



Institute for Multidisciplinary Research University of Belgrade

INNOVATION FUND



BiopolymerWith SuperiorNano-Emulsions forAntimicrobialFilms, Coatingsand Antioxidant& 3-D StructuresProperties

Fig. 1.

Films obtained from nano-emulsions can be made elastic, transparent, and can be used for wrapping products. Patentable nano-emulsions made from unique combinations of biopolymers, essential oils, and nanoparticles produce thin films foils, coatings, and 3-dimensional structures with antimicrobial and antioxidant properties.

Technical features

Unique aqueous nano-emulsion formulations of biopolymer combinations (i.e., different ratios of pectin, chitosan, gelatin), essential oils, and nanoparticles of metal oxide (e.g., ZnO, and TiO₂) or metal salts, such as Zn-acetate, produce exceptional emulsions that can be easily formed into thin durable films, sprayed as coatings, or formed into various 3-dimensional structures. The films are strong, water-insoluble, can be made more or less elastic and transparent (Fig.1), and exhibit significant antimicrobial and antioxidative properties in laboratory tests. All emulsion components are edible, food-safe, Generally Recognized as Safe (GRAS), and the films/coatings/structures are biodegradable. The essential oils impart excellent antimicrobial and antioxidative properties, even at low concentrations in the polymer matrix. The nanoparticles and metal salts synergize with the oils to enhance the antimicrobial and antioxidative properties of the films/coatings/structures, and also slow the release of volatile components of the essential oil, prolonging the active nature of the packaging.

Tests are currently planned (October 2018) to evaluate the film capacity to enhance the shelf-life of fresh fruits and vegetables.



Young modulus of **elasticity** range between 25-156 MPa.

several months.

range of 4.3-40 N/mm².

Depending upon the particular formulation, when dried,

The emulsions are shelf-stable and can be stored at

room temperature for significant periods of at least

0.03mm to 0.1mm, demonstrating a tensile strength

The thickness of films tested have ranged from

the films/coatings/structures can be made to be

water-insoluble, sturdy and moisture resistant.

Biopolymer Nano-Emulsions for Films, Coatings & 3-D Structures

With Superior Antimicrobial and Antioxidant Properties

Applications and Benefits

The films/coatings/structures made using the nano-emulsion invention have been designed primarily for "natural" and biodegradable food packaging, but have other potential applications where antimicrobial/antioxidant properties are useful. For example, drinking straws, packaging cosmetic products, long-term food storage, medical devices and their packaging, etc.

There are also experimetal results confirming that the those emulsion sprays have additional, innovative uses in biocontrol applications. In laboratory studies at the University of Belgrade, the nano-emulsions and foils/coatings have been made using methods and materials that should be easily scalable to industrial manufacturing level. The general applicability of these nano-emulsions provide a wide range of product opportunities, including packaging tailored for particular foods (Fig. 2a), active coatings sprayed onto various surfaces (Fig. 2b), impregnation of existing manufactures with antimicrobial/antioxidant components, and construction of 3-D structures with these active properties.

The inventors have demonstrated the low cost of manufacturing the films.



Stage of Development

The technology has been evaluated for films and coating manufacturability, as well as antimicrobial, antioxidant, and mechanical properties in numerous laboratory tests. Test data is available on request.

Laboratory manufacture is simple and has been done routinely, as demonstrated in videos made by the inventors, in the links below.

Production of test quantities of nano-emulsions and films has been initiated (September 2018).

Numerous in vitro tests have demonstrated the antimicrobial effectiveness of various formulations of the invention. Antioxidant properties have been evaluated by ABTS assay expressed in the equivalents of ascorbic acid, and the results show antioxidative capacity reaching 0.95 ekv Asc (mmol/dm3).

Questionnaires and discussions with potential commercial packaging users is now underway to refine formulations and manufacture for optimal commercialization.



https://www.youtube.com/watch?v=gU-ol_pjnpo

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Review of regulatory requirements is currently being conducted. Active R&D partnerships with food producers now in place is helping guide further technology development. Pilot scale, film-packaging manufacture is being planned and applied shelf-life tests with food products in a commercial environment to be conducted by end of October-2018. The inventors have developed the capability to tailor properties of products made using the nano-emulsions by varying several adjustable parameters of formulation, mixing, and manufacture procedures. Only a few types have been made; and these confirm the invention's basic properties, validate the conceptual product envelope, and strengthen the potential patent position.

Photo examples of the foils and coatings include the following:



Photomicrographs

H/G + ZnO

H/G + Zn-acetate

Intellectual Property

The invention has been compared to the prior art, and determined to be patentable by patent specialists. A PCT patent application (designating all countries) was recently filed. The patent application broadly covers the unique emulsion formulations and products made from them. Trade secrets cover some necessary manufacturing techniques. A technology Trademark now being considered, pending pilot scale test outcome. A global strategy for the IP package (patents, trade secrets, trademark) is being pursued. The IP package is owned by the University of Belgrade and managed jointly by the University and the Serbian Innovation Fund (SIF).

Commercialization Partnerships

The University of Belgrade and the SIF intend to commercialize the IP package through licensing. U. of Belgrade and SIF are currently seeking commercial R&D partners/ licensees to participate in the next phase of development of the materials for commercial application. The invention offers significant opportunity to create unique packaging and other products with special properties. Ideal commercial partners will collaborate with the University of Belgrade inventors to further develop the technology.

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