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Antiaging Cosmeceuticals in Korea and Open Innovation in the Era of the 4th Industrial Revolution: From Research to Business

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Abstract: The importance of the healthcare industry has increased and it has thrived, although the cosmetic industry of Korea has been in depression. A recently issued group of items in Korea, ‘cosmeceuticals’, is defined as a combination of pharmaceuticals and cosmetics proven to have medical effectiveness. Antiaging cosmeceuticals in Korea have performed well in terms of expanding business by combining with beauty services, so they are viewed as high-valued items. This fact supports the evidence that there are various studies on cosmeceuticals. Therefore, this paper shows that the global status and growth potential of cosmeceuticals are documented and the concepts of the application of the demonstration complex and open innovation will be linked together based on research of antiaging cosmeceuticals in Korea for an aging society. This paper intends to provide the basic information for forming a ‘lab to market’ which connects the future cosmeceutical laboratory to the market.

Keywords: cosmeceuticals; anti-aging; open innovation; cosmetics; demonstration complex

1. Introduction

The age of Homo Hundred will soon be approached as the lifespan of humankind is continuously increasing. The average life expectancy in Organization for Economic Cooperation and Development (OECD) countries in 2013 was 80.5 years, which is about 10 years older compared to that in 1970. In Korea, the average life expectancy at the end of 2013 was 81.8 years, which is about 20 years older. In the case of developed countries, such as France, Japan, and the US, the size of the physically and mentally healthy population has increased rapidly [1,2]. Extending a lifespan is a blessing, but the social burden is also growing proportional to the prolonging of decrepitude. It is expected that antiaging science, which has recently been emerging with the development of life sciences, chemistry, and IT technology, will be able to solve this problem [3].

The growth of the elderly population is directly proportional to the increase in the demand for antiaging products [4]. The paradigm of healthcare is shifting from treatment to prevention due to the following reasons: increase in income, development of technology, and fusion of industries. As society becomes more sophisticated, well-being, emotion, etc., arise as the new trend of consumption. Hence, consumers are interested in physical and mental health and, at the same time, demands on beauty have been diversifying. The cosmeceutical industry is an ever-growing and in-demand market, especially in Asia. Korea has been at the forefront of creating the newest generation and most innovative cosmeceutical products [5].

Cosmeceuticals, which have become a center of attention, are defined as a fusion of general cosmetics and highly functional cosmetics which are proven to have medical effectiveness in Korea.

These products fulfill consumers' needs 'to maintain healthy youth', as the medicinal importance of and the interest in well-being increase. Cosmeceuticals combine the advantages of pharmaceuticals and cosmetics, so they consider not only beauty treatment, but also skin protection, and are hence effective as an ancillary remedial agent as well [6].

However, although there are numerous technologies and plenty of research on the development of antiaging cosmetics, cosmetics exist as they are without confirming the demands or evaluations of actual users. Moreover, in the current studies of internal industries related to antiaging, an actual systematic demonstration which is based on the evaluation of actual users has not been constructed yet; hence, there is an urgent need to research commercialization in the actual complexes.

Therefore, in this study, based on the research on the commercialization of antiaging cosmeceuticals in an aging society, the global status of antiaging cosmeceuticals and the growth potential are described in the Section 2 Literature review. In Section 3 construction of a research and development (R and D) platform of antiaging cosmeceuticals, the research frame of studies related to the development of antiaging cosmeceuticals is explained, and in Section 4 the research on antiaging cosmeceuticals and open innovation, the achievement of current studies is examined. Lastly, in Section 5 progress of research, the business strategy of antiaging cosmeceuticals in the era of open innovation is explained.

2. Literature Review

2.1. Skin Aging and Cosmetics

Skin surrounds the whole body and it consists of three layers, which are the epidermis, dermis, and subcutaneous fat. Skin is always in contact with oxygen, and highly exposed to ultraviolet radiation. Histologically, wrinkled skin is characterized by the accumulation of altered elastic fibers and degradation or degeneration of collagen bundles in the dermis [7,8]. Ultraviolet-B (UVB) induced reactive oxygen species (ROS) production activates mitogen-activated protein kinase (MAPK) signaling and the transcription factors activator protein-1 (AP-1) and nuclear factor- κ B (NF- κ B), which further induce inflammaging and apoptosis in cells and cause skin aging [9]. As the skin ages, it becomes drier, and the number of fine wrinkles, which become gradually deeper as time goes by, increases. At the same time, the skin loses its elasticity through changes in the structure and function of the epidermis and dermis. The skin becomes thinner and less elastic as it ages, and this is the characteristic of its clinical change (Figure 1) [10].

The stratum corneum, located at the outermost part of skin, plays a role as a skin barrier to protect the human body from external stimulation [11]. The stratum corneum, which is composed of flat layers of keratinocytes, is filled with 'keratin', which is a hydrophobic and insoluble fibrous protein. Between keratinocytes, there is intercellular lipid, which consists of ceramide, free fatty acids, cholesterol, etc., which stabilizes the structure. This feature has made it possible to effectively protect the body, but at the same time, it has made difficult for cosmetic ingredients to be absorbed into the body [12].

In particular, transdermal drug delivery (TDD), which delivers drugs to the skin, has been continuously studied in the pharmaceutical and cosmetics industries because drugs cannot be metabolized in the liver or stomach, so that drug efficacy can be exercised promptly.

In the meantime, many studies have been conducted for transdermal drug delivery. In order to pass through the intercellular lipids, the size of the ingredients needs to be fine and nanosized. Moreover, to be more efficiently passed, physical methods, such as electrical stimulation and administration methods, such as inhibition of the drug metabolism in the skin, are suggested. In particular, the field of research which has mainly progressed is aimed at developing transdermal drug delivery in an effective way [13].

Therefore, in the cosmetics industry, it is significant to develop new materials for functional cosmetics, such as those for whitening, wrinkle, antioxidant, and antiaging, and to increase the rate of percutaneous absorption when applied to skin. Skin, which is a highly effective barrier, does not allow

most active ingredient to be absorbed into the body; hence, these ingredients cannot show its effects when applied to the skin [14].

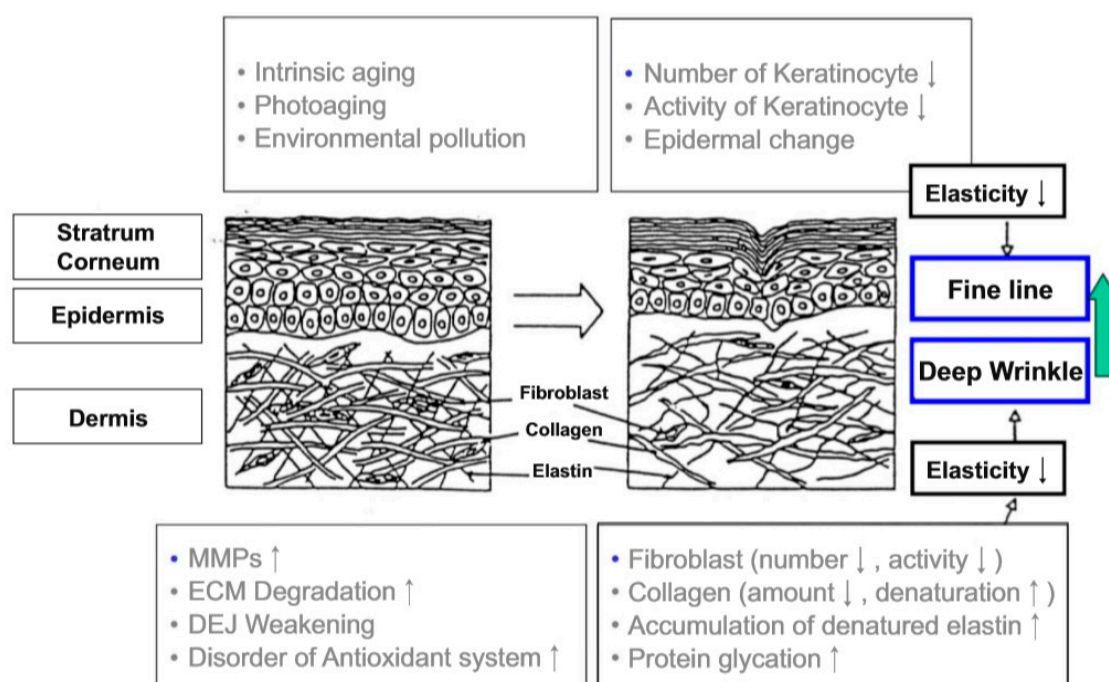


Figure 1. Mechanism of skin aging [10].

2.2. Trend of Cosmeceuticals

According to the Korea Health Industry Development Institute (KHIDI), the global market size was estimated to be US \$43 billion in 2016, and it has a growth rate of 7.5% compared to the previous year. It is increasing at a growth rate of approximately 25% in the overall cosmetics market, and it occupies 8.9% of the global cosmetics market [4]. The antiaging market is steadily growing as the population of elderly people increases, and the interest in beauty is increasing as their income has risen.

The term ‘cosmeceutical’ is made by a combination of pharmaceuticals and cosmetics (Table 1), and this concept was first coined in the magazine ‘*Cosmetics and Toiletries*’ (1993) by Albert M. Kligman, a professor of dermatology at the University of Pennsylvania. It is now widely used [15], and the first cosmeceutical product made of apha-hydroxy acids (AHA) was presented in the market in the early 1990s in the United States [16–18].

Table 1. Comparison between cosmetics, cosmeceuticals, and pharmaceuticals [19].

	Cosmetics	Cosmeceuticals	Pharmaceuticals
Objective	Pursuit of beauty	Subsidiary treatment	Treatment and prevention
Subject	Normal skin (unspecified number of people)	Specified number of people who have visited clinics and normal skin	Skin with problems (Specific person, Patients)
Method	Every day, regularly	Long-term	Normally temporary Priority on effects focusing on notified ingredients
Ingredients	Wide range of all ingredients	Ingredients focusing on subsidiary effects	(accompanied by minor side effects as the occasion)

In Korea, cosmeceuticals were first used by dermatologists for the purpose of treating skin problems of patients. Since then, more and more pharmaceutical products have been selling in pharmacies and gradually, cosmeceuticals have become a product which can be bought without a doctor’s prescription in Korea [6].

In March 2016, customized cosmetics were launched as a pilot project, and ‘cosmeceuticals’ have received attention from the cosmetics market. At the same time, the interest in cosmetics which help to treat skin problems is increasing. The cosmeceutical market in Korea was grown by hospitals and pharmaceutical companies in the 1990s, but currently, it is becoming more popular and diversified because cosmetic companies are taking over pharmaceutical companies in Korea [20].

For instance, overseas, as of 2011, the market size of antiaging cosmetics was the largest in the world in Japan at \$12 billion. The market size of antiaging products grew from US \$19.7 billion in 2008 to US \$31 billion in 2015, and it is now about double the amount. Shiseido, a leading Japanese enterprises, provides a total solution by breaking the mold [21].

In the UK, the antiaging industry is defined as “healthy aging”, and is considered a beauty industry related to face and body care. As of 2011, the market size of antiaging cosmetics in the UK was approximately \$1.7 billion with a year-on-year growth rate of 3.2%. This amount was the ninth largest in the world [21].

In the meantime, the size of the internal cosmetic market is around 500 billion KRW. As of 2016, 25 pharmaceutical companies and 18 biotech companies had launched derma cosmetics and entered into the cosmeceutical market. Although it is only 4% of the world cosmetic market, it is growing at a rate of more than 15% annually. According to research by Datamonitor (2010), the involvement of Korean people in the antiaging issue is 65%, and this value is higher than the world’s average of 37% and higher than that in major developed countries, such as the USA (25%), France (31%), and so on. Hence, there is a high potential for growth in the future [22].

3. Construction of R and D Platform of Antiaging Cosmeceuticals

The domestic antiaging market is steadily growing, and especially, cosmeceutical development with higher efficacy is required by consumers in this aging society. There are four necessary approaches to research on the basic mechanisms of skin physiology to develop highly efficient functional cosmetics (Figure 2).

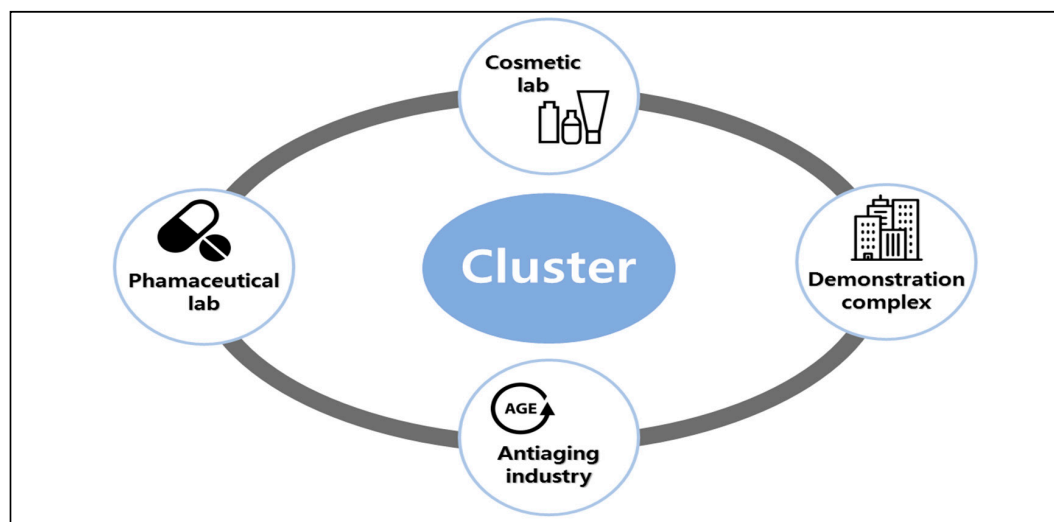


Figure 2. Construction of demonstration complex.

Firstly, it is necessary to study the physiological mechanisms of skin. In terms of dermatology, developing new materials or granting functions are available by revealing new functions and mechanisms of skin.

The second step is the development of highly functional materials. Cosmeceuticals are especially required to have differentiated functions, compared to ordinary cosmetics. There are three methods to fulfill this tendency: To introduce substances that are already known to be effective in the field

of dermatology, pharmacy, and life science; to extract and purify effective ingredients from natural substances; and to develop new ingredients and ways to synthesize derivatives.

The third step is the development of new technology for a transdermal absorption system which enables the delivery of effective ingredients deep into the skin. It is necessary to develop a technology to deliver effective ingredients into the region where they are demanded. To approach this technology, it is necessary to develop the skill to stabilize unstable substances, and to improve solubility and dispersion efficiency. Additionally, highly efficient substances can be selected via research about transdermal delivery systems (TDS), such as the development of liposomes capsule and nano capsules, and ingredients for selective delivery to the epidermis [13,23].

Lastly, it is necessary to develop a technology which can measure the developed materials in an objective way. It is very important to verify the reliability and safety of products in various conditions prior to commercializing newly developed products. It is significant to work on the basics to construct a demonstration complex for products, including antiaging cosmeceuticals [14]. The development of an evaluation method to measure the efficacy and safety of materials needs to be considered. In this field of study, various methods in vitro and in vivo have been developed and applied to demonstrate efficacy objectively.

In particular, in the case of developing and evaluating a product for elderly people, it is necessary to consider not only the product itself, but also its plan for the service linkage.

Moreover, it is meaningful to construct the demonstration complex currently in Korea, since there is not much information about the demands of actual users of antiaging cosmetics, and an evaluating system.

4. Research of Antiaging Cosmeceuticals and Open Innovation

The definition of 'open innovation' differs from that of 'innovation' activities in the past. Innovation activities in the past were limited to internal use only, not to allowing competitors to benefit from our ideas; open innovation, however, allows others to benefit from our ideas, and we also profit in new ways from them. If innovation of the past meant creating new ideas, open innovation additionally means combining internal and external ideas to create new ideas [24]. The significance of open innovation mentioned in 'Creative Innovation and Open Innovation' by Kim, S. W. (2012) is explained in connection with the research business of antiaging cosmeceuticals [25].

The first reason for adopting open innovation in the field of cosmetics, such as in antiaging cosmeceuticals, is the increase in research cost. According to the Korea Development Bank, the research and development cost was approximately 89.8 billion KRW in 2009, but it was raised to 211.9 billion KRW in 2010 [26]. Since research and development costs involve potential profits, it could be a burden for an enterprise to deal with these raising costs. Cosmetics especially have a wide variety of types and prices, and it is a field where small-and-middle sized enterprises are highly involved, it is difficult for one company to cover up the whole cost. For this reason, in the first study of this research, the department for developing new pharmaceutical materials and that for applying cosmetics were operated separately; and in the second study, the efficient method was developed by sharing new materials and continuously researching on it. Therefore, open innovation, which provides a platform to let small-and-middle sized enterprises or individuals participate in research and development for their own profit, can be a good alternative.

Second, there is a shortened lifespan of products and development cycle. For example, Toyota, which represents the Japanese automobile industry, said that it took 33 months in the 1980s, 24 months in the 1990s, and 12 months in 2010 to develop a new car [25]. Even in the case of large industrial products, the lifespan of products has shortened and, accordingly, the responsibility of enterprises to introduce new products in a short time has increased. In the cosmetic industry, the demand of customers and their needs are much more diverse compared to those of the automobile industry, so the development cycle and period of launching new products are much shorter; moreover, some cosmetic products need to be developed and released four times a year considering the seasons. Therefore,

if open innovation is not only used to solve a problem internally, it would be possible to use the information of many other companies and make new developments easier and more quickly; hence, the use of open innovation is important.

Third, there is the complexity of the value chain. A value chain is defined as a set of core processes that provides value to customers. The process of developing a new antiaging ingredient for a new antiaging cosmeceutical is the sum of values created at each stage of the value chain. However, in the case of cosmetics, it is not only the open innovation of the R and D stage that is important, but the management and operation are also very significant when considering the products and sales stage for its practical use. Therefore, the application of open innovation is very significant in this complicated society, because it costs much more to secure controllability than it did in the past.

In the meantime, the application process of open innovation is examined in this study. The success and failure of cosmeceutical business ultimately depends on how to reflect the needs of customers and resolve them. For this, ceaseless communication and interaction with customers are necessary to let them experience products and participate in business activities. In this study, the demands and needs of actual users are identified by constructing a demonstration complex which is linked to the Seongnam Senior Complex, and this information is used and shared with other relevant industries to acquire customer orientation and to reduce the R and D expenses.

Furthermore, there is the application of open innovation using social networks. According to Robert Metcalfe (1980), the cost of building up the value will fall sharply as the number of users increases [27]. In particular, in order to expand the cosmetics market, it is necessary to satisfy the three elements of legal, R and D, and marketing. Additionally, as the saying goes, “People buy cosmetics not based on function, but on emotions”, so it is crucial to have a marketing strategy that can appeal to customers and to build and share a database that grasps the needs of customers. In addition, by using the opinions and ideas of external experts, we have applied the process to each step so as to reduce trial and error and to conduct a more economical and efficient research.

5. Progress of Research

We have developed and applied new ingredients for antiaging effects for an aging society. For this research, a research fund for 5 years since 2017 was provided by the Korean government (Korea Research Foundation) to develop a biomarker composition for measuring skin aging, capable of diagnosing skin aging, in the form of a kit (Figure 3).

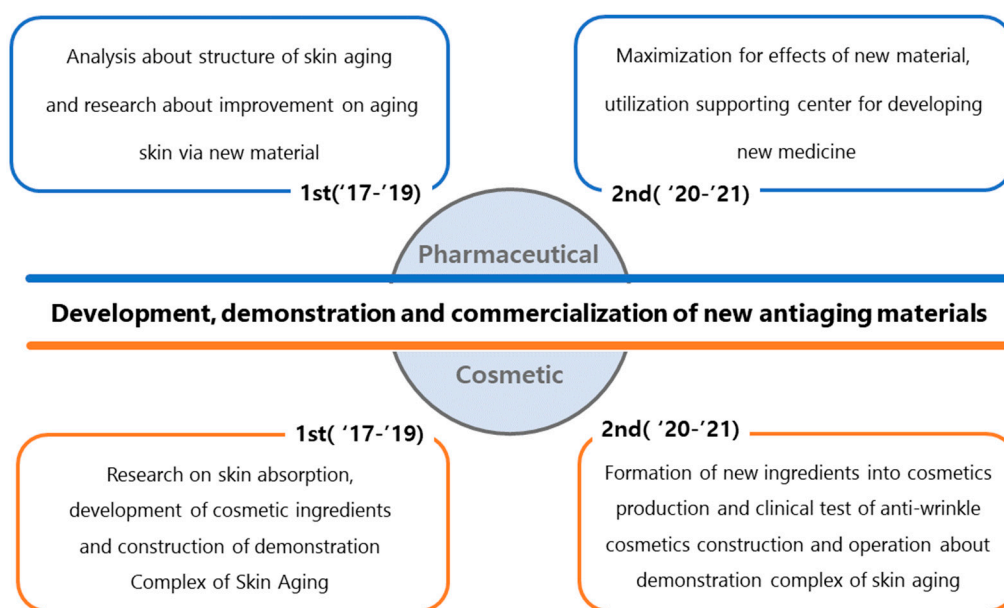


Figure 3. Contents and range of the research.

- (1) New ingredients for anti-aging effects were developed. The new substance, HAPLN1 protein, has reduced expression during aging and has an excellent effect of alleviating and reversing skin aging including wrinkles when administered. In addition, a skin aging preventing or alleviating pharmaceutical composition, cosmetic composition and a wrinkle alleviating cosmetic composition, are provided, all of which contain any one or more selected from the group consisting of an HAPLN1 protein. Moreover, this has obtained an international patent (PCT/KR2017/002395). Therefore, the same research on the human body is currently underway to figure out whether it shows positive results as well.
- (2) The mechanism of cell permeation in a drug delivery system was analyzed. The mechanism of drug delivery in the perspective of the dermatological physiology level was analyzed and studied to reveal the effects of cosmetic active ingredients on the skin. The effects of drug delivery via cell permeation are applied to the dermis. It is necessary to understand the features of the skin, and research to deliver antiaging substances into the dermis is in progress. In particular, a mechanism of drug delivery using intercellular lipids, which are relatively rapidly absorbed, has been identified, and studies are underway to develop formulations that can most effectively cope with this mechanism.
- (3) The research to improve the effectiveness of drug delivery into the dermis is in progress. Skin, which is a highly effective barrier, does not allow active ingredients to be absorbed into the body; hence, these ingredients cannot have dramatic effects when applied to skin. In particular, since the newly developed substance is a protein-derived material from a human body, it is necessary to conduct research on the limitations of absorbing and delivering into the dermis. It is difficult to prevent skin-aging because of the difficulty in penetrating the skin barrier, stratum corneum; hence, substances are not easily absorbed into the dermis. Generally, drugs are absorbed through damaged skin, but cosmetics are applied to normal skin; therefore, although the development of effective ingredients is successful, it is very difficult for them to be absorbed into the dermis. In addition, in the case of antiwrinkle ingredients, they are hardly absorbed into the skin at all, and they may only have very limited effects due to the immune system, so percutaneous permeation screening is carried out in order to confirm the effects of drug delivery of wrinkle-improving peptides.
- (4) A demonstration complex for skin aging is in the process of being built. In addition, Eulji University has the optimized conditions to undertake research about elderly people, since the university is operating the Seongnam Senior Complex as a regional business which consists of an R and D center, education supporting center, and demonstration center. Seongnam Senior Complex is the first internationally accredited testing laboratory for aging-friendly products in the Korean metropolitan area. Other than Seongnam Senior Complex, Eulji University contracted Memorandum of Understanding (MOU) with related organizations for the diagnosis of aging skin. Based on this, a consulting group with regional experts was formed to conduct research and clinical demonstration in connection with the whole country. Additionally, the utilization of social networks was considered to be applied to find solutions against the difficulties in personal participation. Using an external advisory group, we are looking for ways to reduce the gap between different understandings and expertise and solve questions instantly using a web-based social network.
- (5) The achievements of this study will be published and shared via the application of a patent, production of trial manufactured goods and papers. The technology for the development of new antiaging ingredients and new formulas which enable absorption into the dermis will form part of an application for a patent to prove the effects. Furthermore, the possibility of actual commercialization can be considered by producing trial-manufactured goods.

6. Conclusions and Implications

Based on the research on the commercialization of antiaging cosmeceuticals, the process to apply open innovation in a demonstration complex, and the result of this project in the middle of these stages was confirmed.

The antiaging industry is expected to grow globally, and the demand for antiaging products in Korea is relatively high. The antiaging industry is expected to grow continuously with the economic power of active seniors and high technology. In particular, the recognition of cosmetics as an essential product, increase in the female economically active population, with the diversification of consumers' needs, expansion of consumption levels, expansion of on/off sharing platforms, and entry into the aging society being the reasons that the cosmetic industry could be a field where new markets are continuously created despite the global economic crisis [28]. The antiaging industry is expected to continuously grow with the economic power of active seniors and high technology. Based on this fact, there are various studies on cosmeceuticals.

As there are improvements in government policies and bio and medical technologies, there is a high chance of developing antiaging products and services. The antiaging industry is expected to grow globally, and the demand for antiaging products in Korea is relatively high. For example, the American leading spa brand, Cannon Ranch, which offers total antiaging services targeting the wealthy, occupies 40% of US' spas.

In this study, we proposed a technology convergence research model through the construction of a new demonstration complex that could reflect the needs of research institutes, businesses and consumers with individual information and technologies. Moreover, we should try to develop antiaging products and services, and its business models in Korea, which are combined with the value of society, and we should try to create added values via mutual growth of industries through linkage of products and services. In addition, environmentally friendly issues, which are of global concern, should continue to be studied for cosmetic products linked to 'natural', 'organic agriculture', 'no artificial preservatives' and 'no animal ingredients'.

Moreover, in order to develop new antiaging materials and technologies and to use them for commercialization, there is a need to establish support and policies for related research, and at the same time, the useless regulations that prevent commercialization of the new items should be eased. Thereafter, the industry will grow.

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