Journal of Materials Science & Nanotechnology
Volume 11 | Issue 1
ISSN: 2348-9812

Review Article Open Access

A Review on the Role of Acemannan in The *Aloe* -Based Nanostructures

Adamu Tizazu Yadeta*

Department of Chemistry, College of Natural and Computational Sciences, Mekdela Amba University, P.O. Box 32, Tulu Awuliya, Ethiopia

***Corresponding author:** Adamu Tizazu Yadeta, Department of Chemistry, College of Natural and Computational Sciences, Mekdela Amba University, P.O. Box 32, Tulu Awuliya, Ethiopia, Tel: +251935732951, E-mail: adamutizazu500@gmail.com

Citation: Adamu Tizazu Yadeta (2023) A Review On the Role of Acemannan in The *Aloe* -Based Nanostructures. J Mater Sci Nanotechnol 11(1): 102

Abstract

In recent years' nanostructure materials (NSMs) have been of great interest as catalysts and other applications because of their unique textural and structural characteristics. Out of various biomaterials employed for NPs synthesis, plant extracts have attracted much attention due to their effectiveness, availability, and green characteristics. Due to the range of chemical constituents, currently, the incorporation of the *Aloe* chemical constituents into other substances makes the biosynthesis of NPs which are very necessary for the formation and applications of *Aloe*-based NPs. There are various roles of *Aloe* chemical constituents in the formation of *Aloe*-based NPs. The role of the functional groups in acemannan molecules in the formation of nanostructures has been discussed. For instance, acemannan in the AgNP has been described as acting as a reducing and stabilizing agent. It has been reported that capping agent molecules prevent nanoparticles from aggregation and oxidation to stabilize the NPs. The authors proposed the capping of reduced silver by acemannan as the possible chemistry involved in the formation of AgNP. The surrounding acemannan is a surfactant and inhibits the AgNP agglomeration. The enhanced antibacterial activity of AgNPs synthesized using *A. vera* extract was described as it is attributed to active components in the extract especially, acemannan as the main reason. In another way, the addition of *A. vera* in the nanofiber membranes (NFMs) can increase the antibacterial effect of the NFMs. Acemannan has various medicinal applications and when combined with the precursor of NPs, its medicinal potentials make the synthesized NPs have therapeutic activities.

Keywords: Nanostructures; Acemannan; *Aloe*; Role

Introduction

In recent years' nanostructure materials (NSMs) have been of great interest because of their unique textural and structural characteristics [1]. Nanostructure materials can be classified according to dimensions less than 100 nm and they can be single or multi-phase polycrystals with grain sizes on the nanoscale [2]. The development of nanotechnology is a modern multidisciplinary science involving the fields of chemistry, physics, biology, and engineering, the production of nanoparticles (NPs), both in nature and by humans [3]. There are various chemical and physical methods to synthesize nanoparticles (NPs). Among them, the sol-gel process, chemical precipitation, chemical vapor deposition, hydrothermal, and microwave methods have been reported mostly [4]. However, these methods are not effective in many aspects. Therefore, currently, green synthesis, single-pot biomimetic, and/or biological methods of synthesis are preferred over chemical and physical methods due to their rapidity, eco-friendliness, non-pathogenic, and economical attributes. Besides, these biosynthesis methods exclude the use of high temperature, energy, pressure, and toxic chemicals [5]. Therefore, nowadays, biogenic or green synthesis of (NPs) using bacteria, fungi, actinomycetes, algae, and higher plants have emerged as potential nano factories [6-8] and their applications are based on the chemical constituents of these living things. The green synthesis of nanomaterials such as silver [9], zinc oxide [10], magnesium oxide [11], gold [12], cerium oxide [13], copper oxide [14], titanium dioxide [15], activated carbon [16], palladium [17] and tin oxide [18] has been conducted extensively in recent years. Out of various biomaterials employed for these purposes, plant extracts have attracted much attention due to their effectiveness, availability, and green characteristics [19, 20].

Aloe species can store water and important chemical constituents in their swollen and succulent leaves because of their ability to survive in conditions such as hot and dry, which makes them a unique source of phytochemicals [21]. The range of chemical constituents of the *Aloe* species can be used in preparing beauty and cosmetics, medicinal and pharmaceutical, personal care and toiletry products, and bittering agents in alcoholic drinks [22]. Currently, many researchers are focused on the incorporation of *Aloe* extracts into substances such as metal/metal oxides at the nanostructure [23]. This is due to the *Aloe* species having a variety of active constituents responsible for the target application. However, due to the synergetic effect, the identification of exact chemical components responsible for the synthesis and applications of nanoparticles has not been stated clearly in the works of literatures. Moreover, there is a lack of a comprehensive review that presents a general idea about the roles of single chemical constituents like acemannan in both formation and applications of *Aloe*-based NPs. In addition to that almost all kinds of literature, fabricated NPs from leaves of *Aloe* especially, *A. vera.* Herein; the review summarizes the recent update on these ideas somewhat.

Acemannan of *Aloe* species

The *Aloe* acemannan is structurally unique which makes it a characteristic compound of *Aloe* species amongst other well-known plant mannans (which have distinct side chains or are unacetylated and insoluble) [24]. From the parts of the *Aloe*, gel and skin of *Aloe* are the main sources of acemannan, which has β-(1, 4) linkages and a variable degree of acylation. The dry matter of most *Aloe* species are polysaccharides constitute. Acemannan is a type of storage polysaccharide, an acetylated glucomannan, and it is located in the protoplasts of parenchyma cells that contain many polysaccharides in the cell wall matrix. *Aloe* acemannan variability depends greatly on the species and cultivation conditions [25]. The significant effect on the physical and biological characteristics of acemannan is due to the distribution of acetyl groups and galactosyl units in the main chain [26]. Acemannan, found in internal leaf *Aloe* gel, is a polysaccharide composed of β-(1, 4)-linked highly acetylated mannose, β-(1,4)-linked glucose, and α-(1,6)-linked galactose, Figure 1 [24, 27]. Acemannan found in *A. vera* gel has a backbone of β-(1, 4)-D-mannosyl residues acetylated at the C-2 and C-3 positions that exhibit a mannose monomer: acetyl ratio of approximately 1:1 and contains some side chains of main galactose attached to C-6 [28]. Being a carbohydrate, acemannan has the functional groups responsible for its reducing ability.

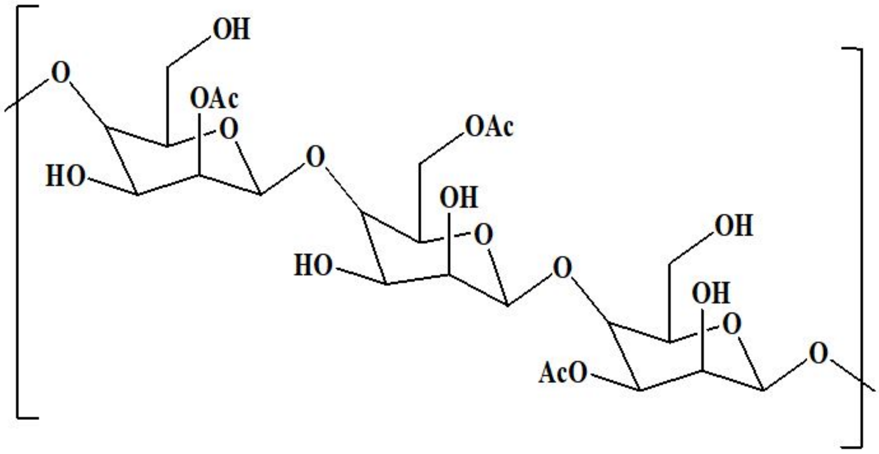

Figure 1: Structure of acemannan

There are different kinds of chromatographic techniques and spectroscopic analyses that are used to determine the structure of acemannan. Chromatographic techniques such as high-performance liquid chromatography (HPLC), gas chromatography (GC), and high-performance gel permeation chromatography (HPGPC) are mostly applicable. Homogeneity and molecular weight are mostly measured by HPLC, HPGPC [29, 30], and SEC [31, 32] technologies. After being completely hydrolyzed by trifluoroacetic acid, the hydrolysate is separated and analyzed by HPLC, GC, or GC-MS [33]. Detection of functional groups is commonly carried out by IR or FT-IR. In order to determine the composition of the main chain and branched chain, methylation analysis combined with GC-MS is an effective method to determine the linkage types of glycosyl residues [34]. Nuclear magnetic resonance (NMR) spectra, including ^{1}H, ^{13}C were widely used to determine the abnormal structure, position, and linkage sequence of glycosyl residues [35]. In order to determine the conformational characteristics of the solution at 540 nm by semi-quantitative estimation by UV, circular dichroism (CD) spectra can directly analyze the conformational structure, usually by characterizing the Congo red polysaccharide complexes [36]. Moreover, recent research shows that *A. vera* polysaccharide can be determined by the use of size exclusion chromatography (SEC)–multi-angle laser light scattering (MALS)–differential refractive index (DRI) [37].

Role of acemannan in the *Aloe*-based nanostructure

Role of acemannan in the synthesis of *Aloe*-based nanostructures

There are various roles of *Aloe* phytochemicals in the formation of *Aloe*-based NPs. However, roles such as reducing, capping, and stabilizing agents are very important in the characterizations and applications of *Aloe*-based NPs. These three properties are interrelated to one another. If the formed NPs are reduced or capped to precursor, then it stays stable. The stable NPs can be applied to the target applications. Reducing agents have the role of driving electrons from the solution to the ions (usually metallic ones) to form atoms. In other words, they reduce the salts into the reduced form, which is usually insoluble [38]. There is the presence of a -OH group in most phytochemicals obtained from *Aloe* spp. and this -OH served as a reducing agent, converting metal ions into metal/metal oxide NPs. Also, carbonyl functional groups are present in the phytochemical of *Aloe* spp. play a significant role in NPs fabrication [23]. The role of the functional groups in acemannan molecules in the formation of AgNP has been described as acting as a reducing and stabilizing agent [39]. It has been reported that capping agent molecules prevent nanoparticles from aggregation and oxidation to stabilize the NPs [40]. *Aloe* species have phytochemicals and/or functional groups responsible for capping agents [41, 42]. The appearance of prominent bands indicated the surface association of O–H bearing carbohydrates. The authors proposed the capping of reduced silver by acemannan as the possible chemistry involved in the formation of AgNP as represented in Figure 2. The surrounding acemannan is a surfactant and inhibits the AgNP agglomeration.

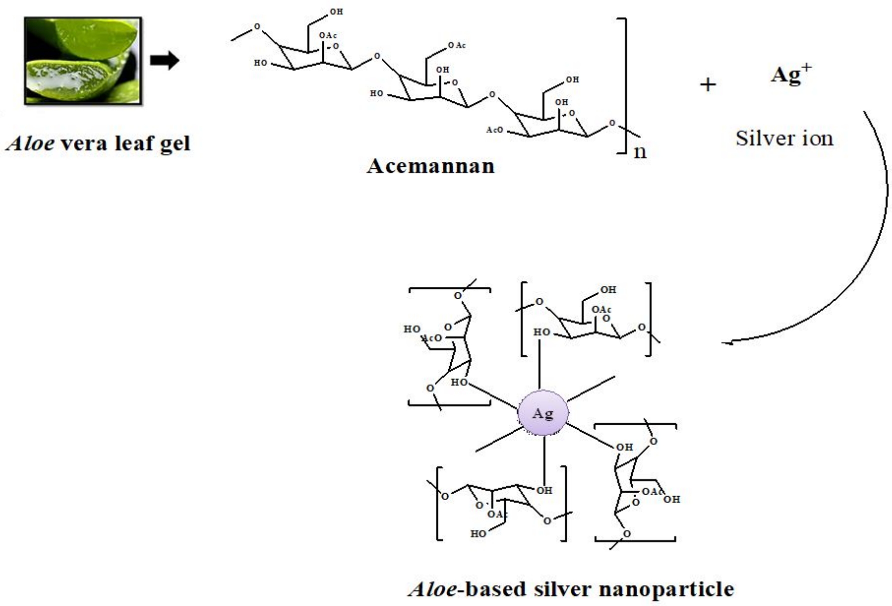

Figure 2: The possible mechanism involved in the synthesis of AgNP by *A. vera* gel acemannan.

Role of Acemannan in the medicinal activities of *Aloe*-based nanostructures

The influence of additional particles of *Aloe* phytochemicals attached to the nanoparticle can change its overall properties [23]. The enhanced antibacterial activity of AgNPs synthesized using *A. vera* extract was described as it is attributed to active components in the extract especially, acemannan as the main reason [41]. In another study, the addition of *A. vera* in the nanofiber membranes (NFMs) can increase the antibacterial effect of the NFMs. This might be due to the presence of substances such as acemannan, and other constituents in *A. vera*, resulting in its better antimicrobial activity [43]. In literature, acemannan has been mentioned as one of the responsible polysaccharides in the wound healing potential of insulin-loaded nanoemulsion with *A. vera* gel in diabetic rats [44]. The β-(1, 4)-glycosidic bond configuration of acemannan is an important consideration in terms of the therapeutic effects of *A. vera* gel since humans cannot enzymatically break down these bonds [45]. Acemannan has various medicinal applications and when combined with precursor of NPs, its medicinal potentials make the synthesized NPs to have therapeutic activities.

Conclusion and Future Aspects

Currently, the incorporation of the *Aloe* chemical constituents into other substances makes the biosynthesis of NPs which are very necessary for the formation and applications of *Aloe*-based NPs. Due to the reason the unique nature of *Aloe* plants, *Aloe*-based nanoparticles are very important in a broad area of study. Although the activities of *Aloe* phytochemicals are discussed synergistically in NPs, active constituents like *Aloe* acemannan have a great role in the formation and applications of *Aloe*-based nanostructure particles. This is because in nanobiotechnology plants serve as incredibly rich sources of naturally synthesized chemical compounds that are an environmentally acceptable, readily available, inexpensive, and renewable source of materials. This means nanoparticle synthesis using the *Aloe* plant provides a simple, eco-friendly, and efficient route. However, in most kinds of literature, only the leaf gel of *A. vera* has been studied. Therefore, two points are recommendable in the future perspectives. The first point is using other parts of the plant such as leaf latex, flower, root, etc. to synthesize NPs, due to the *Aloe* plants are rich in phytochemicals in other parts of the plant other than leaf gel. Secondly, there are hundreds of species in the genus *Aloe*; hence limited *A. vera* is not recommendable. Using other *Aloe* species has two advantages; comparative study and as the result to get more effective species among the genus. Another idea for the future perspective is to test phytochemicals' role separately based on their identity which may use for the formation of NPs in various applications such as medicine, food, environmental protection, material preparations, etc.

Funding

Not applicable

Acknowledgements

Not applicable

References

1. Malekshahi Byranvand M, Nemati Kharat A, Fatholahi L, Malekshahi Beiranvand Z (2013) A review on synthesis of nano-TiO2 via different methods. Journal of nanostructures. 3: 1-9.

2. Rafique M, Tahir MB, Rafique MS, Safdar N, Tahir R (2020) Nanostructure materials and their classification by dimensionality. InNanotechnology and Photocatalysis for Environmental Applications Elsevier.

3. Benelmekki M (2021) Introduction to nanoparticles and nanotechnology. In Designing Hybrid Nanoparticles (Second Edition).

4. Logeswari P, Silambarasan S, Abraham J (2013) Eco friendly synthesis of silver nanoparticles from commercially available plant powders and their antibacterial properties. Scientia. Iranica. Transactions F: Nanotechnol. 20: 1049-54.

5. Gnanasangeetha D, SaralaThambavani D (2013) One pot synthesis of zinc oxide nanoparticles via chemical and green method. Res J Mater Sci. 2320: 6055.

6. Husen A, Siddiqi KS (2014) Phytosynthesis of nanoparticles: concept, controversy and application. Nanoscale research letters. 9:1-24.

7. Sharma S, Kumar K (2021) A. vera leaf extract as a green agent for the synthesis of CuO nanoparticles inactivating bacterial pathogens and dye. Journal of Dispersion Science and Technology. 42:1950-62.

8. Bachheti RK, Abate L, Bachheti A, Madhusudhan A, Husen A (2021) Algae-, fungi-, and yeast-mediated biological synthesis of nanoparticles and their various biomedical applications. InHandbook of greener synthesis of nanomaterials and compounds Elsevier.

9. Ravichandran V, Vasanthi S, Shalini S, Shah SA, Tripathy M et al (2019) Green synthesis, characterization, antibacterial, antioxidant and photocatalytic activity of Parkia speciosa leaves extract mediated silver nanoparticles. Results in Physics. 15: 102565.

10. Rajabi HR, Naghiha R, Kheirizadeh M, Sadatfaraji H, Mirzaei A et al. (2017) Microwave assisted extraction as an efficient approach for biosynthesis of zinc oxide nanoparticles: synthesis, characterization, and biological properties. Materials Science and Engineering: C. 78: 1109-18.

11. Ramanujam K, Sundrarajan M (2014) Antibacterial effects of biosynthesized MgO nanoparticles using ethanolic fruit extract of Emblica officinalis. Journal of photochemistry and photobiology B: biology. 141: 296-300.

12. Patra JK, Kwon Y, Baek KH (2016) Green biosynthesis of gold nanoparticles by onion peel extract: Synthesis, characterization

and biological activities. Advanced Powder Technology. 27: 2204-13.

13. Rajeshkumar S, Naik P (2018) Synthesis and biomedical applications of cerium oxide nanoparticles–a review. Biotechnology Reports. 17: 1-5.

14. Vidovix TB, Quesada HB, Januário EF, Bergamasco R, Vieira AM (2019) Green synthesis of copper oxide nanoparticles using Punica granatum leaf extract applied to the removal of methylene blue. Materials Letters. 257: 126685.

15. Dobrucka R (2017) "Synthesis of titanium dioxide nanoparticles using Echinacea purpurea herba." Iran, J. Pharm. Res. 16: 756-62.

16. Karnan M, Subramani K, Sudhan N, Ilayaraja N, Sathish M (2016) A. vera derived activated high-surface-area carbon for flexible and high-energy supercapacitors. ACS applied materials & interfaces. 8: 35191-202.

17. Nasrollahzadeh M, Sajjadi M, Dadashi J, Ghafuri H (2020) Pd-based nanoparticles: Plant-assisted biosynthesis, characterization, mechanism, stability, catalytic and antimicrobial activities. Advances in colloid and interface science. 276: 102103.

18. Matussin S, Harunsani MH, Tan AL, Khan MM (2020) Plant-extract-mediated SnO2 nanoparticles: synthesis and applications. ACS Sustainable Chemistry & Engineering. 8: 3040-54.

19. Njagi EC, Huang H, Stafford L, Genuino H, Galindo HM, et al. (2011) Biosynthesis of iron and silver nanoparticles at room temperature using aqueous sorghum bran extracts. Langmuir. 27: 264-71.

20. Govindaraju K, Basha SK, Kumar VG, Singaravelu G (2008) Silver, gold and bimetallic nanoparticles production using single-cell protein (Spirulina platensis) Geitler. Journal of Materials Science. 43: 5115-22.

21. Yadeta AT (2022) Food applications of *Aloe* species: A review. J Plant Sci Phytopathol. 6: 024-32.

22. Sbhatu DB, Berhe GG, Hndeya AG, Abdu A, Mulugeta A, et al. (2020) Hair Washing Formulations from *Aloe* elegans Todaro Gel: The Potential for Making Hair Shampoo. Advances in Pharmacological and Pharmaceutical Sciences.

23. Bachheti A, Bachheti RK, Abate L, Husen A (2021) Current status of *Aloe*-based nanoparticle fabrication, characterization and their application in some cutting-edge areas. South African Journal of Botany.

24. Ni Y, Yates KM, Tizard IR (2004) *Aloe* polysaccharides. In *Aloe*s CRC Press.

25. Liu C, Cui Y, Pi F, Cheng Y, Guo Y et al. (2019) Extraction, purification, structural characteristics, biological activities and pharmacological applications of acemannan, a polysaccharide from A. vera: A review. Molecules. 24: 1554.

26. Rodríguez-González VM, Femenia A, González-Laredo RF, Rocha-Guzmán NE, Gallegos-Infante JA, et al. (2011) Effects of pasteurization on bioactive polysaccharide acemannan and cell wall polymers from *Aloe* barbadensis Miller. Carbohydrate Polymers. 86:1675-83.

27. Manna S, McAnalley BH (1993) Determination of the position of the O-acetyl group in a β-(1→ 4)-mannan (acemannan) from *Aloe* barbardensis Miller. Carbohydrate Research. 241: 317-9.

28. Hamman JH (2008) Composition and applications of A. vera leaf gel. Molecules. 13: 1599-616.

29. Leung MY, Liu C, Zhu LF, Hui YZ, Yu B et al. (2004) Chemical and biological characterization of a polysaccharide biological response modifier from A. vera L. var. chinensis (Haw.) Berg. Glycobiology. 14: 501-10.

30. Shi XD, Nie SP, Yin JY, Que ZQ, Zhang LJ et al. (2017) Polysaccharide from leaf skin of A. barbadensis Miller: Part I. Extraction, fractionation, physicochemical properties and structural characterization. Food Hydrocolloids. 73: 176-83.

31. Boonyagul S, Banlunara W, Sangvanich P, Thunyakitpisal P (2014) Effect of acemannan, an extracted polysaccharide from A. vera, on BMSCs proliferation, differentiation, extracellular matrix synthesis, mineralization, and bone formation in a tooth extraction model. Odontology. 102: 310-7.

32. Shi XD, Yin JY, Huang XJ, Que ZQ, Nie SP (2018) Structural and conformational characterization of linear O-acetyl-glucomannan purified from gel of A. barbadensis Miller. International journal of biological macromolecules. 120: 2373-80.

33. Salinas C, Handford M, Pauly M, Dupree P, Cardemil L (2016) Structural modifications of fructans in A. barbadensis Miller (*Aloe* vera) grown under water stress. PLoS One. 11: e0159819.

34. Simões J, Nunes FM, Domingues P, Coimbra MA, Domingues MR (2012) Mass spectrometry characterization of an A. vera mannan presenting immunostimulatory activity. Carbohydrate polymers. 90: 229-36.

35. Davis B, Goux WJ (2009) Single-laboratory validation of an NMR method for the determination of A. vera polysaccharide in pharmaceutical formulations. Journal of AOAC International. 92: 1607-16.

36. Kiran P, Rao PS (2016) Development and characterization of reconstituted hydrogel from A. vera (A. barbadensis Miller) powder. Journal of Food Measurement and Characterization. 10: 411-24.

37. Zhang Y, Bao Z, Ye X, Xie Z, He K, et al. (2018) Chemical investigation of major constituents in A. vera leaves and several commercial *Aloe* juice powders. Journal of AOAC International. 101: 1741-51.

38. Villaverde-Cantizano G, Laurenti M, Rubio-Retama J, Contreras-Cáceres R (2021) Reducing Agents in Colloidal Nanoparticle Synthesis–an Introduction. 1-27.

39. Anju TR, Parvathy S, Veettil MV, Rosemary J, Ansalna TH et al. (2021) Green synthesis of silver nanoparticles from A. vera leaf extract and its antimicrobial activity. Materials Today: Proceedings. 43: 3956-60.

40. Ajitha B, Reddy YA, Reddy PS, Jeon HJ, Ahn CW (2016) Role of capping agents in controlling silver nanoparticles size, antibacterial activity and potential application as optical hydrogen peroxide sensor. RSC advances. 6: 36171-9.

41. Fahimmunisha BA, Ishwarya R, AlSalhi MS, Devanesan S, Govindarajan M et al. (2020) Green fabrication, characterization and antibacterial potential of zinc oxide nanoparticles using *Aloe* socotrina leaf extract: A novel drug delivery approach. Journal of Drug Delivery Science and Technology. 55: 101465.

42. Arshad H, Saleem M, Pasha U, Sadaf S (2022) Synthesis of A. vera-conjugated silver nanoparticles for use against multidrug-resistant microorganisms. Electronic Journal of Biotechnology. 55: 55-64.

43. Yin J, Xu L (2020) Batch preparation of electrospun polycaprolactone/chitosan/A. vera blended nanofiber membranes for novel wound dressing. International Journal of Biological Macromolecules. 160: 352-63.

44. Chakraborty T, Gupta S, Nair A, Chauhan S, Saini V (2021) Wound healing potential of insulin-loaded nanoemulsion with A.

vera gel in diabetic rats. Journal of Drug Delivery Science and Technology. 64: 102601.

45. Boudreau MD, Beland FA (2006) An evaluation of the biological and toxicological properties of *Aloe* barbadensis (miller), A. vera. Journal of Environmental Science and Health Part C. 24 :103-54.