system functioning. The pH is tightly regulated by a complex system that works to maintain an acidic skin pH and an alkaline pH for the body. The management system is based on cellular communication because all cells have a certain function, and the regulatory authority that controls the skin's and body's metabolic function is the pH. The efficiency of this pH-regulating system decreases with age. The health of the skin and body is determined by products applied to the skin, fluids and food consumed, and the air that is breathed. All the regulatory systems and molecules (antioxidants, enzymes, kidney cells, liver cells, etc) serve the purpose of balancing the pH of the skin and body. The skin and body need to neutralize chemicals (free radicals) that alter their pH.[1]

It is important to understand the fundamentals of pH and how the skin and body regulate the acid-alkaline balance on a minute-to-minute basis. The body's pH is regulated by intracellular fluid (fluid found in all cells that makes up about two-thirds of the total amount of fluid in the body) and extracellular fluid (fluid found outside cells that is composed of plasma in the blood stream and interstitial fluid which surrounds cells). The skin's pH is regulated by glandular secretions and cellular components. The body needs to maintain a pH of 7.35 to 7.45 for its cells to function properly. Skin needs to maintain a pH of 4.5 +/− 1.0 for skin cells to function

Dr. Samuels is Chief of Dermatology, St. Luke's Hospital, St. Louis, Missouri.

Dr. Samuels has an equity position in Rx Systems PF.

Correspondence: Lawrence E. Samuels, MD, 1976 Congressional Dr, St. Louis, MO 63146 (samuelsmd@aol.com).

properly. The proteins in the skin and body are unique and proteins must maintain a specific geometric shape to function. These proteins are affected by the smallest change in pH of the skin and body.

FACTORS THAT CONTROL SKIN AND BODY pH

There are 3 main forces that influence and alter the pH of the skin and body. They are environmental injuries to the skin, the acid or alkaline effects of the food and liquids ingested, and the waste products produced by the metabolic activity of the cells. Fortunately, there are 3 major mechanisms at work to prevent these activities from shifting the pH of the skin and body outside their normal ranges. They include chemical buffering systems, elimination of carbon dioxide, and urinary excretion.

The chemical buffering systems guard against sudden shifts in pH. This system uses a combination of the skin's and body's naturally occurring antioxidants, enzymes, weak acids, and weak bases to minimize changes in the skin's and body's pH. This mechanism is very sensitive and rapid, controlling pH on a second-to-second basis.

Elimination of carbon dioxide occurs in the lungs. Carbon dioxide is mildly acidic and as it accumulates in the blood, the pH of the blood decreases (acidosis). The brain regulates the amount of carbon dioxide that is exhaled by controlling the speed and depth of breathing. Thus, an accumulation of carbon dioxide in the blood will initiate faster and deeper breaths raising the pH of the blood into a normal range. This mechanism is sensitive and rapid, controlling pH on a minute-to-minute basis.

Urinary excretion of acids and bases help control the body's pH. The kidneys make these adjustments much slower than the lungs, generally taking several days.

The pH of the skin is a complex mixture of glandular-secreted material (sweat glands, apocrine glands, and sebaceous glands) and cellular material. It consists of fatty acids, squalene, cholesterol, amino acids, small peptides, lipids, and electrolytes. Many of these molecules have acidic chemical structures, which create the acidic pH of the skin. The combination of these molecules and cellular material creates what has been called the acid mantle layer on the surface of the skin. The acidic pH of the acid mantle layer regulates normal skin physiology. In addition, pH plays a major role in regulating the aging process of the skin (and body) and protects the skin from environmental stresses (UV rays from the sun or tanning beds, pollutants, and cigarette smoke).

There is a change in skin pH with age. At puberty, individuals start to produce more hair on their bodies. Hair follicles have an associated sebaceous gland or glands, which become active as hair growth increases, causing changes in the skin pH. The hormones that control sweat also become active and the whole surface of a teenager's skin is totally different than the skin of a young child. This is the body's way of increasing its defense system.

In the late teens to early 20s, the acid mantle layer is well developed and provides protection against potentially harmful, external environmental factors. The skin usually looks healthy, heals quickly when injured, and seems to take care of itself.

With increasing age, the skin's pH becomes more and more neutral, and thus more susceptible to bacterial growth. This reduced acidity kills fewer bacteria than before, leaving the skin susceptible to bacterial growth and infections. The skin weakens as a result and begins developing problems with increasing age.

The aging process of the skin causes biochemical changes in collagen and elastin, the connective tissues underlying the skin that give the skin its firmness and elasticity. The rate of loss of skin firmness and elasticity differs from individual to individual, depending on their genetic makeup, general health, amount of exposure to the sun, skin care regimen (or lack thereof), pH of the skin, and other factors.

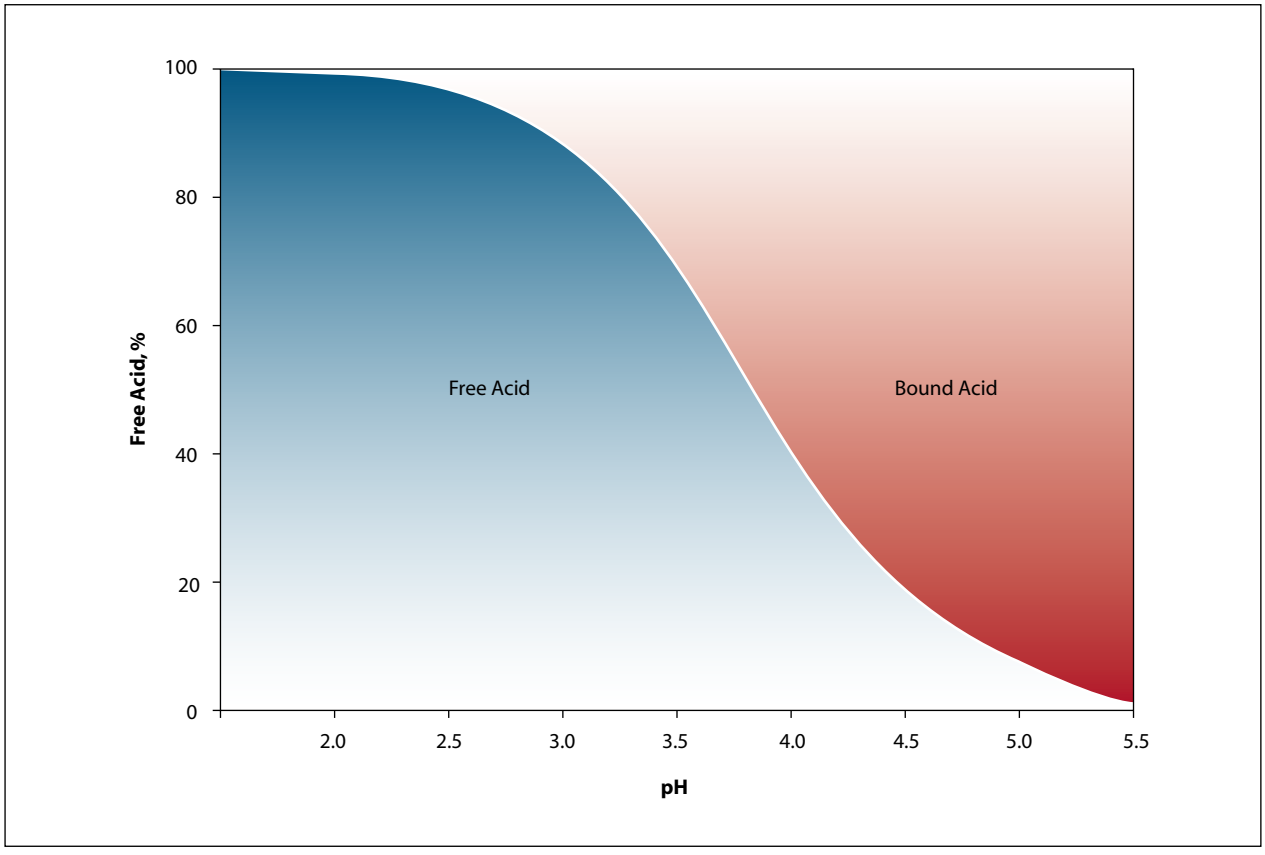
As the skin becomes less elastic, it also becomes drier; the underlying fatty tissue begins to disappear resulting in the skin beginning to sag. Skin becomes less supple and wrinkles begin to form. At this stage, the skin is more easily injured, heals more slowly, and tends to dry out more quickly.

It is therefore of great importance to have a good skin care regimen in place in which high-quality, scientifically advanced skin care products are employed.

The pH of the skin is responsible for controlling the biologic environment of the skin. The pH plays a role in cell growth, cell metabolism, the concentration and biologic activity of molecules, enzymatic activity, antioxidant activity, skin exfoliation, cell hydration, and glandular secretion.

One could say that pH is the thermostat of the skin and regulates biologic activity, concentration, potency, and clinical benefit of all the important molecules present in the skin.

This emphasizes the importance of pH in cosmeceutical products. The pH of cosmeceutical products regulates the biologic activity, concentration, potency, and clinical benefit of cosmeceutical skin care products.[2] The pH influences the free acid concentration, the biologically active form, of all the important molecules present in the skin. This directly affects the biologic activity of glycolic acid, alpha-lipoic acid, enzymes, L-ascorbic acid, retinol, peptides, lipids, and other molecules.[3]



Glycolic acid dissociation curve.

Glycolic acid is an α-hydroxy acid with documented scientific studies.[4] Glycolic acid in a solution, lotion, or cream exists in a free acid form HOCH2CO2− (biologically active) and a bound form HOCH2CO2H (biologically inactive). There is equilibrium between the free acid form and the bound form in a product which is pH-dependent.[5] This is demonstrated by the glycolic acid dissociation curve (Figure). The free acid concentration of glycolic acid is determined by the pH of the skin care product or glycolic acid peel.

Obviously, a product could state the free acid concentration and the pH, which is the standard used by Rx Systems PF. However, if one knows the total glycolic acid concentration and pH of a product, the free acid concentration can be determined using the glycolic acid dissociation curve.

The free acid form of glycolic acid represents the biologically active molecule. The lower the pH of a product, the greater the percent free acid concentration of glycolic acid in that product.[6]

Skin care programs treat and/or prevent the signs of aging skin caused by intrinsic aging and photodamage. Fundamentally these are changes in the physical and optical properties of the skin. The unwanted physical properties are laxity, wrinkles, loss of skin turgor, flaking, dryness, and oily skin. The unwanted optical properties include skin dullness, mottled skin, and brown spots.

Patients need to be given the knowledge that preventive measures during their teens and 20s will help ensure beautiful skin later in life. A treatment regimen should be designed that includes a balanced diet (15 calories per pound), restricted sugar and fats (not to exceed 30% and should be unsaturated), and increased fruit and vegetable intake to get antioxidants. In addition, include the regular use of a home skin care program and regular visits to the aesthetician or dermatologist.

An initial skin care program should include a cleanser, cream or lotion, and sun protection. Additional products, facial peels, masks, and treatments can be added to a program to address specific individual needs. Facial treatments improve lymphatic drainage and improve circulation. They also stimulate fibroblast formation, and improve skin tone and strength of dermal tissue.

Normal skin pH is somewhat acidic and in the range of 4.5 +/− 1.0. It varies from one part of the body to another and, in general, the pH of a man's skin is more

acidic than a woman's skin. The coating on the skin is a combination of sebum (oily fats), glandular secretions, perspiration, and cellular material called the acid mantle layer. The acid mantle layer is constantly secreted to cover the skin's surface and maintain a proper skin pH. The acid mantle protects the skin in several ways.

The lipids (antioxidants) in the mantle are sacrificially oxidized to protect the underlying skin from excessive oxidation. This is why "whiteheads," which are unoxidized sebum in pores, turn into "blackheads" as the sebum is oxidized. Antioxidants help neutralize free radicals that cause oxidation.

The fats in the mantle repel water from the skin just like the oil on a duck's feathers repels water. This keeps water from loosening and damaging the outermost skin layers and renders the skin less vulnerable to damage and attack by environmental factors such as sun and wind, and less prone to dehydration.

The acidic pH of the mantle inhibits bacterial growth on the skin. Thus, the skin remains healthier and has fewer infections and blemishes.

The outer skin proteins are made of keratin, a very hard protein that makes up animal horns. Keratin must be kept at an acidic pH to maintain its hardness by keeping the protective proteins tightly bound together. A higher alkaline pH (greater than 7) softens and loosens the fibers of keratin and creates gaps in the protective covering. This allows more allergens, irritants, bacteria, and viruses to penetrate the skin.

The pH is essential to our health because the body only operates well at a balanced pH. One of the most important roles of our skin is to protect our insides from the external environment, acting both as a barrier and a filter between the outside and inside. In addition, the skin is involved with immune function, temperature regulation, sensation, storage of molecular compounds, eliminating toxins created by cell metabolism, synthesis of molecules, and determining physical characteristics.

Glycolic complex is a scientifically advanced ingredient that represents a combination of a natural reparative molecule, glycolic acid, and a natural antioxidant molecule, alpha-lipoic acid. Both ingredients are water-soluble and require a similar pH for maximum benefit. Rx Systems PF products that contain trademarked "glypoic complex" are the only products that combine the effectiveness and stability of a reparative molecule and a rejuvenating molecule in one product. It is important for a product to be pH-adjusted (2.5−3.5) to maintain the free acid concentration of "gylpoic complex." Glypoic complex represents an ingredient with established clinical trials and peer-reviewed literature of each product individually (and Rx Systems PF has an 8-week clinical trial that shows the benefit of the glypoic complex), which documents the importance of the free acid concentration related to its clinical benefit (clinical benefits begin with a free acid concentration of 3% and increase with higher percentages). The combination of a reparative agent (glycolic acid) and an antioxidant agent (alpha-lipoic acid) creates a product with greater clinical benefit than either agent used alone.

Glycolic acid has the smallest molecular size of the α-hydroxy acids, which allows improved penetration into the epidermis. The US Pharmacopeia–grade glycolic acid is the glycolic acid molecule used in glypoic complex and represents the highest quality glycolic acid available for use in skin care products and is the glycolic acid used in documented clinical trials in the scientific literature.[4]

The epidermal cells are aligned like bricks, stacked in rows. There is scientific data regarding epidermal cell growth and the transport of these cells from the bottom layer of the epidermis to the outer cell layer of the stratum corneum. This process of renewing cells is called epidermal cell kinetics and is responsible for the normal exfoliation process of the epidermis. Renewing cells are found in the epidermis and can be divided into 3 categories. The germinative compartment are the 2 lower cell layers of the epidermis (basal and suprabasal layer). The differentiated compartment is the cells of the epidermis (spiny layers and the granular layer) between the germinative compartment and the cornified stratum corneum cells of the epidermis. The cornified compartment is the cells represented by the stratum corneum. The stratum corneum is constantly being lost to the environment and replaces itself about every 30 days. Age, sun damage, radiation, smoking, obesity, pollutants, herbicides, and illegal drugs damage the rate of cell growth in the epidermis. Glycolic acid stimulates cell renewal (growth) and cell repair in the epidermis.[7] Glycolic acid penetrates the epidermis and it is believed that glycolic acid–binding proteins are transported into the epidermal cells through receptor-dependent and receptor-independent processes. This signals the nucleus of the cell to begin the cell renewal process (a single cell undergoes cell division to create 2 new cells which mainly occurs in the basal and suprabasal cell layers). The initiation of the renewal process increases the thickness of the epidermis, reduces the cohesion of the stratum corneum cells, repairs the normal exfoliation of the stratum corneum, increases collagen formation, increases glycosaminoglycans (hyaluronic acid), improves the function of melanocytes, and stimulates new blood vessel formation in the dermis.

Alpha-lipoic acid is a combination of a carboxylic acid and a disulfide moiety (C8H14O2S2). Only the R-enantiomer is biologically active. This structure allows the molecule to penetrate the epidermis. In addition, alpha-lipoic acid has diverse biologic activity,

Study Results Assessing the Addition of Glypoic Complex to Skin Care Regimen (N=24)

8-Week Challenge With Glycolic Peels

Improvement in skin texture	24	100%
Improvement in skin tone	21	88%
Improvement in skin color	18	75%
Reduced number of brown spots	17	71%
Reduction of fine lines and wrinkles	15	63%

8-Week Challenge Without Glycolic Peels

Improvement in skin texture	24	100%
Improvement in skin tone	14	58%
Improvement in skin color	12	50%
Reduced number of brown spots	11	46%
Reduction of fine lines and wrinkles	13	54%

which includes antioxidant activity, antioxidant recycling activity, anti-inflammatory properties, and activity-enhancing biological energy production.

Age, sun damage, radiation, cigarette smoking, pollutants, herbicides, and cell metabolism create free radicals. Free radicals are any atom or molecule with an unpaired electron. A free radical is like a pellet that attacks cell membranes (lipid peroxidation), proteins, and DNA leading to cell damage and cell death. Free radicals are commonly associated with an inflammatory response felt to be greatest 24 hours after the injury. Alpha-lipoic acid has substantial antioxidant activity. This means it is like the pellet eating "Pac Man" that neutralizes free radicals.[7] Thus, alpha-lipoic acid helps prevent cell damage by free radicals. Alpha-lipoic acid reduces free radicals without becoming reactive due to its chemical structure. This rejuvenating process prevents cell damage and cell death resulting in normal cell metabolism, normal epidermal cell structure, improved collagen synthesis, and improved glycosaminoglycan production.

Rx Systems PF has created a group of reparative products in an oil-free, pH-adjusted base to maintain the highest free acid concentration of glypoic complex.

The products in the reparative program are pH-adjusted to create a product with an acidic pH, which increases the free acid concentration of both the glycolic acid and the alpha-lipoic acid in glypoic complex.

PILOT STUDY TO ASSESS THE BENEFIT OF THE INGREDIENT GLYPOIC COMPLEX

A pilot study was conducted to assess the benefit of a skin care treatment regimen which contains the active ingredient "glypoic complex" (a trademarked combination of glycolic acid and alpha-lipoic acid) with glycolic acid peels for 8 weeks. A second group was treated with the skin care products containing the active ingredient "glypoic complex" but without the use of glycolic peels. This will assess the benefit of the glycolic peels as an active ingredient and added value of glycolic acid peels to enhance and accelerate the benefits of glypoic complex alone.

Before-and-after photographs should be used to evaluate the skin care regimen used to treat skin damage due to aging and sun damage. This will establish a correlation between the interventions and the clinical outcome.

A total of 48 female participants aged 35 to 60 years were assessed for skin damage due to sun and aging that

included fine lines and wrinkles, skin discoloration, loss of skin tone, and rough texture. Their skin type was identified, through use of a questionnaire and visual assessment, as dry/normal or normal/oily; sensitive or resistant; and pigmented/wrinkled or nonpigmented/unwrinkled.

Inclusion criteria included women aged 35 to 60 years in good health with mild to moderate skin discoloration and/or brown spots, fine lines and mild wrinkles, rough skin texture, and decreased skin tone.

Exclusion criteria included a history of notable skin anomalies, skin cancer, or dermatitis; a history of serious allergies; topical retinoid use within one month; facial treatment programs or products used within one month; smoking more than 1 pack of cigarettes per day; pregnancy; medical conditions requiring oral medication; and no signs of sun damage or aging.

Participants were then prescribed skin care regimens based on their skin assessments that included cleanser, cream or lotion, and moisturizer with sun protection factor 30. Twenty-four participants also were prescribed office-based glycolic acid facial peels (Table).

Adverse events reported during the course of the trial were documented. The frequency of the most commonly reported events were assessed as definitely, probably, or most possibly related to the study, and were analyzed. Each patient was given a skin evaluation questionnaire to fill out at each visit, as well as a final skin evaluation at the conclusion of the study.

CONCLUSION

Compared to the baseline, an 8-week home skin care program with glypoic complex (Rx Systems PF Reparative System) improved skin texture, tone, and discoloration and reduced the appearance of brown spots, fine lines, and wrinkles. More importantly is the remarkable improvement in skin tone and discoloration, reduction of the appearance of brown spots, and the decrease in the appearance of fine lines and wrinkles with the addition of a series of glycolic peels (Rx Systems PF Glycolic Peels with Glypure-L). An 8-week program combining Rx Systems PF reparative skin care products and a series of glycolic peels improved the appearance and health of aging and sun-damaged skin. The skin's and body's pH is the science responsible for life. The skin is the largest organ of the body making up nearly 15% of the total weight. Skin is amazingly complex and well-designed. Skin is a multipurpose organ providing numerous functions, many we take for granted. The skin is flexible and elastic; it protects us from environmental stresses (sun, pollutants, wind, cold, etc); provides us with sensation because there are thousands of nerve endings per square inch; maintains and protects our internal organs; and controls its pH in order to maintain healthy skin.

The advantages of using skin care products that are pH-adjusted include an increased concentration of the active ingredient (ie, L-ascorbic acid), increased penetration of the active ingredient into the skin (ie, retinol), and increased clinical benefit for patients.

Understanding the pH of skin care products is vital. Small changes in pH can make a big difference in the skin's vitality. The use of ordinary soap not only increases the pH of the skin, removing its protective acid mantle layer, but it also kills the bacteria responsible for maintaining the acidic pH of the skin. Knowing the real science behind pH will produce healthy skin results.

REFERENCES

1. Pinnell SR. Cutaneous photodamage, oxidative stress, and topical antioxidant protection. *J Am Acad Dermatol.* 2003;48:1-19.
2. Pinnell SR, Yang H, Omar M, et al. Topical L-ascorbic acid: percutaneous absorption studies. *Dermatol Surg.* 2001;27:137-142.
3. Yu RJ, Van Scott EJ. Bioavailability of alpha-hydroxy acids in topical formulations. *Cosmet Dermatol.* 1996;9:54-62.
4. Van Scott EJ, Ditre CM, Yu RJ. Alpha-hydroxy acids in the treatment of signs of photoaging. *Clin Dermatol.* 1996;14:217-226.
5. DiNardo JC, Grove GL, Moy LS. Clinical and histological effects of glycolic acid at different concentrations and pH levels. *Dermatol Surg.* 1996;22:421-424.
6. Johnson AW, Nole GE, Rozen MG, et al. Skin tolerance of AHAs: a comparison of lactic and glycolic acids and the role of pH. *Cosmet Dermatol.* 1997;10:38-45.
7. Draelos ZD. Hydroxy acid update. *Cosmet Dermatol.* 1998;11:27-29. ■