

BIBLIOGRAPHIC INFORMATION SYSTEM

Journal Full Title: Journal of Biomedical Research & Environmental Sciences

Journal NLM Abbreviation: J Biomed Res Environ Sci

Journal Website Link: <https://www.jelsciences.com>

Journal ISSN: 2766-2276

Category: Multidisciplinary

Subject Areas: Medicine Group, Biology Group, General, Environmental Sciences

Topics Summation: 128

Issue Regularity: Monthly

Review Process type: Double Blind

Time to Publication: 7-14 Days

Indexing catalog: [Visit here](#)

Publication fee catalog: [Visit here](#)

DOI: 10.37871 ([CrossRef](#))

Plagiarism detection software: iThenticate

Managing entity: USA

Language: English

Research work collecting capability: Worldwide


Organized by: [SciRes Literature LLC](#)

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LETTER

Bio Polymers to Save Human Health and Environment: Chitin and Lignin

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ABSTRACT

The actual human ecosystems are producing a high quantity of plastic waste that represents a tough problem to be solved. Thus the need of operating and living by the circular green economy using food and agro-forestry by-products, such as nano-sized chitin and lignin, to make innovative biodegradable products and packagings at zero waste. These natural polymers may be used, for example, to make smart tissues which, copying the Extra Cellular Matrix (ECM)' structure, result effective and safe, for medical and cosmetic use, also because packaged into biodegradable containers. This new way to produce and consume will be useful to stop plastic waste and pollution invading land and oceans, safeguarding the natural raw materials and the Earth' biodiversity for the incoming generations.

Introduction

Chitin and lignin are natural biopolymers obtainable from waste material at low cost. They, found in the exoskeleton of crustaceans and insects as well as cell walls of fungi or in waste material of paper production are recovered as by-products of fishery and wood pulp respectively [1]. These interesting biopolymers have been used from our research group as block polymeric micro/nano complexes which, bound to natural fibers of non-woven tissues, have been utilized for producing innovative medical and cosmetic active carriers [2-4]. The micro/nanosize of chitin, lignin and their block polymeric nanoparticles used are necessary to increase the area weight ratio and their effectiveness [5]. Efficiency of encapsulation as well as the morphological structure and relative bio- and eco compatibility of the obtained complexes and tissues, have been verified in advance by *in vitro* and *in vivo* technologies [6,7]. The biopolymers, in fact, may be easily complexed each to other because of the different electrical charges covering their surface, respectively positive for chitin and negative for lignin. Moreover the micro/nano particles (NPs), obtained in water solution by the gelation method (Figure 1), have been produced encapsulating various active ingredients, selected according to the activity designed for the final product. Successively the NPs have been bound to non-woven tissue made by the electrospinning technology for realizing smart advanced medications and innovative cosmeceuticals [8,9]. Naturally all the steps for producing particles and tissues have

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DOI: 10.37871/jbres1626

Submitted: 05 November 2022

Accepted: 19 December 2022

Published: 20 December 2022

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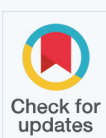
Keywords

- > Circular economy
- > Waste
- > Pollution
- > Environment
- > Extra cellular matrix
- > Biopolymers
- > Electro spinning
- > Chitin nanofibrils
- > Nanolignin

ENVIRONMENTAL SCIENCES

NATURAL RESOURCE MANAGEMENT

VOLUME: 3 ISSUE: 12 - DECEMBER, 2022



How to cite this article: Morganti P. Bio Polymers to Save Human Health and Environment: Chitin and Lignin 2022 Dec 20; 3(12): 1507-1510. doi: 10.37871/jbres/jbres1626, Article ID: JBRES1626, Available at: <https://www.jelsciences.com/articles/jbres1626.pdf>

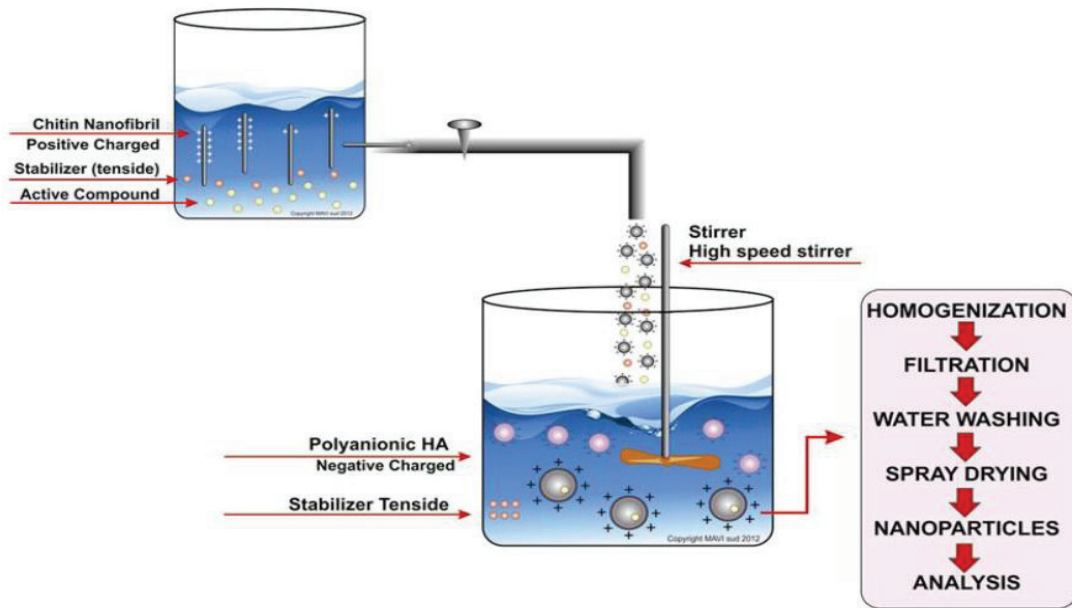


Figure 1 Gelation method used for producing chitin-lignin Nanoparticles.

to respect particular conditions of pH, humidity and temperature necessary to optimize the skin homeostasis and the crosstalk between the different cells, such as keratinocytes and fibroblasts [10-12]. To regenerate a wounded, burned or rejuvenate an aged skin, in fact, it is necessary to provide a tissue acting as an artificial matrix. Therefore, structure and morphology of the obtained tissues have to mimic the porous scaffold of the natural Extra Cellular Matrix (ECM) (Figure 2). They, in fact, have to be able to facilitate adhesion, growth and proliferation of human keratinocytes and fibroblasts, necessary to enhance the regeneration of the wounded, burned or precociously aged skin [13,14]. Thus these innovative tissues, incorporated with selected bioactive ingredients, opportunely engineered and therefore named cosmeceutical-tissues, seem to be able to rejuvenate an aged skin reducing fine lines and wrinkles, being skin- and environmental-friendly [13,14]. At this purpose it is interesting also to underline the possibility chitin and lignin have to be used for making biodegradable packagings, usually made by plastic material, contributing to create a more green and healthy environment [15,16]. These biopolymers, in fact, are easily degraded by human and environmental microorganisms and are obtained from natural by-products of food and agro-forestry, as previously reported. At this purpose it is to remember that plastic packagings are increasing day by day, invading rivers, lakes and sea of their

non-biodegradable waste. Consequently, production of plastic materials increased from around 1.5 million tons in 1950 to 4,60 million tonnes in 2019, created a 275 million tons of waste per year, the majority of which is invading oceans (Figure 3) [17].

Unfortunately this waste, transformed in plastic' microparticles by microbial enzymes and sun energy, become seafood for birds, mammals and humans together with the toxic ingredients. Thus the so called microplastics, recovered in tea bags, and human blood and placenta, will represent a probable cause of future toxic side effects, not well known and studied until now [18-20]. Moreover the great quantity of waste, stored up for the actual way of producing and consuming, is the main cause of the increased Greenhouse Gas (GHG) emissions with the consequent worldwide climate changing characterized by increase of temperature and disasters [21-23]. Therefore the most of our society is to change the lifestyle, transforming the actual linear economy based on the taking, making and producing waste in circular economy based on redesigning, reducing, reusing and recycling [24,25]. Thus the future human growth has to be sustainable with a more inclusive access to labor-market and healthcare [26]. Therefore we hope that, acceleration of a more organized work and economy through advanced technologies and innovations capable to maintain the Planet' biodiversity, will become a reality [26]. In conclusion the use on natural polymers

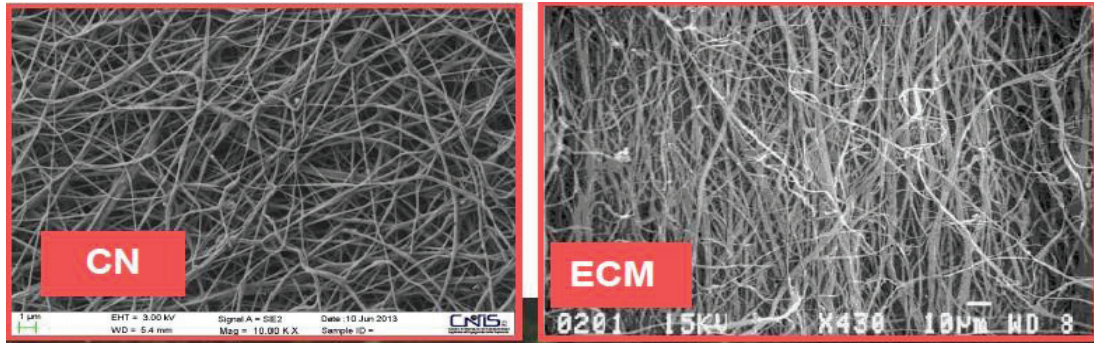


Figure 2 The chitin Nanofibril lignin (CN) scaffold compared to the natural Extra Cellular structure (ECM).

The pathway by which plastic enters the world's oceans

Our World in Data

Estimates of global plastics entering the oceans from land-based sources in 2010 based on the pathway from primary production through to marine plastic inputs.

Global primary plastic production:
270 million tonnes per year

Global plastic waste:
275 million tonnes per year
It can exceed primary production in a given year since it can incorporate production from previous years.

Coastal plastic waste:
99.5 million tonnes per year

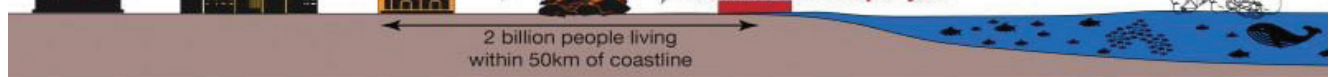
This is the total of plastic waste generated by all populations within 50 kilometres of a coastline (therefore at risk of entering the ocean).

Mismanaged coastal plastic waste:
31.9 million tonnes per year
This is the annual sum of inadequately managed and littered plastic waste from coastal populations. Inadequately managed waste is that which is stored in open or insecure landfills (and therefore at risk of leakage or loss).

Plastic inputs to the oceans:
8 million tonnes per year

Plastic in surface waters:
10,000s to 100,000s tonnes

There is a wide range of estimates of the quantity of plastics in surface waters. It remains unclear where the majority of plastic inputs end up — a large quantity might accumulate at greater depths or on the seafloor.



Source: based on Jambeck et al. (2015) and Eriksen et al. (2014). Icon graphics from Noun Project.

Data is based on global estimates from Jambeck et al. (2015) based on plastic waste generation rates, coastal population sizes, and waste management practices by country.

This is a visualization from OurWorldinData.org, where you will find data and research on how the world is changing.

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Figure 3 Plastic production and plastic waste (by courtesy of Our World in Data [17]).

such as the proposed chitin and lignin seem to go in this direction.

Conflict of Interest: The author declares no conflict of interest.

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How to cite this article: Morganti P. Bio Polymers to Save Human Health and Environment: Chitin and Lignin 2022 Dec 20; 3(12): 1507-1510. doi: 10.37871/jbres1626, Article ID: JBRES1626, Available at: <https://www.jelsciences.com/articles/jbres1626.pdf>