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Article

Microplastics and cosmetics: Problems and solutions

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Abstract: Plastic waste and microplastics are invading lands and oceans, creating problems for animals, human health and the environment. Packaging, building and construction, textiles and cosmetic sectors are the main industries that utilize these non biodegradable materials. Thus, there is a necessity to find a new way of producing and consuming skin- and eco-compatible' goods. For this purpose, it's important to remember that the cosmetic and diet supplement markets are continually increasing, due also to the introduction of "Beauty from within," based on the contemporary consumption of cosmeceuticals applied to the skin and nutraceuticals taken by oral route. Moreover, both of these products are made by emulsions or solutions based on a great consumption of water with the use of carriers rich in chemicals, which often cause allergy and sensitization problems. Thus, the proposed solution to use smart tissue-carriers, which are embedded with natural ingredients, and is based on the use of raw materials and biopolymers obtained from food and agro-forestry waste. These new carriers, with a structure similar to the Extra Cellular Matrix, may be used to realize smart cosme-nutraceuticals useful to reduce water consumption, producing innovative products free of emulsifiers, preservatives, colors, fragrances and other chemicals. So, it will possible to save the human health and the environment by maintaining natural raw materials and the biodiversity of the earth for the future generations.

Keywords: cosmeceuticals; nutraceuticals; chitin nanofibrils; nano lignin; waste; microplastics; cosmetic market; diet supplement market; water consumption; skin and mucous barriers

1. Introduction

As known production and consumption of cosmetics contribute to the microplastics released into the oceans as microbeads by materials used for making buildings and producing foods, cosmetics, packagings and tissues, all impacting environment and the human health (**Figure 1**) [1]. Microplastics are defined as plastic fragments with a size lower than 5 mm. They released into the oceans, has reached the number of 24.4 trillion with a weight between 82 and 578 million tons and an estimated increasing by 4.8 to 12 million tonnes yearly (**Figure 1**) [2,3]. This great quantity of plastic microparticles, ingested by fishes and marine mammals, enter into the food chain up to the human food. In fact, microplastics have been recovered into tea cups, placenta, blood and drinking water [4–7]. It is suspected that they can act as vectors for potentially toxic elements such as Fe, Mn, Sl, S, Pb, Cu, Ag and Zn and contaminants, including polychlorinated bisphenols and phthalates utilized to make some kind of plastic packaging [8,9]. Textiles can be considered the primary source of microplastics because generated during their washing. While the

presence of plastic items in land and ocean can be limited by an increased education and new technologies, the microplastics due to the textiles' use can not be eliminated easily, hence an increased use and consumption of fashionable clothes based on biobased fibres (degradable in water) are promoted day by day [10].

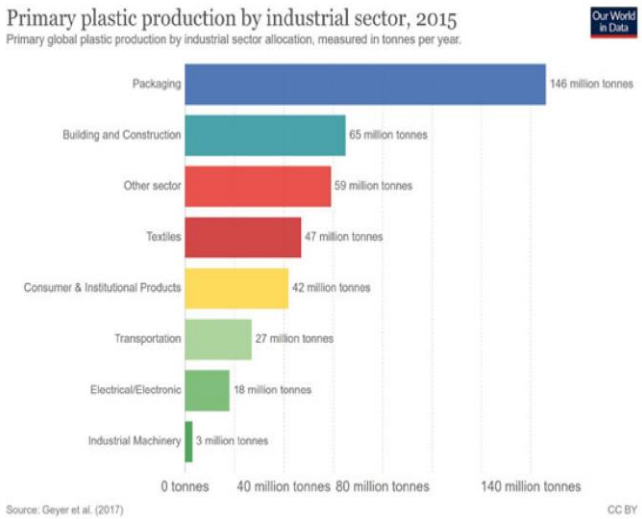


Figure 1. Plastic industrial production cause of the microplastics' release (courtesy of Richie and Roser-Our World in Data [3]).

Regarding the cosmetic products, the global market was valued at USD 375.30 billion in 2022 and it is expected to expand to USD 560.50 by 2030 with a compound annual growth rate (CAGR) of 5.1% from 2021 to 2030 (**Figure 2**) [11]. The principal key factors driving the market are due to the global aging population and the rapidly changing lifestyle with the adoption of skin care and personal care products from aged and young consumers, driven by social media and the increasing e-commerce [11,12].

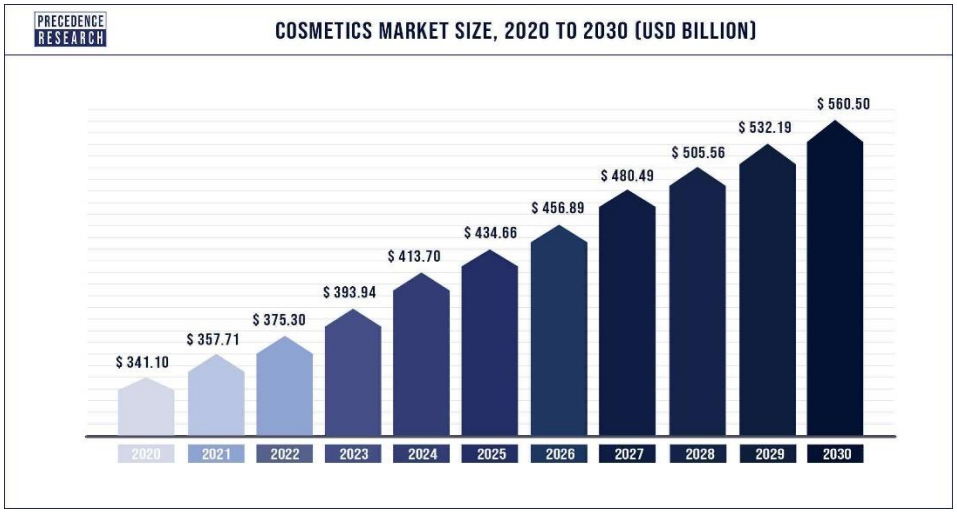


Figure 2. Global cosmetic market (courtesy of Precedence Research Company) [12].

Moreover, for maintaining the actual health and beauty, the so called "Beauty from within" has born, based on the integration of cosmeceuticals applied on the skin with nutraceuticals (functional food) taken by oral route. Thus, it will be possible to

obtain the global health and beauty of the body, acting contemporarily from inside and outside by the use of the so-called nutricosmetics [13]. Consequently, it could be useful to add the cosmetic market size (USD 376) to the nutraceuticals ones (USD 493) (**Figure 3**) [9] for understanding the real value of the global beauty healthy market which, from USD 870 billion in 2022, has been valued to range USD 1553 billion by 2030 [12,14].

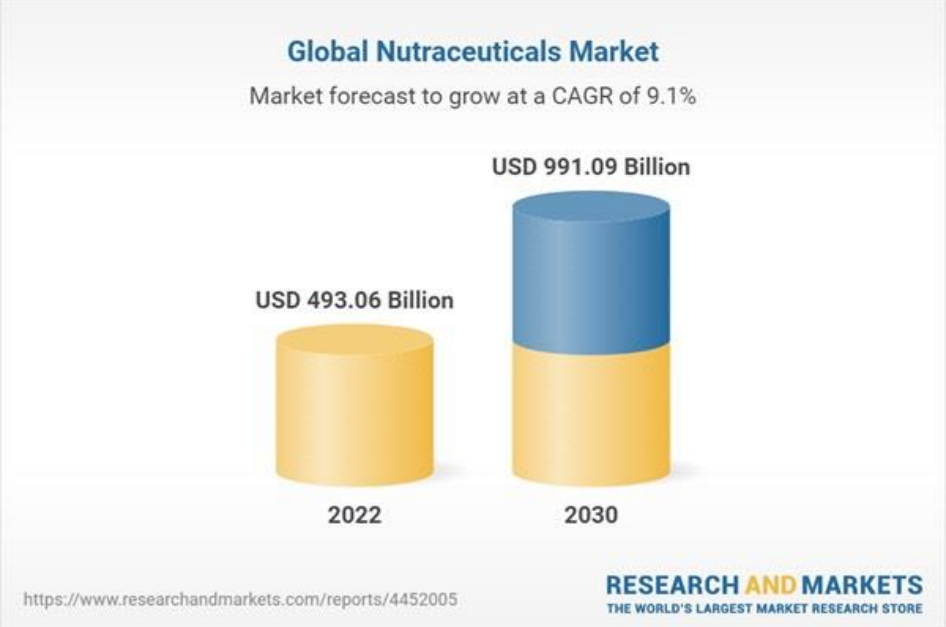


Figure 3. The global nutraceutical market (courtesy of Research and Markets [14]).

At this purpose it is important to underline that both these products may content and are packed by plastic polymers such as polyethylene and polypropylene, remembering that beauty industry only produces more than 120 billion units of not recyclable plastic packaging every year [12,15].

Consequently, it has been valued that the global bottles into which cosmeceuticals and nutraceuticals are filled up, will range around 480 billion units by 2029, from the actual 240 billion ones. Moreover, the bottles 'fossil origin and limited recyclability due to their incineration and contamination with the product also, result in further greenhouse gas emissions.

Therefore, there is the urgent necessity to increase production and use of biobased and biodegradable polymers for realizing innovative skin- and eco-friendly cosmeceuticals and nutraceuticals by sustainable productive processes, reducing the great micro nanoparticles invading the oceans also [1–3,15].

2. Cosmeceuticals & nutraceuticals needs

As a consequence, the consumer request for cosmeceuticals and nutraceuticals skin- and eco-friendly is continually increasing. These specific products, in fact, are considered made by natural and biodegradable ingredients, carriers and packaging, and therefore characterized for their high effectiveness and safeness [16–19]. However, to result effective, both ingredients and carriers must be capable to pass throughout the keratin-lipidic matrix of the skin lamellar membranes as well as the

glycoproteic polymer and fibers forming the mucous barrier, possibly maintaining balanced the physiological activity of the microbes living on their surface (**Figure 4**) [19–21].At this purpose, in fact, it results of fundamental importance not only the active ingredients 'selection but also the different carriers (vehicles) used because, driving the penetration of the active molecules through the skin and mucous membrane 'barriers, have the possibility to give effectiveness and texture to the final formulation [19–21].

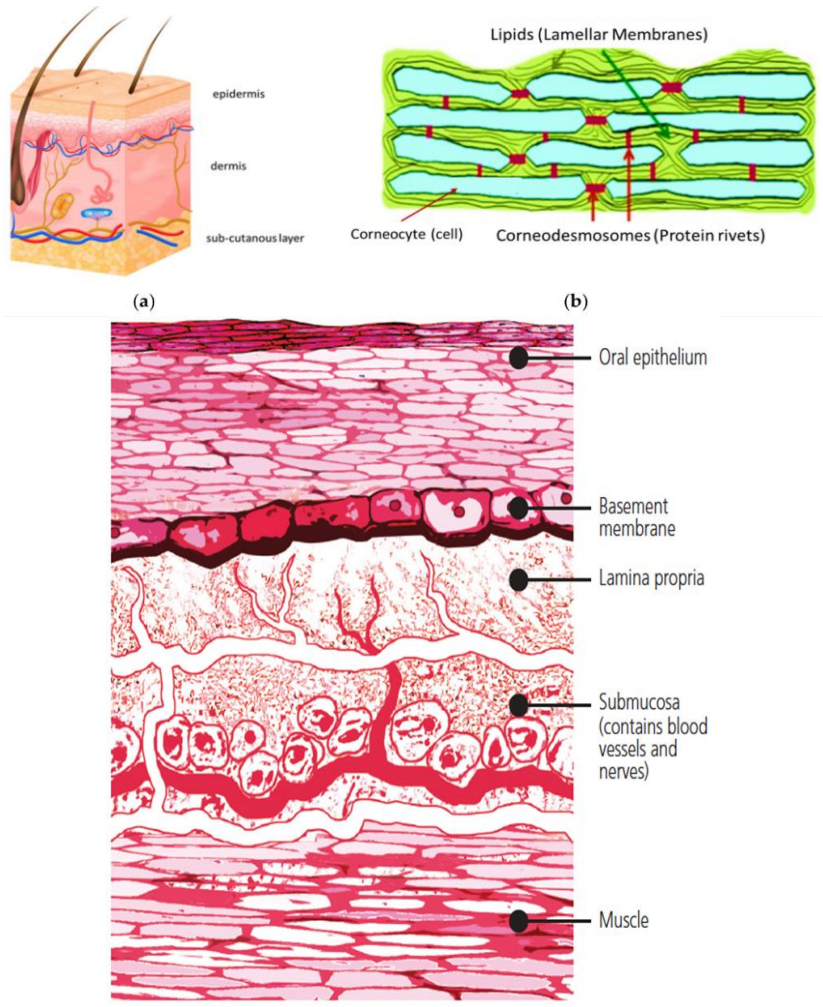


Figure 4. (a) skin structure; **(b)** corneocytes organized by lipid lamellae; and **(c)** the mucous membrane.

Skin lipid lamellae and oral epithelium, in fact, modulate the penetration of active ingredients depending on the carrier used naturally, all the selected ingredients have to be biodegradable and obtained possibly by food and agro-forestry waste for maintaining the natural sources and the planet' biodiversity for the future generations [22].

It is important to remember, in fact, that "nature and biodiversity loss is a material risk to climate stability, economy and financial increasing and to the global development". Therefore, protection of biodiversity safeguards climate too, avoiding the planet disasters [22]. Unfortunately, the great problem of biodegradability of

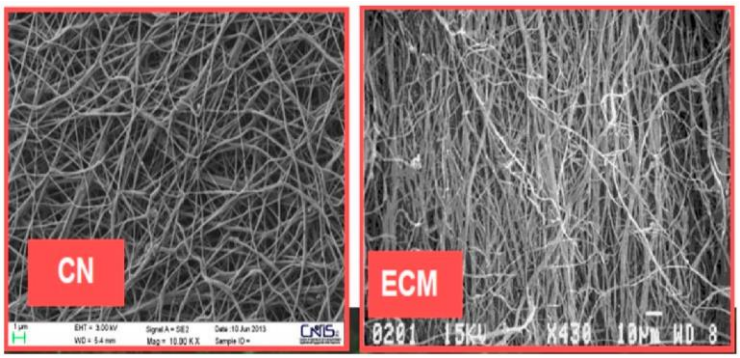
both cosmetics and nutraceuticals ’packaging is practically not jet solved and the use of non-biodegradable plastic polymers increase year by year. Consequently, polyethylene (PE) dominates the composition of plastic waste at lands and oceans followed by polypropylene (PP) and polystyrene (PS), contributing to the reported formation of microplastics [23]. Moreover, the many and different active ingredients, formulating the majority of all the so-called nutri- and eco-cosmetics (combined use of cosmeceuticals and nutraceuticals) carried by emulsions based on the use of preservatives, emulsifiers, fragrances, colors and other chemicals are often cause of allergic and sensitizing phenomena [24], being packaged by non-biodegradable plastic containers also. Thus, as previously reported consumers are looking for the so-called “clean beauty” and “beauty from within” focusing their purchases on products which, free of common harmful ingredients, and made with less plastic materials, renewable energy and regenerative ingredients, release less waste being skin- and environmentally friendly [12,25–28]. The majority of the nutricosmetics, in fact, are packed by plastic polymers such as polypropylene and other plastics including PET and acrylic ingredients. By all these considerations our proposed solution is reported soon after. It is based on the production of smart-tissues as novel carriers to make innovative cosmetic and nutraceutical vehicles that, alternative to the actual emulsions, could be packaged by simply paper also [19].

3. Proposed solution

To partially solve some of these problems our research group has proposed to substitute the carrier-emulsions of the active eco-nutri-cosmetics with natural-biodegradable tissues which, made by the electrospinning technology, result characterized by the same morphology of the extracellular matrix (ECM) (**Figure 5**) [19,29–33]. Moreover, due to the natural ECM similarity of these innovative tissues, the skin layers ’penetration seems to be more interesting and effective [28–33]. Finally, during the electrospinning process the block-polymeric micro-nano particles have been bound to the polymer ’fibers by a patented technology able not only to create stable micro-nanoparticles, but also to encapsulate various active ingredients utilizing water as solvent only [29–33]. It is also interesting to underline that, while to produce one cosmetic product (emulsion or shampoo) it seems necessary to consume between 60 and 90 mL of water, to make a piece of the new tissue-carrier the necessary water should be around 0.5 mL. In conclusion, the quantity of water necessary to produce the supposed 120 billion units per year of cosmetic products made by the reported tissues, will be of around 60 tons in comparison with the normal emulsions for which it will be necessary to consume around 9 million tons.

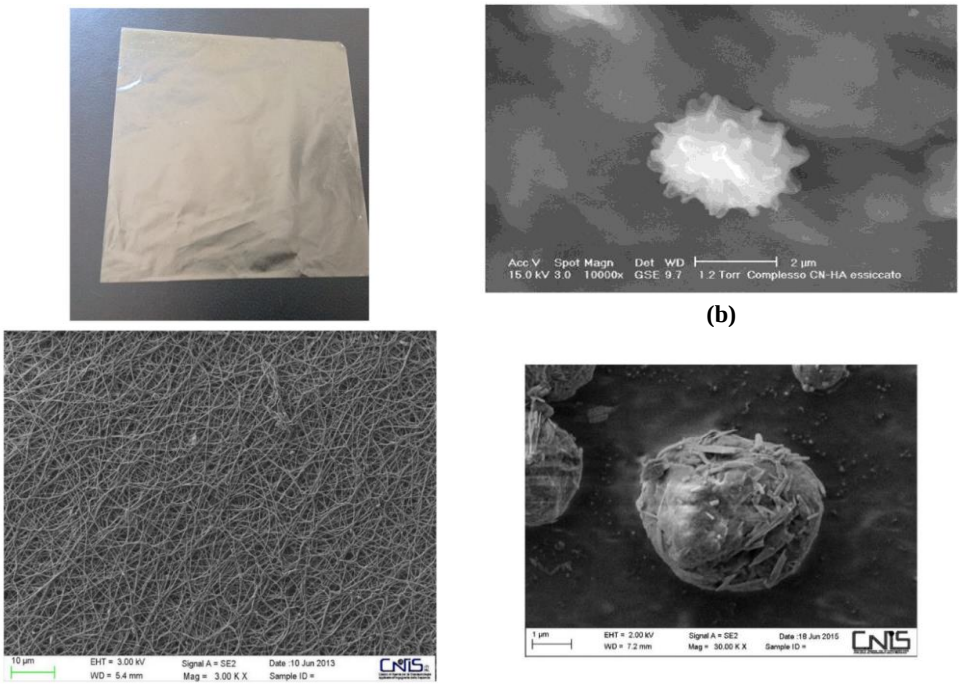
By our technology, the electrospun tissues have been functionalized embedding the fibers by chitin nanofibrils-nanolignin or chitin nanofibril-yaluronan block polymeric complexes (**Figure 6**). These complexes have the possibility to encapsulate different active ingredients, necessary to characterize the final product: cosmeceutical or nutraceutical [32–34]. It is interesting to underline that these smart tissues, made by biodegradable water soluble or water insoluble polymers, embedded by selected active bio-ingredients, may be applied on the skin and/or on oral mucous membranes, acting as tissue-regenerative products [32–35]. Moreover, the usual non-

biodegradable polypropylene support, normally utilized for the non-woven tissues made by the electrospinning technology, has been substituted by a biodegradable bamboo-tissue, rendering globally biodegradable the final product for both the ingredients used and the packaging materials [36,37].



(a) **(b)**

Figure 5. (a) structure at the SEM of the proposed tissue (CN); **(b)** compared to the Extracellular Matrix (ECM).



(b)

(a) **(c)**

Figure 6. (a) tissue structure (up) and at SEM (down); **(b)** chitin nanofibrils yaluronan; **(c)** chitin nanofibrils-nanolignin.

4. Conclusion

As reported by many scientific papers plastics and microplastics' invading lands and oceans became a great problem to be solved for saving human health and the environment. Thus, the necessity to change the way of living ameliorating our actual economical and social approaches, transforming the current linear model of economy based on "take-make-consume-throw away", in a circular economy. This new

producing circular-methodology, in fact, keeping in use products and materials of post-consumption waste rich in high value-natural resources, might achieve and facilitate a greater level of social and environmental sustainability [38–43]. Therefore, the proposed use of smart biodegradable tissues as new vehicles able to carry natural active ingredients through the skin layers and/or the mucous membranes, could be useful to make innovative cosmeceuticals and nutraceuticals [19,29,30,44–47]. These new carriers seem also able to slow down the actual worldwide side effects (i.e., allergic and sensitizing phenomena), being free of water, preservatives, emulsifiers, fragrances, colors and other chemicals normally contained into the actual in-use emulsions. In conclusion, these natural-made tissues could be useful to realize innovative and sustainable products skin- and environmentally-friendly and packed by biodegradable plastic-free containers [9,19,48–50]. Moreover, by this new way of producing, it will be possible to partially reduce the great quantity of plastics and microplastics invading lands and oceans safeguarding the natural raw materials and the Planet 'biodiversity for the future generations.

Author contributions: Conceptualization, PM; methodology, PM; software, PM; validation, PM; formal analysis, PM; investigation, PM; resources, PM; data curation, PM; writing—original draft preparation, PM, GM and MBC; writing—review and editing, PM and MBC; visualization, PM, GM and MBC; supervision, PM, GM and MBC; project administration, PM, GM and MBC. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

1. Ziani K, Ionita-Mindrican CB, Mititelu M, et al. Microplastics: A real global threat for environment and food safety: A state of the art review. Nutrients 2023; 15(3): 617. doi: 10.3390/nu15030617
2. Isobe A, Azusa T, Cordova MR, et al. A multilevel dataset of microplastic abundance in the world's upper ocean and the Laurentian Great Lakes. Microplastics and Nanoplastics 2022; 1(1): 1–14. doi: 10.1186/s43591-022-00013-z
3. Richie H, Roser M. Plastic pollution, Our Word in Data. Available online: https://ourworldindata.org/plastic-pollution (accessed on 25 July 2023).
4. Hernandez LM, Xu EG, Larsson HCE, et al. Plastic tea bags release billions of Microplastics and nanoparticles into tea. Environmental Science and Technology 2019; 3(21): 12300–12310. doi: 10.1021/asc.est.9b02540
5. Ragusa A, Svelato A, Santacroce C, et al. Plasticenta: First evidence of microplastics in human placenta. Environment International 2021; 146: 106274. doi: 10.1016/j.envying.2020.106274
6. Leslie HA, van Velzen MJM, Brandsma SH, et al. Discover and quantification of plastic particle pollution in human blood. Environment International 2022; 163: 107199. doi: 10.1016/j.envint.2022.107199
7. Shen M, Zheng Z, Wen X, et al. Presence of microplastics in drinking water from freshwater sources: The investigation in Changsha, China. Environmental Science and Pollution Research International 2021; 28(31): 42313–42324. doi: 10.1007/s11356-021-13769-x
8. Verla AW, Enyoh CE, Verla EN, Nwarnorh KO. Microplastics-toxic chemicals interaction: A review study on quantified levels, mechanism and implication. SN Applied Sciences 2019; 1: 1400. doi: 10.1007/s42452-019-1352-0
9. Morganti P, Morganti G, Gagliardini A, Lohani A. From cosmetics to innovative cosmeceuticals—Non-woven tissues as new biodegradable carriers. Cosmetics 2021; 8(3): 65. doi: 10.3390/cosmeticd8030065
10. Bianchi S, Bartoli F, Bruni C, et al. Opportunities and limitations in recycling fossil polymers from textiles. Macromol 2023; 3(2): 120–148. doi: 10.3390/macromol3020009

11. Westbrook G, Angus A. Top 10 global consumer trends 2021. Available online: https://go.euromonitor.com/white-paper-EC-2021-Top-10-Global-Consumer-Trends.html (accessed on 11 July 2023).
12. Precedence Research. Cosmetics market trends and forecast 2021–2030. Available online: https://www.precedenceresearch.com/ (accessed on 25 July 2023).
13. Morganti P. Natural products work in multiple ways, 2009. In: A Tabor and R Blair Nutritional Cosmetics.Beauty from within William Andrew, Burlington, MA, USA.
14. RM. Nutraceuticals Global Market Report. Research and Markets; 2023.
15. Plastic Pollution Coalition. The ugly side of beauty: The cosmetics industry's plastic packaging problem. Available online: https://www.plasticpollutioncoalition.org/blog/2022/1/25/the-ugly-side-of-beauty-the-cosmetics-industrys-plastic-packaging-problem (accessed on 25 January 2022).
16. Tolnay A, Koris A, Magda R. Sustainable development of cosmetic products in the frame of the laboratory market. Visegrad Journal on Bioeconomy and Sustainable Development 2018; 7(2): 62–66. doi: 10.2478/vjbsd-2018-0012
17. Fisher A. Sustainable skincare in 2021 and beyond. Available online: https://www.mintel.com/beauty-and-personal-care-market-news/sustainable-skincare-in-2021-and-beyond/ (accessed on 16 December 2020).
18. Dini I, Laneri S. The new challenge of green cosmetics: Natural food ingredients for cosmetic formulations. Molecules 2021; 26(13): 3921. doi: 10.3390/molecules262
19. Montero-Rivière NA. Structure and function of skin. In: Monteiro-Riviere NA. Toxicology of Skin. CRC Press; 2010. pp. 1–18.
20. Wertz PW. Roles of lipides in the permeability barriers of skin and oral mucous. International Journal of Molecular Sciences 2021; 22(10): 5229. doi: 10.3390/ijms22105229
21. Lee HJ, Kim M. Skin barrier function and the microbiome. International Journal of Molecular Sciences 2022; 23(21): 13071. doi: 10.3310/ijms232113071
22. The World Bank. Securing our future through biodiversity. Available online: https://www.worldbank.org/en/news/immersive-story/2022/12/07/securing-our-future-through-biodiversity (accessed on 7 December 2022).
23. Auta HS, Emenike CU, Fauziah SH. Distribution and importance of microplastics in the marine environment: A review of the sources, fate, effects and potential solutions. Environment International 2017; 102: 165–176. doi: 10.1016/j.envint.2017.02.013
24. Martins MS, Ferreira MS, Almeida IF, Sousa E. Occurrence of allergens in cosmetics for sensitive skin. Cosmetics 2022; 9(2): 32. doi: 10.3390/cosmetics902003
25. Herich D. What consumers want from beauty in 2023. Available online: https://www.gcimagazine.com/consumers-markets/news/22512091/what-consumers-want-from-beauty-in-2023 (accessed on 24 October 2022).
26. Berg A, Davillard S, Balchandani A, et al. Apparel, Fashion & Luxury 2022**,** McKinsey Report. Available online: www.MacKinseyandcompany.com (accessed on 25 July 2023).
27. NielsenIQ. The Blurring Lines of Beauty. Health & Wellness; 2022.
28. Cosmetica Italia. Cosmetic Industry: Manufacture. Market and Foreign Trade; 2022.
29. Morganti P, Coltelli MB. A new carrier for advanced cosmeceuticals. Cosmetics 2019; 6(1): 10. doi: 10.3390/cosmetics6010010
30. Morganti P, Morganti G, Colao C. Biofunctional textiles for aging skin. Biomedicines 2019; 7(3): 51. doi: 10.3390/biomedicines7030051
31. Morganti P, Morganti G, Coltelli MB. Skin and pollution: The smart nano-based cosmeceuticals-tissues to save the Planet'ecosystem. In: Nanda A, Nanda S, Nguyen TA, et al. (editors). Nanocosmetics: Fundamentals, Applications and Toxicity. Elsevier; 2020. pp. 287–304.
32. Coltelli MB, Morganti P, Castelvetrano V, et al. Chitin nanofibril-nanolignin complexes as carriers of functional molecules of skin contact applications. Nanomaterials 2022; 12(8): 1295. doi: 10.3390/12081295
33. Danti S, Trombi L, Fusco A, et al. Chitin nanofibrils and nanolignin as functional agents in skin regeneration. International Journal of Molecular Sciences 2019; 20(11): 2669. doi: 10.3390/ijms20112669
34. Morganti P, Morganti G, Yudin VE, Chen HD. Chitin and lignin: Old polymers and new bio-tissue-carriers. Dermatology and Dermatitis 2021; 6(3). doi: 10.31579/2578-8949/083

35. Morganti P, Morganti G, Memic A, et al. The New Renaissance of Beauty and Wellness through the Green Economy. Latest Trends in Textile and Fashion Designing 2021; 4(2); doi: 10.32474/LTTFD.2021.04.000185
36. Cimini C, Gagliardini A, Di Fazio V. Bamboo-fibers: Physicochemical characteristics, biological properties and production process. Nanoscience & Nanotechnology, Rome; 2022; unpublished work.
37. Morganti P, Chen HD and Morganti G. Nanocosmetics: Future Perspective. In: A Nanda, S Nanda, TA Nguyen, S Rajendran, and S Slimani (editors). Nanocosmetics: Fundamentals, Applications and Toxicity**,** Elsevier; 2020. pp. 455–481.
38. Laurenti R, Singh J, Frostell B, et al. The Socio-economic embeddedness of the circular economy: An integrative framework. Sustainability 2018; 10(7): 2129. doi: 10.3390/su10072129
39. Padilla-Rivera A, Russo-Garrido S, Merveille N. Addressing the social aspects of a circular economy: A systematic literature review. Sustainability 2020; 12(19): 7912. doi: 10.3390/su12197912
40. Liu L, Ramakrishna S. An Introduction to Circular Economy. Springer Singapore; 2021.
41. EU. Circular economy: Definition, importance and benefits. Available online: https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits (accessed on 7 June 2023).
42. UN. The circular economy, cooperatives and the social and solidarity economy. Available online: https://www.un.org/development/desa/cooperatives/2021/08/02/the-circular-economy-cooperatives-and-the-social-and-solidarity-economy/ (accessed on 7 June 2023).
43. EMAF. The circular economy in detail. Available online: https://ellenmacarthurfoundation.org/the-circular-economy-in-detail-deep-dive (accessed on 7 June 2023).
44. Morganti P, Morganti G, Memic A, et al. The new renaissance of beauty and wellness through the green economy. Latest Trends in Textile & Fashion Design 2021; 4(2). doi: 10.32474/LTTFD.2021.04.000185
45. Morganti P, Morganti G, Danti S, et al. Biodegradable nanomaterials for cosmetic and medical use. In: Kumar V, Guleria P, Dasgupta N, et al. (editors). Functionalized Nanomaterials. II Applications. CRC Press; 2021. pp. 62–73.
46. Morganti P, Morganti G, Coltelli MB, et al. Non-woven tissues as novel cosmetic carriers for a green beauty. Advances in Environmental and Engineering Research 2022; 3(2): 21. doi: 10.21926/aeer.2202021
47. Morganti P, Morganti G, Gao X. Cosmeceutical-tissues as anti-aging active carriers. In: Morganti P (editor). Biofunctional Textiles for an Aging Skin. Lambert Academic Publishing; 2022. pp. 696–733.
48. Morganti P, Morganti G, Palombo M. Research & innovation for sustainable products: Polysaccharides for a smart circular economy at zero waste. Clinical Research and Clinical Trials 2021; 3(3): 37. doi: 10.31579/2693-4779/037
49. Panariello L, Vannozzi A, Morganti P, et al. Biobased and eco-compatible beauty films coated with Chitin nanofibrils, nanolignin and Vitamin E. Cosmetics 2021; 8(2): 27. doi: 10.3390/cosmetics8020027
50. Coltelli MB, Morganti P, Lazzeri A. Sustainability assessment, environmental impact, and recycling strategies of biodegradable polymer nanocomposites. In: Deshmukh K, Pandey M (editors). Biodegradable and Biocompatible Polymer Nanocomposites. Elsevier; 2023. pp. 699–737.