MORPHOLOGICAL STUDY OF BIOLOGICALLY SYNTHESIZED IRON OXIDE NANOPARTICLES

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Abstract: - Nanotechnology is a rapidly advancing field in modern pharmaceutical and medical sciences. It involves the use of particles at the nanometer scale, which exhibit unique properties that enhance their effectiveness, particularly in addressing diseases and abnormalities. Over recent decades, various advanced and artificial techniques have been developed and applied in this field. However, increasing awareness of the potential toxic effects of these technologies on human health and the environment has raised significant global concerns, thereby influencing the direction of scientific research. A wide range of materials can be used to produce nanoparticles, each possessing distinct functionalities. Their electrical, optical, and catalytic properties are largely determined by their quantum-scale dimensions. In this study, plant extracts were investigated and found to be effective in synthesizing iron oxide nanoparticles. Surface morphology and elemental composition were analyzed using Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Analysis (EDX) and Dynamic light scattering (DLS).

Keywords: - Nanotechnology, Nanoparticles, Plant extract, SEM, EDX.

1 Introduction:- Science has come up with several techniques to make nanoparticles. These techniques employ a wide range of harmful and potentially hazardous compounds [1]. Synthetic chemical methods employed to develop biomimetic approaches have generated more environmental issues. A hazardous solvent, high pressure and energy conversion, high-temperature conversion and microbe-supported synthesis are used in the chemical synthesis because of the laboratory's upkeep [2,3]. For ecologically advantageous synthesis, no hazardous compounds are employed in the protocols. In this sense, synthetic methods based on natural biomaterials offer an alternative method of producing nanoparticles. Nanoparticle production is an essential element of biological methodological synthetic methods, encouraged by green chemistry principles [4]. Plant-mediated synthesis may produce nanoparticles cheaply, efficiently, and in an environmentally friendly manner [5].

Metal oxides have a wide range of applications in material science, including their use in fuel cells, microelectronic circuits, piezoelectric devices, sensors, and protective coatings that prevent surface erosion or act as catalysts. They are also employed in environmental remediation to remove pollutants. Oxide nanoparticles are distinguished by their extremely small size and the presence of a high number of active surface sites compared to other types of nanoparticles. For instance, metal oxides such as TiO_2, ZnO, MgO, and CaO exhibit high stability even under harsh processing conditions, which makes them suitable for applications involving both humans and animals. Owing to their strong antibacterial properties, nanoparticles of silver and zinc oxide are considered promising candidates for preventing infectious diseases. The intrinsic properties of metal nanoparticles are largely influenced by factors such as their size, shape, composition, crystalline, and overall morphology.

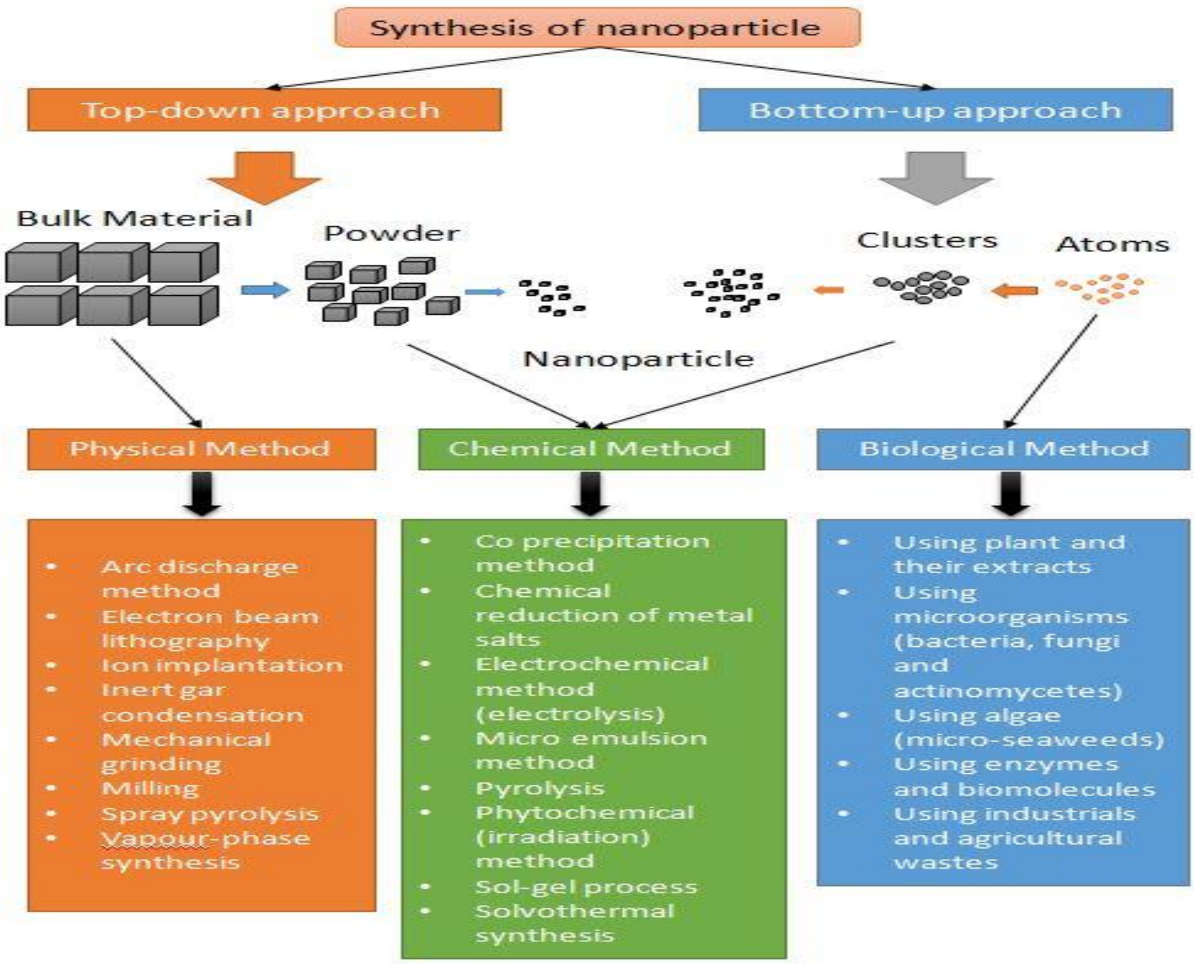

Figure 1: Synthesis Methods of Nanoparticles

In Plants mediated synthesis process plant extract has a crucial role in formation of nanoparticles so collection authentication of plants is also a key factor of synthesis process. In this study we synthesized iron oxide nanoparticles by using Aloevera plant leaves. Aloevera becomes effective in anti-inflammatory activity [6], antioxidant activity [7], and wound healing [8], Anti cancer [9] and also in antimicrobial properties [10].

2. Materials and methods: - Leaves of Aloevera were collected. Ferrous sulphate ($FeSo_4$) was obtained from GlaxoSmithKline Pharmaceuticals Limited, Mumbai. Whatman filter paper (No. 12) was used for filtration, and deionised (DI) water served as the synthesis medium. All chemicals used in this study were of analytical grade and of high purity.

2.1 Extract Preparation: - The washed and dried Aloevera leaves are grinded in to fine powder and stored in an airtight jar for future experiments. 60 gm of Aloevera leaves powder dispersed and mixed with 200 ml DI water and heated for 50 minutes at 50^{o}C; after that, the mixture was filtered with Whatman paper to find the extract. The extract is kept at 4 °C for further testing.

2.2 Synthesis process:-

3 gm $Feso_4$ mixed with 150 ml DI and stirring at 45 ^{o}C for 15 minutes to prepare sample A. 1.2 gm NaOH mixed with 100 ml DI at stirring at 50 ^{o}C for 10 min to prepare sample B then then mix both the samples. 100 ml extract of Aloevera leaves powder mixed with 100 ml of both mixture for 60 minute stirring at 30 ^{o}C. Leave it for 10 days. After washing it properly with double-ionized water, Filtering and drying in the oven for night, we found iron oxide nanoparticles in powder form.

3. Characterization techniques:-

Characterization is essential in identifying the nanoparticle's size, shape, morphology etc. Morphological characterizations at the nanoscale and micrometer scales may be confirmed by Field Emission Scanning Electron Microscopy (FESEM). The elemental composition in Iron Oxide nanoparticles by plant leaves extracts was calculated by Energy dispersive X-Ray spectroscopy (EDX). The particle size confirmed by Dynamic light scattering (DLS) [11-13].

4. Result and discussion:-

4.1 FESEM:- Field Emission Scanning Electron Microscopy (FESEM) analysis revealed that the nanoparticles possess an irregular surface morphology, as illustrated in Figure 2. The particles tend to aggregate due to their large surface area. The average particle size observed from the FESEM images was approximately 250 nm.

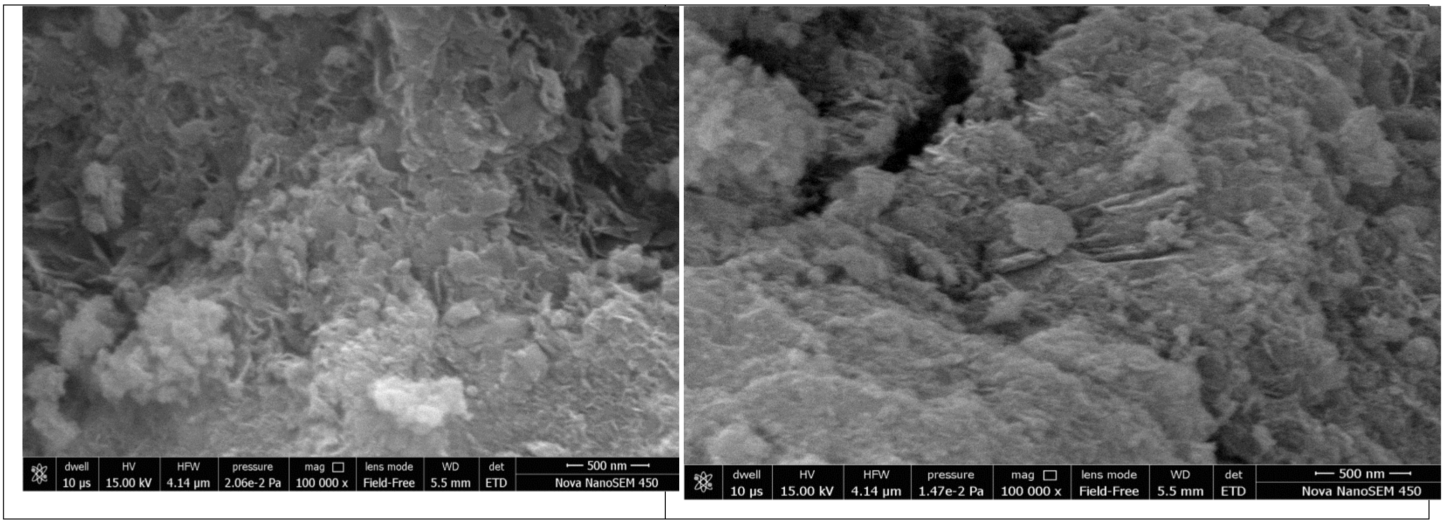

Figure 2: SEM micrographs of Iron Oxide Nanoparticles

4.2 EDX: -The elemental composition in Iron Oxide nanoparticles was calculated by EDS, and representative spectra for nanoparticles are shown in Figure 3. The elemental concentration was determined from the atomic percentage. The signals that appeared in the EDX pattern revealed Fe and O in our sample with weight percent of 57.68 % and 21.84%, respectively and also some part found in the form of C, Na.

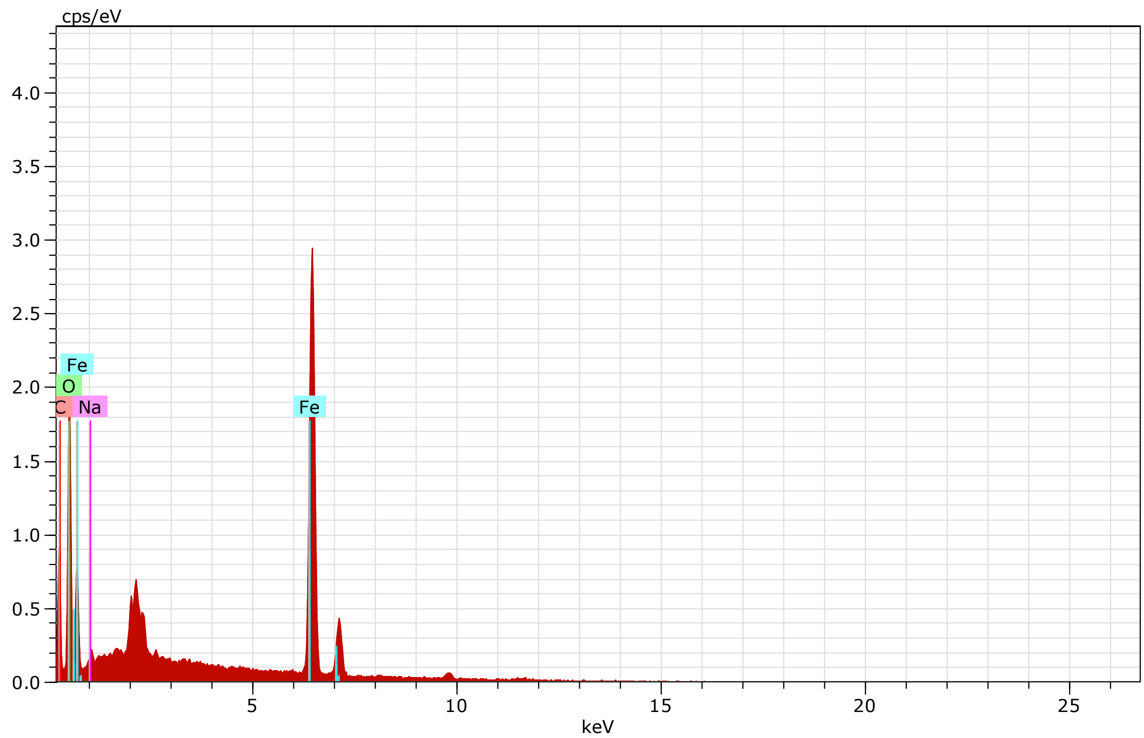

Figure 3: EDX Pattern of Iron oxide nanoparticles

4.3 DLS:- Dynamic light scattering revealed the particle size range from 100-700 nm. This technique determines particle size by analyzing Brownian motion in accordance with the Stokes–Einstein equation, which states that particle size is inversely related to the diffusion coefficient. Accordingly, smaller particles diffuse more rapidly than larger ones. The light scattered by the particles provides information about their diffusion behaviour and, consequently, their size. The particle size distribution is as in histogram Figure 4.

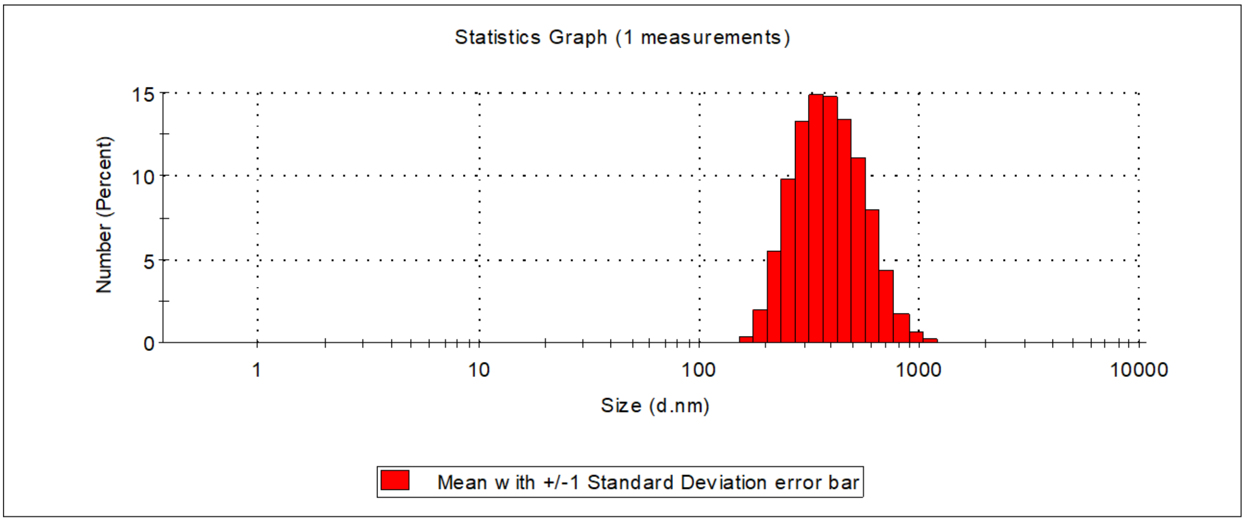

Figure 4: Particle size histogram of Iron Oxide nanoparticles

The rate at which the correlation coefficient decays over time is indicative of particle size, with smaller particles showing a faster decay. Dynamic Light Scattering (DLS) analysis revealed that the average particle size was approximately 200-300 nm.

Conclusion: - Iron oxide nanoparticles are prepared in a biologically fast manner utilizing *Aloevera* leaves. Extract can make benign nanoparticles environmentally favourable, straightforward, and effective. The plant extract ratio to metal ion concentration is critical for nanoparticles. The nanoparticles are not evenly distributed, but with agglomeration. Different magnification levels illustrate the morphology and the average size of nanoparticles ranging around 250 nm. EDX spectra of biosynthesized Iron oxide NPs verifies its order of purity and DLS analysis is also shows the size of nanoparticles. So Biosynthesis method can provide significant nanomaterials for the clean and eco-friendly environment.

References:-

[1] Thakkar, K.N., Mhatre, S.S., Parikh, R.Y. Biological synthesis of metallic nanoparticles. Nanomedicine: nanotechnology, biology and medicine. 6 (2010) 257-62.

[2] Baranwal, A., Mahato, K., Srivastava, A., Maurya, P.K., Chandra, P. Phytofabricated metallic nanoparticles and their clinical applications. RSC advances. 6 (2016) 105996-6010.

[3] Ramrakhiani, L., Ghosh, S. Metallic nanoparticle synthesised by biological route: safer candidate for diverse applications. IET nanobiotechnology. 12 (2018) 392-404.

[4] Shenashen, M.A., El-Safty, S.A., Elshehy, E.A. Synthesis, morphological control, and properties of silver nanoparticles in potential applications. Particle & Particle Systems Characterization. 31 (2014) 293-316.

[5] Das, M., Chatterjee, S. Green synthesis of metal/metal oxide nanoparticles toward biomedical applications: Boon or bane. In: Green synthesis, characterization and applications of nanoparticles, Elsevier, 2019, pp. 265-301.

[6] Miguel, M.G. Antioxidant and anti-inflammatory activities of essential oils: a short review. Molecules. 15 (2010) 9252-87.

[7] Langmead, L., Makins, R.J., Rampton, D.S. Anti-inflammatory effects of aloe vera gel in human colorectal mucosa in vitro. Alimentary pharmacology & therapeutics. 19 (2004) 521-7.

[8] Heggers, J.P., Kucukcelebi, A., Listengarten, D., Stabenau, J., Ko, F., Broemeling, L.D., et al. Beneficial effect of Aloe on wound healing in an excisional wound model. The Journal of Alternative and Complementary Medicine. 2 (1996) 271-7.

[9] Steenkamp, V., Stewart, M. Medicinal applications and toxicological activities of Aloe. Products. Pharmaceutical biology. 45 (2007) 411-20.

[10] Alves, D.S., Pérez-Fons, L., Estepa, A., Micol, V. Membrane-related effects underlying the biological activity of the anthraquinones emodin and barbaloin. Biochemical pharmacology. 68 (2004) 549-61.

[11] Sharma, S., Yadav, D.K., Chawla, K., LAL, N., Lal, C., Synthesis and Characterization of CuO nanoparticles by Aloe Barbadensis leaves. (2021). Quantum Journal of Engineering, Science and Technology, (2021) 2(5), 1-9.

[12] Sharma, S., Yadav, D.K., Chawla, K., LAL, N., Alvi, P. A. Lal, C., Degradation of dyes using Biologically Synthesized Iron Oxide Nanoparticles by Manilkara Zapota leaves extract, Rasayan J.Chem., (2022),Vol 15(3), 2165-2170.

[13] Sharma, S., Yadav, D.K., Chawla, K., LAL, Jain,P.K., Kumar, S., P. A. Lal, C., Synthesis and Characterization of Silver Nanoparticles by Murraya Koenigii Leaves, Jurnal Kejuruteraan 34(5) 2022: 819-824.