SEZANNE: Green-Silver Nanoparticles-Zeolite Nanocomposite as Antibacterial Talcum Powder

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ABSTRACT

Malaysia, a tropical country with high humidity and temperatures, is a favourable environment for the growth of microorganisms. When harmful germs or bacteria infect the skin, the odour and quality of the skin can quickly deteriorate. These disorders can lead to unpleasant secondary complications, such as major skin problems that may require hospitalisation. The cost of hospitalisation is prohibitively high, putting a hardship on low-income families. As a result, controlling bacterial development on our bodies is important to treating the problem. It is possible to accomplish so by applying Sezanne to certain parts of our bodies, with silver nanoparticles (AgNP) deposited on zeolites performing the antibacterial function. Immobilizing AgNP on zeolite may also minimise the amount of AgNP used, resulting in less silver being discharged into the environment. The environmentally safe approach of making AgNP from plant extract could eventually replace the dangerous chemical process. Body odour and skin problems have an impact on our lifestyle and productivity, which can be alleviated by removing bad germs or bacteria from our skin. This can be accomplished with Sezanne, a green antibacterial chemical created after extensive research. A patent application (PI2020006064) has been filed for the process of creating a zeolite loaded with biosynthesized AgNP using plant extract, proving the composite's uniqueness. The plant extract is employed as a bioreducing agent in the synthesis of AgNP on zeolite surfaces. Based on in vitro human cell studies, this compound has considerable antibacterial action against common bacteria and is safe for humans. TRL4 (Technology Readiness Level 4) has been achieved, and some expenditure will be required. Because everyone is looking for an effective and ecologically friendly antimicrobial agent to help us maintain a healthy and clean lifestyle, which has also been impacted by the COVID-19 pandemic, the market is large.

Keywords: Silver nanoparticles; zeolite; biosynthesis; antibacterial

INTRODUCTION

Silver nanoparticles (AgNP) are widely used in the home and pharmaceutical industries as an antibacterial talcum powder, deodorant, and medical bandage active component. The antibacterial mechanism of AgNP was discovered to be linked to the release of silver ions (Ag+) from the nanoparticles, which then killed the bacteria via Ag+ action [1]. Despite AgNP's excellent antibacterial activity and efficacy, its widespread use leads to a growth in antibacterial resistance. In comparison to the wild type strain, a mutation in the porin protein of the bacteria Escherichia coli resulted in increased resistance to AgNP [2]. Bacterial resistance to an antibacterial agent may cause a secondary problem that must be addressed sooner rather than later. As a result, one strategy is to reduce AgNP usage while keeping its effectiveness. This can be accomplished by immobilising AgNP on inorganic materials like zeolite, a form of aluminosilicate with a high surface area, stability, and low toxicity [3]. Zeolite is a porous material with a variety of molecular size channels that allows it to perform specialised roles in catalysis, separation, and ion exchange [4], and these qualities are crucial for AgNP immobilisation. The combination of zeolite immobilised or functionalized with other components yields innovative materials with biological and medicinal uses. Unless it is treated with antibacterial chemicals, raw and unmodified zeolite cannot suppress bacterial growth.

The immobilisation of bio-green AgNP on synthesised zeolite utilising an in-situ reduction technique is the subject of this invention. In situ refers to the conversion of AgNPs from Ag^+ that took place inside the synthesised zeolite. It's a unique technique based on in situ Ag/zeolite synthesis with $NaBH_4$ as a chemical reducing agent [5]. Chemical reducing agents such as $NaBH_4$ and trisodium citrate ($Na_3C_6H_5O_7$) have previously been associated with environmental hazards if improperly dumped. As a result, biological sources such as plants, microorganisms, and yeast can be used as a reducing agent in the synthesis process to make AgNP in a more environmentally friendly way [6]. As a result, the current study focuses on the application of Orthosiphon aristatus, a native herb, as a green reducing agent. The plant grows abundantly in Southeast Asia's tropical climates, including Thailand, Malaysia, and Indonesia, and it's used to treat renal disease, bladder inflammation, arthritis, and diabetes [7]. The antioxidant activity of the plant is attributed to phytochemical components in the plant extract, and this activity may also be responsible for the reduction of Ag^+ to Ag^0 (AgNP) [8].

The growing trend of using microorganisms and plants as resources in the green production of nanoparticles has opened up a world of possibilities for researchers. Plant extracts such as Dodonaea viscosa [9], Polygonum minus [10], and Mikania micrantha [11] have been used in numerous research to synthesise nanoparticles. Green syntheses are more biocompatible, scalable, and adaptable to a wide range of applications [12]. As a result, the goal of this invention is to immobilise AgNP on the zeolite by decreasing Ag+ and generating AgNP inside the synthesised zeolite using an in-situ technique employing plant leaf extract. The substance is then combined with talc to create antimicrobial talcum.

INNOVATION DEVELOPMENT

Sezanne is a talcum powder with antibacterial properties that can be used to kill bacteria or prevent bacteria from growing on the skin. It can be used to treat skin conditions like eczema, rashes, acne, and other skin conditions. Sezanne is made up of AgNP that has been immobilised on zeolite. Plant extracts, such as extract misai kucing plant, are used to make AgNP, while zeolite is a mineral found in volcanic areas. Sezanne's originality and uniqueness are supported by the claims in the patent for the production technique of bio-AgNP-zeolite composite [13]. A method of making this composite, according to the claim, entails mixing zeolite with silver nitrate to make silver-zeolite, then adding plant extract to the silver-zeolite to produce AgNP, which is then loaded into the zeolite [13].

This product has a very high level of originality. As previously stated, there are a few critical phases involved in the manufacture of AgNP-zeolite composites. This is done to ensure that the zeolite can trap the maximum number of silver ions in the zeolite structure before using the plant extract as a green and sustainable reducing agent to produce AgNP. The AgNP that has been synthesised using a green and sustainable manner can then be placed on the zeolite framework and its release can be controlled in this way. The development of the product is based on solid scientific concepts that we discovered in the lab. The experiment's findings were reported in the Q1 journal Particuology [14]. Figure 1 depicts key findings from the development of a bio-AgNP-zeolite nanocomposite. AgNP has been loaded on the zeolite, as seen by the X-ray diffractogram and infrared spectroscopy. The particle size of AgNP is in the range of 20 nm, and it is positioned within the zeolite framework, according to the TEM image. Furthermore, the cream contains antibacterial properties against two common germs found on human skin (Figure 2). In vitro cytotoxicity against normal human fibroblast cells (Figure 2) revealed that the bio-AgNP-zeolite composite was not harmful to human cells. This result demonstrates that the substance is suitable for topical human use [14].

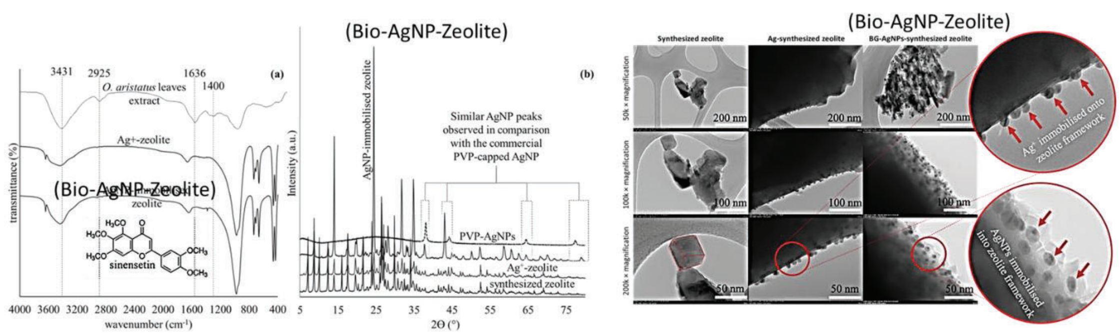

Figure 1: (a) Infrared spectra, (b) X-ray diffractogram, and (c) Transmission electron microscope (TEM) images of Bio-AgNP-zeolite as comparison with other materials.

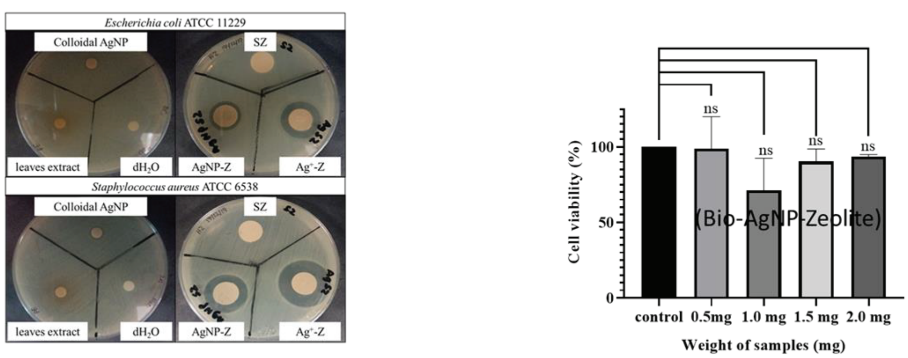

Figure 2: Antibacterial (Left) and cytotoxic (right) activities of the composite.

It's a small, lightweight item that can endure temperatures of up to 40 degrees Celsius. The powder form is noted for its stability in most situations, where its qualities do not easily alter. The powder form, unlike other oil or cream-based treatments, does not smear and is not oily. It's easy to clean with water or a damp cloth. The antibacterial agent in the product, AgNP, is the most effective, destroying a wide range of pathogenic microorganisms. According to scientific evidence, the product is safe. Because no hazardous chemicals are utilised in the manufacture of AgNP, it does not contain any additional additions or compounds. Plant extract is used as a substitute for chemicals. The powder is fine and pleasant to the touch.

Figure 3: Image of SEZANNE, a green-AgNP-zeolite nanocomposite as antibacterial talcum powder.

Green technology is used in the product development. AgNP produced from plant extract and chemicals have similar antibacterial efficacies, however plant extract is safer. As a result of the usage of harmful and carcinogenic substances in some products, consumer awareness has developed over time. The use of selected plants and herbs to synthesise AgNP and zeolite to include the produced AgNP has opened up new pathways for green technology applications in medical and cosmetics. The usage of a bio-AgNP-zeolite composite in combination with talcum powder is a green technology method for integrating cosmetics and medicine.

Additional energy, high temperatures, chemicals or reagents, or specialised machinery or instruments are not required in the synthesis of bio-AgNP-zeolite composite talcum powder. Plants and zeolite are easily available as raw materials, and the cost of production is minimal because silver nitrate is the only chemical used. Natural elements like zeolite and plant extracts have been proven to be safe for humans and the environment. The product has antibacterial active as well as cytocompatible (Compatible to the human cells), hence, it is utilised to enhance the cosmetic value of this product by soothing the skin.

This product empowers the customer to choose from a wider choice of products that best suit their needs. Talcum powder is a basic substance that can be safely applied to the skin. The commercialization of this product will result in increased large-scale manufacturing of this novel material, necessitating nanotechnology expertise. This product can prevent pathogenic germs from growing on the skin, preventing the bacterium from spreading throughout the organisation. This product is also appropriate for persons of all ages. Infants, toddlers, teenagers, adults, and the elderly can all benefit from it. As a result, when a person buys this device, his or her complete family can utilise it.

TRL 5 is the stage of product development where the product has been proven and validated in the lab. The next phase is to seek precommercialization finance from government organisations and develop joint partnerships with related companies. The precommercialization funded project will focus on optimising large-scale production and will create a market-ready prototype with Ministry of Health (MoH) approval. The fundamental goal of commercialization is to optimise Bio-AgNP-zeolite nanocomposite synthesis in order to lower costs. Sezanne will be produced in big quantities by an OEM with a GMP (Good Manufacturing Practices) facility, and it will be supplied to customers by other businesses.

Because everyone is seeking for an effective antimicrobial product as a result of COVID-19, the global market for AgNP is huge. However, broad usage of AgNP will lead to secondary and, eventually, tertiary concerns such as antibiotic resistance in bacteria and environmental pollution. Bacterial resistance to AgNP is likely to develop in the future if this material is widely employed as an antibacterial agent over the world and in our everyday life. Furthermore, the enormous demand for AgNP produced through physical and chemical synthesis methods necessitates the use of dangerous chemicals and a large amount of energy. As a result, adhering to the Sustainable Development Goals (SDG) is required in order to carry out a more sustainable production or alternative.

If AgNPs are immobilised on a suitable carrier system, such as zeolite, they can be used more effectively. Because of its high surface area and porosity, as well as its stability and inertness, zeolite was chosen. It is also harmless for humans because it is a mineral. Plant extract is utilised as a bioreducing agent in the biological synthesis process to manufacture immobilised AgNP on zeolite. This environmentally friendly method can be used instead of physical or chemical methods, and the plant extract is far safer than employing toxic chemicals. Sezanne is a talc that contains immobilised AgNP on zeolite, as well as talc mineral and plant extract.

Bio-AgNP-Zeolite, a beneficial combination of AgNP, plant bioactive chemicals, and zeolite, is found in Sezanne. The product is effective against a variety of harmful bacteria and is unlikely to cause bacterial resistance. The product has been shown to boost the viability and proliferation of human skin cells in vitro cell culture experiments and is safe for human skin. Manufacturing costs are inexpensive since the process does not require a lot of energy, a sophisticated reactor, a lot of heat, a lot of solvent, and so on. Because AgNP are immobilised on zeolite, their concentration is low, yet they are still functional.

Table 1: Competitor analysis

Product image	Product name	Active ingredients	Product feature	Issue
	Sezanne	Silver nanoparticles, herbs bioactive compounds, zeolite	Low amount of silver nanoparticles and bioactive compounds kill the bacteria, and zeolite remove stains.	No issue
	Agnesia	Zinc oxide	It absorbs sweat and prevents bacterial growth.	Allergic reaction, lower antibacterial activity of zinc oxide compared to silver.
	Aiken	Licorice Extract, Fermented Green Tea & Lemon Myrtle Oil	Natural protection with Herbal Protective Therapy ingredients	Herbal products has lower stability, and hence, shorter shelf-life

Sezanne competes with any medicated talc that performs a comparable function, such as antibacterial action. The analysis of competitors is shown in Table 1. Agnesia talcum powder is the primary competitor. Copper oxide, an inorganic antibacterial agent with lower activity than silver, is used in this product. Another competitor is Johnson&Johnson's talcum powder.

This commercial product, however, is fraught with controversy because it contains asbestos, a known carcinogen. Unlike Sezanne, which contains AgNP immobilised zeolite, there is no antibacterial talcum powder generated from AgNP on the market.

CONCLUSION

Sezanne is a talcum powder with antibacterial properties that can be used to kill bacteria or prevent bacterial growth on the skin. It can be used on the skin to treat skin diseases or to reduce body odour. Sezanne's originality is based on a claim in the patent that explains the bio-AgNP-zeolite nanocomposite's unique technique. It has a large market because everyone is looking for an antimicrobial product that is both effective and safe for humans. In the not-too-distant future, product development will reach the pre-commercialization stage, and it will be ready to join the market.

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