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Biosynthesis of Silver Nanoparticles on Biomedical Moulding Sand Properties for Casting Applications

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ABSTRACT

Present work explains green nanotechnology technique in solid waste management. Solid wastes are generated from domestic, industrial, agricultural, commercial, health care and individual activities etc. Because of rising population, urbanisation, construction activities, and improper medical waste management, there is an increase in biomedical waste, which contributes to widespread landscape littering. Due to its inability to biodegrade, waste disposal has consequently become a significant issue on a global scale. Research is being carried out to develop ways for environment friendly disposal of biomedical wastes. Also, to enhance the moulding properties for better casting quality by using nanoparticles prepared in laboratory by green nanotechnology technique. The main objective of the work is preparation and characteristic study of modified biomedical waste used in green sand moulding for casting industry. The sand silica in green sand moulding material is replaced by biomedical waste. Nanoparticles are synthesized by green nano technology technique used as an additive in bio medical waste which will be treated as modified bio medical waste. Present study evaluated the influence of nano particles on biomedical waste which helps in metal moulding applications.

INTRODUCTION

The field of waste management has been the subject of numerous research projects. Waste disposal-related pollution is a pressing problem. Infrastructure and growth are directly related to a country's progress. Nanotechnology is being used to increase the strength, economy, durability, and beauty of materials. Bio-waste recycling is a growing concern in the fight against pollution. Their current disposal, if it is not recycling, involves either land filling, which is bad for the ecology. In such a situation, finding another use for the leftover plastic is urgently needed. In this work, an effort is undertaken to evaluate the characteristics of bituminous mixes when biomedical plastic wastes are added to them. So recent works on various feasible techniques to utilize solid waste materials in place of sand silica with other possible alternatives like use of nano particles to enhance the properties of mould material for better casting quality. In this study the effects of Ag nano particles on bio-medical waste- bio moulding sand nano particles were studied.

LITERATURE REVIEW

Concrete of the M20 grade was created by using coconut shell in place of granite. Concrete's compressive strength decreased as the percentage of replacement rose. The findings suggested that coconut shell concrete could be employed in building. (Ahlawat, D., & Kalurkar, L. 2014)

To assess effectiveness of reusing hospital incinerator ash, compressive strength combinations formed from bottom and fly hospital ash were compared with microsilica. Results indicated that temperature and concrete cubes have an impact on the material's compressive strength. Concrete's compressive strength is increased when fly ash is used in place of cement at 800^{0}C temperatures. (Al-Mutairi, N. *et al.* 2004). It was looked into whether incinerator ash could replace sand and cement. Results show that slump values were reduced as a result of incinerator ash. Higher compressive strength was demonstrated when up to 40% of the sand was replaced with incinerator ash. Recycling of bagasse ash as cement substitute in concrete is studied. Investigations on the effects of baggase ash on mechanical qualities like compressive strength and tensile strength conducted. Results with 20% replacement ratio demonstrated good strength. (Al-Rawas, A. *et al.*2005; Amin, N. 2011).

In order to decrease leachability and improve the mechanical properties of bottom ash, author investigated the solidification of fly and bottom ash from hospital waste incinerators. As percentage of cement loading was reduced, the strength declined. The use of molten slag from hospital waste as alternative material to replace traditional aggregates in road and construction work. Findings demonstrated that 5.53% of asphalt combined with slag was most effective. (Anastasiadou, K. *et al.* 2012; Azni, I. *et al.* 2005). The pattern of energy usage is taken into account for palm kernel mills. In small, medium, and large mills, palm nut breaking and oil expression accounted for 73.4% and 85.2%, respectively, of the energy used. (Bamgboye, A., & Jekayinfa, S. 2006). This study describes attrition-based green sand reclamation in a gas solid fluidized bed. Studies were done on green sand to ascertain the impact of previous calcinations, and the results indicate that calcinations make it easier to remove clay from green sand. (Cruz, N. *et al.* 2009). This study looked into the viability of using leftover materials in cement-based mixes.

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Portland cement in various combinations with bottom ash are evaluated for bulk density and compressive strength. Bottom ash's minimal chemical reactivity was revealed by the results. (Filipponi, P. *et al.* 2003).Typically, coastal areas are mined for silica sand, which degrades the ecology. Mining for silica sand has a severe influence on the ecosystem that takes a long time to recover from. The addition of hospital waste ash to cement matrices is evaluated in this paper. The outcomes demonstrated respectable strength levels and performance in the leading test. (Garel, E. *et al.* 2009; Genazzini, C. *et al.* 2005).

In this study, 1200C high temperature melting point was used to remediate hospital waste incinerator ash. Sio2, Cao, Al2O3, Sn, Ni, Cu, and Ba were present in slag. According to the leaching results, slag complies with disposal requirements and is not dangerous. (Idris, A., & Saed, K. 2002).

In this work, sugar cane juice is extracted, and ash is formed by burning bagasse at a high temperature; the bagasse ash in the concrete is partially replaced with cement, and results reveal strength of the concrete increases by up to 15% . (Kawada, U. *et al* 2013). This essay contains the findings of research on the production of concrete's strength properties and comparative cost analysis. According to the findings, concrete's compressive strength declined as the percentage of shell increased. (Olanipekun, E. *et al.* 2006). The procedures for recycling used foundry sands and sterilising their residue are taken into consideration in this study. Coal waste powder was applied to the surfaces after the powder leftovers were pelletized. Heavy metals are stabilised by coal ash and sodium silicate, providing an affordable option. (Park, C. *et al.* 2012). In this project, cement is used in place of bagasse ash to make concrete. We measured the material's flexural, split tensile, and compressive strengths.

The findings revealed that concrete's strength has improved. (R, S., & K, S. 2010)In laboratory testing, coconut fibre ash (CFA) was used to partially substitute cement in the creation of concrete. The findings showed that as ash concentration increased and ash compressive strength increased, workability of concrete reduced. (Sen, S., & Chandak, R. 2015). The utilisation of agricultural wastes as aggregates is examined in this research. Solid wastes can be used as a cost-effective and energy-saving alternative to traditional aggregate. (Shafigh *et al.* 2014).

This essay examines an alternate strategy that integrates energy usage and access. The degree of market integration can be determined by looking at the access dimension. (Shonali Pachauri, & Daniel Spreng. 2004).This study demonstrates the use of spent foundary sand (SFS) as alternative for ordinary sand in the production of regulated low strength materials. The strength of a concrete mixture improves as percentage of foundry sand increases. In order to produce high-quality concrete, waste foundary sand (WFS) is used, as described in this study. It was discovered that poly acromatic hydrocarbons are present in waste foundry sands. As a result, WFS contains little organics. (Siddique, R.*et al.*2008; Srinivasan, K. *et al.* 2018).

MATERIALS AND METHODS

The following materials were utilised in this work:

a. For green Ag nano particles - Whattman's filter paper No. 4, analytical-grade silver nitrate ($AgNO_3$) acquired from local supplier, double-distilled water, etc. Use of all compounds without additional purification.

b. For bio medical waste sample – Bio medical waste sample (ash) collected from Suryakanth Environmental Technologies Bellary Karnataka State India.

Malus Domestica Leaf Extract Preparation

The leaves of Malus domestica were collected, frequently cleansed with deionized water, and then dried. 10^0 g of leaves were broken up into small pieces and mixed in deionized water. This mixture was then heated at 80^0C for two hours to a dark green colour. The prepared leaf extract was then allowed at room temperature to cool, after which it was twice filtered using Whattman's filter paper no. 4 and stored for later use at 10^0C.

Silver Nanoparticle Synthesis

Ag nanoparticles typically generated using a typical reaction process in aqueous media. In order to create a binary mixture, 0.01M of $AgNO_3$ was taken dissolved in 5 ml of deionized water. This binary mixture held under 70^0C with steady stirring for 15 min. The Malus domestica leaf extract was added drop wise until it shows change in the color from colorless to dark yellow. Ag nanoparticle production verified by a change in colour. Ag nanoparticles centrifuged several times and washed to get impurities free Ag nanoparticles colloidal solution, then dried up to formation of dry powder sample. Obtained Ag particles were used for further characterization to study surface morphology, particle size, functional group, elemental analysis etc. through different techniques.

Preparation of Biomedical Waste

Authors have visited the plant and studied the procedure for gathering, Biomedical waste transportation, treatment, and disposal monitored and controlled by Karnatak Pollution Control board.

RESULTS AND DISCUSSION

Analyzing Ag nanoparticles optically (UV-Visible spectroscopy)

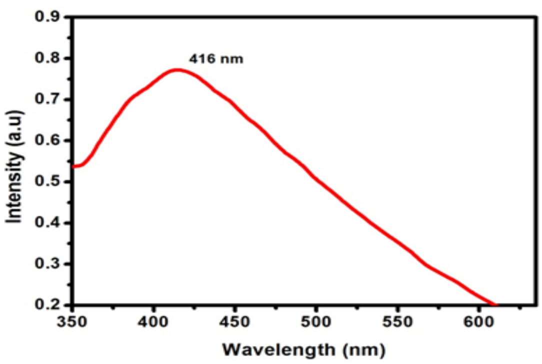

Figure 1: Ag nanoparticle UV-Vis absorption spectra

As a starting point, UV-Vis absorption spectroscopy created to examine surface Plasmon resonance of metal nanoparticles. A surface plasmon resonance peak at 416 nm in the produced colloidal nanoparticles indicates the development of silver nanoparticles 10-15 nm in size.

Analysis of Ag nanoparticles using FT-IR

A FT-IR investigation was conducted to examine the functional groups of silver nanoparticles, and the results are displayed in Fig. 2. FT-IR analysis used to analyse the bond formation of nanoparticles. The coordination of ligands in the solids is demonstrated by the Ag nanoparticles that were obtained for each of the solids. N-H stretching visible in the broad band at 3426.12 cm^{-1} for the silver complex.

The C-H asymmetric and symmetric stretching were responsible for bands at 2924.19 cm^{-1} and 2854.95 cm^{-1}, respectively. A carbonyl group was visible in the band at 1748.16 cm^{-1} because of the photochemicals in the extract. Aqueous phase synthesis at 1374.33 cm^{-1} exhibits

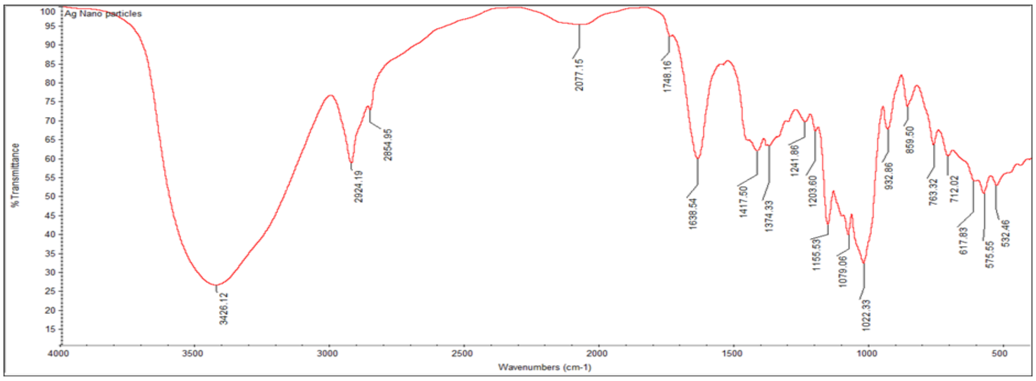

Figure 2: Ag nanoparticle FT-IR spectra

O-H bending while 1417.50 cm^{-1} exhibits asymmetric C-H bending. C-H bending visible in bands at 1203.60 cm^{-1} and 1155.53 cm^{-1} (aromatic in plane). C-C vibrations are visible in the band at 1079.06 cm^{-1}, while C-H bending was visible at 932.86 cm-1 (out of plane). Aliphatic iodo compounds C-I stretch is seen at 532.46 cm^{-1}.

Atomic Force Microscopy Analysis of Ag Nanoparticles

The Atomic force microscope (AFM) image (Fig. 3) shows the synthesized Ag nanoparticles spherical in shape with typical 15 nm diameter size particles. AFM image shows the particles are uniformly arranged and smaller in size. Such nanoparticles show enormous applications in various fields.

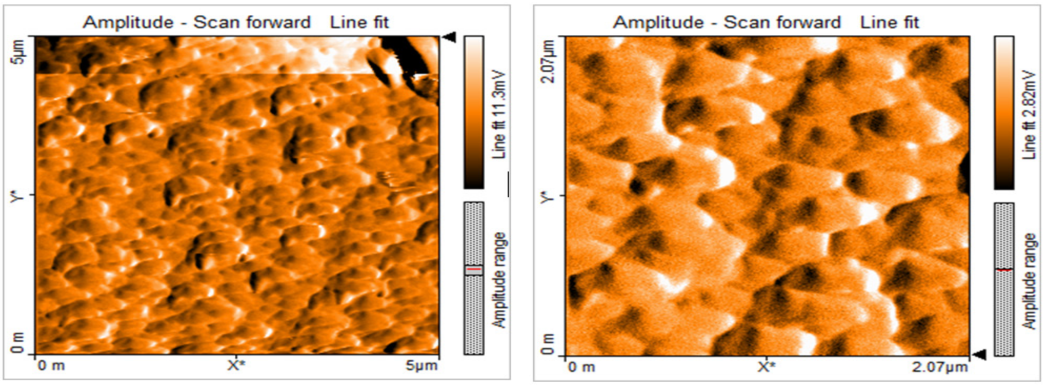

Figure 3: AFM images of Ag nanoparticles

Scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) (EDS)

Fig.4 displays a SEM picture of Ag nanoparticles. It demonstrates that Ag nanoparticles are spherical in shape, with average particle size 15 nm determined by pixel ruler. Ag nanoparticles created using the green approach are smaller and don't aggregate. The arrangement of the particles is regular and uniform.

Ag nanoparticles created by synthetic means have demonstrated stability in air and aqueous medium without changing into any other substance

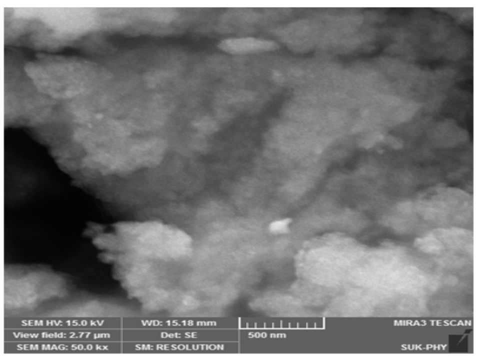

Figure 4: SEM analysis of silver nanoparticles

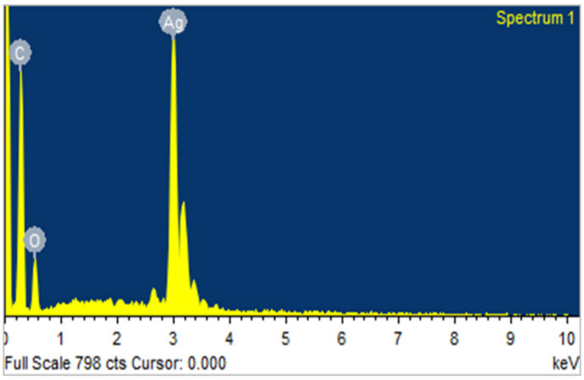

Figure 5: Energy dispersive spectra for Ag nanoparticles.

The EDS spectrum for green produced Ag nanoparticles is shown in Fig. 5. By providing semi-quantitative information about the elemental composition, this spectrum aids in confirming the sample's structure. The presence of carbon, silver, and oxygen, which is close to the stoichiometric ratio in silver nanoparticles, may be seen in an energy dispersive spectrum.

XRD Analysis of Ag Nanoparticles

The EDS spectrum for green produced Ag nanoparticles is shown in Fig. 5, which aids in validating the sample's structure by offering semi-quantitative information on the elemental composition. With respect to the stoichiometric ratio in silver nanoparticles, an energy dispersive spectrum reveals the existence of carbon, silver, and oxygen. The XRD pattern shows the synthesized nanoparticles are having nano crystalline structure with Bragg reflections (111), (200), (220) and (311) corresponds to 2θ values of 38.02^0, 43.58^0, 64.32^0 and 77.22^0 respectively. The Debye-Scherrer formula can be used to calculate the typical silver nanoparticle particle size synthesised using Malus domestica leaf extract.

$$D = K\lambda / \beta \cos \theta \quad (1)$$

D the crystallite size of green silver nanoparticles, λ the wavelength of x-ray source (1.542Å) used in XRD, diffraction peak full width at half maximum β , K Scherrer 0.94, θ the Bragg angle.

According to the Debye-Scherrer calculations, the silver nanoparticles produced by green synthesis have an average grain size of 10 nm.

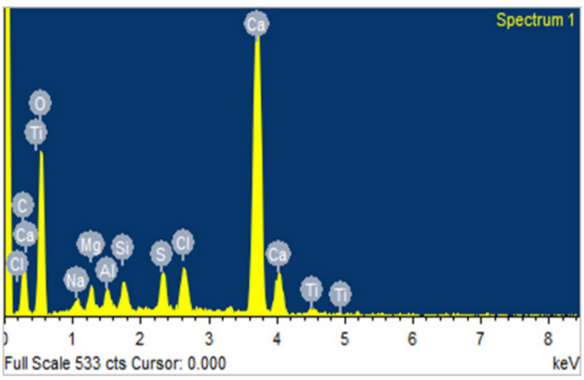

Figure 6: Energy dispersive spectra for Ag nanoparticles.

Also to enhance the moulding properties of moulding materials by using nanoparticles prepared in the laboratory by green nanotechnology technique. Here the main aim is to test the mechanical properties of casting material by substituting sand in green sand in biomedical waste having nanoparticles as additives.

It shows the elemental composition in biomedical waste which can be used for various applications. In reality, the existence of undesirable chemicals may have an impact on a material's fundamental (mechanical) properties. Thus by adding nanoparticles to biomedical waste can enhance the property of material for different applications. This becomes the secondary material of better quality and which is suitable for few important applications. Presence of various elements in biomedical solid waste is studied through EDS analysis shown in Fig.7.

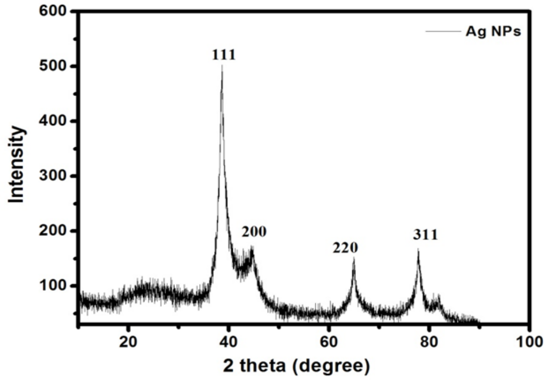

Figure 7: EDS spectrum of biomedical solid waste.

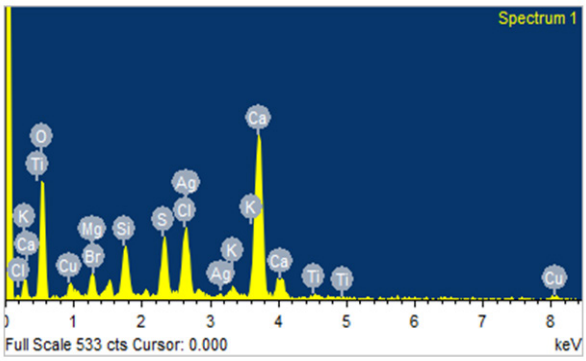

Figure 8: EDS spectrum of Ag nanoparticles treated biomedical waste

The presence of Si & Al give good adhesion to the moulding. Ti minimizing the process of mould reaction.

It demonstrates the presence of Si, Cu, Ag, and Ti, demonstrating that nanowaste has been enhanced to better match the features of contemporary trash management. This paper offers better advice about the handling of nanowaste, which improves material strength in metal moulding applications. It is possible to say that the qualities of materials will be improved by the usage of nanoparticles in biomedical waste.

CONCLUSION

We have successfully synthesized silver nanoparticles via Malus domestica leaf extract mediated process.

The phytochemicals found in the leaf extract, as seen by the nanoparticles FTIR spectra, cap the produced nanoparticles. Silver nanoparticle production is visible in the UV-VIS spectrum, with the surface Plasmon resonance peak occurring at 416 nm. The XRD pattern shows that the produced nanoparticles have a crystalline structure. The studies demonstrate the formation of silver nanoparticles with an average size of 15 nm. Due to high coefficient of Ag nano particles with solid waste, there is every possibility of enhancing the adhesive property of nano particles treated waste with casting materials. The presence of elements in the nano particles treated waste will help to improve the strength of moulding materials including mechanical properties of prepared casting materials.

Green synthesized Ag NPs have huge applications in many fields of science, medicine and other fields. Hence, reported material can use for metal moulding applications in casting. The main challenges in relation to further research within nanomaterials and waste has great impact on enormous applications. The results have shown that the green nano particles pose a remarkable improvement in mold properties and casting quality gives justification for selection of bio medical waste in place of silica sand.

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