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APPLICATION OF NiO NANOPARTICLES IN MODERN TEXTILE AND FOOD NUTRITION

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ABSTRACT:
Nanotechnology is considered as one of the most promising technologies for the 21st century. This technology overcomes the drawback of applying traditional methods to impart certain properties to textile materials. There is no hesitation that in the upcoming years, nanotechnology will break through into every vicinity of the textile industry. Application of NiO nanoparticles in modern textile lies in areas where innovative principles will be combined into long-lasting, multifunctional textile structures without compromising the intrinsic textile properties including aesthetic, breathability, flexibility etc. The current condition of NiO nanoparticles used in textiles area is reviewed with an emphasis on improving various properties of textiles.
From the current state-of-the-art, it is clear that nanotechnology applications are expected to bring a range of benefits to the food sector aiming at providing better quality and conservation. The last decade has witnessed the development and arrival of novel nano-based food materials, innovative food packaging, intelligent delivery mechanisms of nutrients and bioactive materials, implementation of green nanotechnologiesfor crop production and nano-biosensors to provide safer foods and waste reduction. Opportunities to exploit and develop nanotechnologies in the food sector have resulted in a large number of patents as food technologists and engineers continue to identify novel ways to re-invent food products that would appeal to consumers on a global scale. This article will review the applications of NiO nanoparticles in modern textile and food science technology.
Keywords: NiO nanoparticles, chemical precipitation method, textile, food and nutrition

Introduction

Nanotechnology is an emerging area which is expected to have wide ranging implications in all fields of science and technology such as material science, materials processing technology, mechanics, electronics, optics, medicine, energy and aerospace, plastics and textiles. Although this technology is still in its infancy, it is already proving to be a useful tool in improving the performance of textiles and generating worldwide interest. The novel application of nanotechnologies in textiles affords an expanded array of properties with potential for improved and new use in products [1-2]. Changed or improved properties with nanotechnologies can provide new or enhanced functionalities. Use of nanooxide particle is growing at an incredible rate in all fields of science and technology. There are various metal oxides incorporated with textiles starting from nanocomposites and nanofibers to smart polymeric coatings are getting their way not only in high performance applications, but also successfully being used in different conventional textiles to provide new functionality and improved performance [3-6]. The main advantages of NiO nanoparticle in textiles are incorporated with greater repeatability, reliability and toughness. Functionization of NiO nanoparticles during various textiles processing like dyeing, finishing and coating enhances the product performance manifold and provides unachieved functionality.

Due to high-volume production of consumer products such as nanoparticles (NPs) of,NiO, ZnO and TiO_2 etc., human exposure to these man-made NPs is possible directly (via personal healthcare products, cosmetics, food, water, drinking, drugs and drug delivery system) and/or indirectly, e.g., through the release of these compounds into the environment [7-8]. The latter may potentially result in the contamination of drinking water and uptake into the human food chain. An area that could highly benefit from nanotechnology is the food industry with big potentials for food safety, quality, and preservation (shelf life extension) [9]. In the food sector, the uses of nanooxide-based food ingredients, additives, supplements and contact materials are expected to grow rapidly. Nanotechnology analysts estimated that between 150–600 nanofoods and 400–500 nanofood packaging applications are already on the market [10].

Application of NiO nanoparticles in agri-food industry may poses new indirect sources of food contamination, as may arise from e.g., nano-sized pesticides and veterinary medicines, contact of food with nanoparticulate-based coatings during preparation or processing, or potential migration of NiO NPs from food packaging. There are already known examples of pesticide

formulations that are based on microemulsion or microencapsulation technology [11]. A literature review on nanopesticides was published recently that combines the existing information and concludes that the nanoformulations expected to have significant impacts on the fate of active ingredients and introduced new ingredients for which the environmental fate is still poorly understood (e.g., Ag·NPs) [12].This transition metal oxide (NiO), when falling in the nanosized regime, is expected to lead to even more attractive applications in modern textile and food nutrition. In this paper, we report a facile approach to synthesize NiO nanoparticles and provide information on this synthesized NiO nanoparticle applied in the modern textile and food industry.

Experimental

Materials and methods

Nickel carbonate hexahydrate (99%) was purchased from Merck. Other supplement chemicals were of AR grade. Sodium hydroxide (NaOH) was purchased from Sigma-Aldrich. Methanol and acetone were received from Merck. All solutions were prepared with deionized water.

Synthesis of NiO nanoparticles

NiO nanoparticles were prepared by the simple approach of chemical precipitation method in which, 1gm starch solution prepared in 100ml distilled water was added in 0.1M nickel carbonate hexahydrate ($NiCo_3.6H_2O$) solution and the mixture was stirred at room temperature for 1h. Then 1M sodium hydroxide (NaOH) was added drop wise in the prepared solution under the constant stirring for 2h. After complete addition of sodium hydroxide, the solution with light green ppt was filtered using membrane filtration assembly and washed with deionized water and ethanol to remove the impurities and then dried at 70°C in hot air oven [13]. Dried sample was treated at different temperatures to maintain the stability of compound. The colour of the sample was changed from green to faint gray at 100°C to 700°C. Hence, nanoparticles of NiO were fabricated by chemical reaction as follows:

$$NiCo_3.6H_2O + 2NaOH \longrightarrow Ni(OH)_2 + 2NaCo_3$$

$$Ni(OH)_2 \xrightarrow{700^oC} NiO + H_2O$$

Application of NiO nanoparticles:

1] Textile clothing

There are various types of newly developed coating techniques like sol-gel, layer-by-layer can develop multi-functional, intelligent, excellent durability and weather resistance to fabrics [14]. The present study primarily focuses on the improvement and potential application of NiO NPs in developing multifunctional and smart nanofibers and other new finished and coated textiles with nanotechnology-based ideas. The idea of NiO nanomaterials in textile finishing and processing to enhance product performance. Nanocoating is relatively a new technique in the area of textile sector and currently under research and development stage. There are various polymeric nanocomposite coatings where NiO nanoparticles are dispersed as polymeric media and used for coating applications is really a promising route to develop multifunctional and smart high-performance textiles. The foremost researched area to produce multifunctional, intelligent fibers is the preparation of nanocomposite fibers where the exceptional properties of NiO nanoparticles have been utilized to enhance and to impart several functionalities on traditional textile-based fibers [15-16]. Investigation also revealed that, NiO nanoparticles which are nanosize in diameter are also gaining much more popularity in specialized technical applications such as filter fabric, antibacterial patches, tissue engineering and chemical protective suits.

Nano-electronics in textiles:

Energy oriented textile-based products that lead to wearable 'smart' technology can control integrated electronics along with sensors through conventional body movements; interwoven solar cells that turn T-shirts into power textiles; a wearable smart textile battery that can be recharged by sunlight; nanoelectronics at the tip of a gloved finger; 'e-textile' coated with graphene detect noxious gases. Some researchers investigated that, electrical conductivity of conducting polymers and NiO, both of which are attractive for creating textiles enable the incorporation of sensors and actuators. Some scholarly works postulated about lightweight fabric carbon nanotube super-capacitor electrodes; stretchable NiO and PANI (Polyaniline)-based super capacitors; triboelectric nanogenerators; flexible fiber and stripe

batteries, stretchable PANI based super capacitors for energy transfer [17]. Adding digital components to these e-textiles would open up an entirely new area of functional clothing. OLEDs in fiber form could lead to revolutionary applications by integrating optical and optoelectronic devices into textile. Combined with nanoelectronic device, one day the whole world will see flexible optical sensors and display screens woven into shirts and other garments.

Food Nutrition:

The availability of different types of nanooxides [18] with varying properties and compositions have enabled food engineers to design and incorporate nanomaterials inventively to produce novel food products. As scientists increase their understanding of the structure-functional relationships of different nanooxide materials, the impact of this 'newly acquired knowledge' on the future development of food will greatly accelerate in years to come. At the present time, realization of the functional significance of the nanomaterials is predicted to have the greatest impact in the design of greener processes to produce healthier and more nutriently enriched foods of the highest quality and safety.

Inorganic nanoparticles of nickel oxide are being used for numerous applications. Examples of soluble organic nanoparticles include liposomes, vesicles, micelles and polymers. Other sources of nano-derived materials of technological interest for future applications have focused on carbon, nanoparticles (fullerenes e.g. SiO_2), nanocomposites (NiO nanoparticles embedded in a matrix just as polymers) and nanofibers. Nanocomposite materials have also attracted much interest in food technology [19] because of a number of key characteristics largely owing to their mechanical strength. The structures are generally composed of a polymeric material in combination with a nanoparticle filler of one or more variety. The polymer types that can be widely used to form nanocomposites are broad and this has led to a better understanding of the key structural elements in their design. Such materials include nanoclays, polymer carbon nanotubes and nanocomposites that exhibit varying physical and chemical properties

Table 1. Overview of the Wide-Ranging Potential Applications of Nanotechnology Being Researched, Tested, and in Some Cases Already Applied in the Food Industry:

Agriculture	Food Processing	Food packaging	Supplements
Nanotechnology-enabled single molecule detection for determining enzyme/substrate interactions	Nanocapsules for improving bioavailability of nutraceuticals in standard ingredients such as cooking oils	Fluorescent nanoparticles with attached antibodies for detecting chemicals or foodborne pathogens	Nanosize powders for increasing absorption of nutrients
Nanocapsules for delivery of pesticides, fertilizers, and other agrichemicals more efficiently	Nanoencapsulated flavor enhancers Biodegradable	Biodegradable Nano sensors for temperature, moisture, and time monitoring	Cellulose nanocrystal composites as drug carriers
Nanotechnology enabled delivery of growth hormones in a controlled fashion Nanosensors for monitoring soil conditions and crop growth	Nanotubes and nanoparticles as gelation and viscosifying agents Nanocapsule infusions of plant-based steroids as a replacement for meat cholesterol	Nanoclays and nano-films as barrier materials to prevent spoilage and oxygen absorption Electrochemical Nano sensors for detecting ethylene	Nano cochleates (coiled nanoparticles) for more efficient nutrient delivery to cells without affecting color or taste of food Vitamin sprays that disperse nanodroplets with

			better absorption
Nanochips for identity preservation and tracking Nanosensors for detecting animal and plant pathogens Nanocapsules for vaccine delivery Nanoparticles for NDA delivery to plants (targeted genetic engineering)	Nanoparticles that selectively bind and remove chemicals or pathogens from food Nanoemulsions and nanoparticles for better availability and dispersion of nutrients	Nanoparticle containing antimicrobial and antifungal surface coatings Lighter, stronger, and more heat resistant films made of silicate nanoparticles Nanotechnology enabled modified permeation behaviour of foils	

Current and Future developments

There is no denying of the fact that, nanotechnology has been emerged as the essential technology, which has revitalized the material science and has the prospects for development and advancement of new range of intelligent materials including polymers and textiles. To wrap up about application of nanotechnology in textiles, definitely has the potential to being revolution in the field of technical textiles. There is however a word of carefulness because industrial commercialization of the nanotechnology-based products can become a commercial reality. Through improved knowledge of nanomaterials and the realization of their potential in the food industry, the introduction of nanotech foods will provide solutions for persisting problems associated with foods and will offer long-term economic benefits. Globally, nations will profit from increased food productivity with cost effective returns, innovative products with tuneable properties to deliver smarter and healthier foods and equally intelligent packaging systems with enhanced storage properties for better food protection.

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Conclusion: At the dawn of 21st century, nanomaterials ensures much for the human being germinating with huge promises and characterized by total insurance of human welfare. Now a days, in the crowd of many technologies, nanotechnology has given "Midas-touch" to the science. Nanomaterials are eco-friendly, does not disturb symmetry of environment having wide applications in robotics, transportation, textile and clothing, food and nutrition, electronics etc. Textile with nanotechnological finish can be washed less frequently and at lower temperature. It makes clothes water and stain repellent or wrinkle free. However, in the pursuit of delivering patentable technologies, concerns over consumer health and safety in the use of nanooxide particles in food is an ongoing challenge. NiO nanoparticle has the potential of application in the food industry and processing as new tools for pathogen detection, disease treatment delivery systems, food packaging, and delivery of bioactive compounds to target sites. The application of NiO nanoparticle for food systems will provide new methods to improve safety and the nutritional value of food products. So one can certainly expect nanomaterials growth in textile, food and nutrition will surely helpful to accomplish welfare of existing human generation as well as generation to come.

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