SYNTHESIS, CHARACTERIZATION AND ANTIBACTERIAL ACTIVITY OF ALUMINIUM OXIDE NANOPARTICLES

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Abstract:

In the present study, the synthesized aluminium oxide nanoparticles were characterized and their antibacterial activity against gram positive and gram negative organisms were studied. We have used Combustion Synthesis technique for synthesis of Aluminium Oxide nanoparticle using Urea as an fuel and Aluminium Nitrate as an Oxidizer. This method is found to be easy & economical route & is able to produce Nano phase Alumina powder. The synthesized aluminium oxide nanoparticles were characterized by using X-ray diffraction (XRD), This study also determines the antibacterial activity of Al_2O_3nanoparticles against gram-positive (*Staphylococcus aureus)* and gram-negative (*E. coli*) bacteria.The average crystalline size of aluminium oxide nanoparticles was found to be 55 nm by X-ray diffraction. Among the tested bacteria, 500 micro grams was found to be most resistant with a inhibition zone of 8.5 and 9.5 mm for Aluminium Nanoparticles against *E. coli* and *S. aureus* . Similarly 3 and 5.5 mm for Aluminium Nanoparticles at 250 μg/well against *E. coli* and *S. aureus*. The study clearly reveals that Aluminium Nanoparticles that can be used for topical application against bacteria.

Keywords: Al_20_3 nanoparticles, Antibacterial activity, Fuel combustion synthesis, XRD.

I. INTRODUCTION

Nanotechnology is evolving as a rapidly developing area with its application in science and technology for the purpose of engineering new materials at the nanoscale level [1]. Nanoparticles possess different chemical properties when compared to bulk types of similar chemical composition [2]. Metal oxide nanoparticles have exhibited better durability, lower toxicity, higher stability and selectivity when compared to organic compounds [3]. Moreover, the size of such particles is responsible for the changes in their basic physical and chemical properties. These particles exhibits remarkable applications in catalysis, diagnosis, drug delivery, water treatment, cosmetics, semiconductors, sensing and solid oxide fuels [4, 5]. Aluminium oxide nanoparticles have important applications in ceramic industry [6] and can be used as an abrasive material, in heterogeneous catalysis as an absorbent, as a biomaterial and as reinforcements of metal-matrix composites [7, 8].

II. MATERIALS AND METHODS

Synthesis of Al_2O_3 nanoparticles

The combustion synthesis technology is used effectively for preparing Al_2O_3 nanoparticles using Urea as a fuel. The stoichiometric Aluminium Nitrate and Urea molar ratio is 1:2.5, required for the complete combustion of precursor. To prepare the precursor 15g of Aluminium Nitrate is mixed with 24ml of distilled water using a magnetic stirrer. Similarly 5.5g of Urea is dissolved in 5.5 ml of distilled water. This Urea solution is added to the above solution with continuous stirring and homogenized well. The aqueous redox solution containing Aluminium Nitrate and Urea, when introduced into a muffle furnace preheated to 600°C, it boils, froths, ignites and catches fire. The metal nitrate decomposes into metal oxide i.e. Aluminium Nitrate decomposes into Aluminium Oxide which is the required product and oxides of nitrogen and hence acts as a oxidizer for the combustion which leads to a voluminous foaming combustion residue in less than 5 minutes. The foam is then cooled and taken out from the furnace. Then is lightly grounded in agate mortar with pestle to obtain fine particles of Alumina or Aluminium Oxide nanoparticles. Then the final product is obtained.

Characterization

The X-ray diffraction (XRD) of the powdered sample of Al_2O_3 was recorded using an XRD diffractometer, and the patterns were recorded.

The antibacterial activity of the Al_2O_3 nanoparticles was determined by agar well diffusion method against two microorganisms, E. coli (MTCC. 443) and Staphylococcus aureus (MTCC. 902) were procured from MTCC, Chandidar, India.

RESULTS AND DISCUSSION

X-ray Diffraction

The powder XRD patterns of the prepared Aluminium Oxide Nanoparticles are recorded with automated X-ray diffractometers at wavelength 1.54056 Å. The sample is scanned over 2ϴ.The X-ray diffraction is an ideal technique for the determination of crystallite size of powder samples. The basic principle for such a determination involves precise quantification of broadening of the diffraction peaks. The broadening of the peaks indicates the particle size. The obtained XRD pattern is shown in Fig 1.

The PXRD pattern is compared well with that available in the literature, which indicates that the material of the sample, prepared in the present study is basically Al_2O_3. The diffraction peaks at 2θ values of 25.6545 (012), 35.2312 (104), 45.5513 (113),, 57.7513 (024), 66.5683 (122), 68.2609 (300), 74.3890 (119) were selected for calculating the crystalline size for peaks in the XRD pattern significantly supported formation of nanosized Al_2O_3 nanoparticles from JCPDS file (71-1683) having rhombohedral structure. Many reflections were observed at 2θ angles around 25.6545 (012), 35.2312 (104), 45.5513 (113),, 57.7513 (024), 66.5683 (122), 68.2609 (300), 74.3890 (119). The size of Al_2O_3 nanoparticles was obtained by Debye-Scherrer's formula given by the equation:

$$D = 0.9\lambda/\beta\cos\theta$$

Where, D-the crystal size, the λ-the wavelength of the X-ray radiation, θ is the diffraction angle, and β-the full width half maximum height [9]. The calculated average crystallite size was found to be 55 nm is in close agreement with reported values.

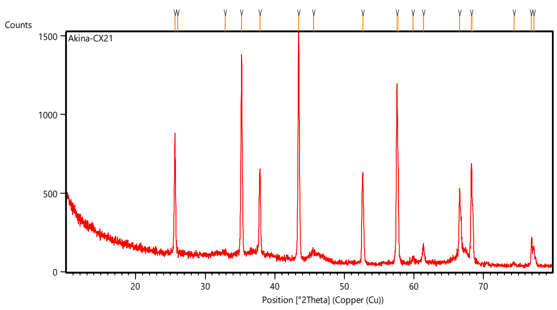
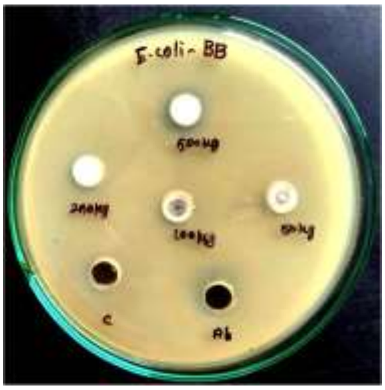


Fig 1. PXRD graph for Aluminium Oxide nanoparticles

Antibacterial activity of the Al_2O_3

The antibacterial activity of as prepared Aluminium Oxide nanoparticles was investigated against *E.coli* and *S. aureus* using the agar well diffusion assay. The zones of inhibition (mm) around each well containing as prepared Aluminium nanoparticles were represented in Figure. Fig. 2.1 & 2.2 represents the antibacterial activity of Aluminium Oxide nanoparticles.

Fig :2.1 Effect of sample against *E.Coli*



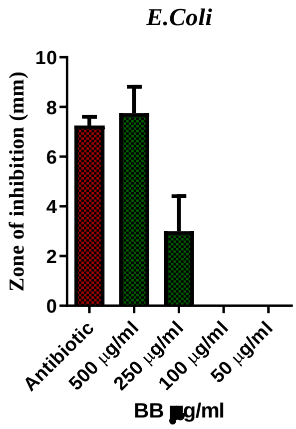
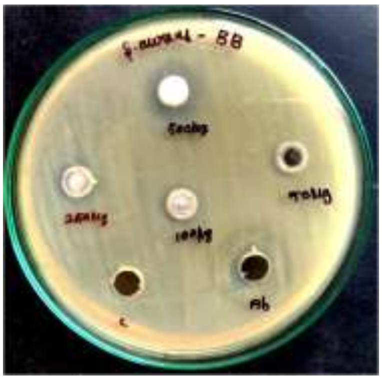
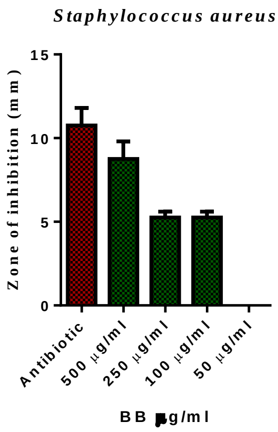


Fig :2.2 Effect of sample against *Staphylococcus aureus.*





Zone of inhibition obtained by sample against the pathogens *E.Coli and Staphylococcus aureus.*

S.No.	Name of the organism	500 µg/ml	250 µg/ml	100 µg/ml	50 µg/ml
1	*E.Coli*	8.5±1.5	8.5±1.5	0	0
2	*Staphylococcus aureus*	9.5±1.5	5.5±0.5	5.5±0.5	0

The zones of inhibition (mm) around each well containing as prepared Aluminium nanoparticles were represented in the figure. Among the tested bacteria, 500 micro grams was found to be most resistant with a inhibition zone of 8.5 and 9.5 mm for Aluminium Nanoparticles against *E. coli* and *S. aureus* . Similarly 3 and 5.5 mm for Aluminium Oxide Nanoparticles at 250 μg/well against *E. coli* and *S. aureus* . The enhanced antibacterial activity of Aluminium Oxide Nanoparticles is attributed to their large surface area that provides more surface contact with microorganisms. Another important reason of enhanced antibacterial activity of Aluminium Oxide Nanoparticles as documented in the literature is the synergistic effect between particles and natural compounds . The mechanism of action of the antibacterial activity of Aluminium Oxide Nanoparticles is attacking the respiratory chain and cell division that ultimately leads to cell death. The Aluminium Oxide Nanoparticles nanoparticles reported to release Aluminium ions inside the bacterial cells, further enhancing their bactericidal activity. There was approximately 90% growth inhibition for all strains of antibiotics. The study clearly reveals that Aluminium Oxide Nanoparticles that can be used for topical application against bacteria.

CONCLUSION

The Combustion synthesis method has been used to synthesize aluminium oxide nanoparticles. The XRD result confirmed aluminium oxide has the crystallite size of 55 nm. The aluminium oxide nanoparticles showed their antibacterial properties on both gram positive and gram negative bacterial strains. Due to the formation of the zone of inhibition, we can conclude that aluminium oxide is a good antibacterial agent.

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