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Synthesis, characterization, and catalytic activity of platinum nanoparticles

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***Abstract*---**According to the Creative Commons Attribution License, open access articles such as this one may be freely used, distributed, and reproduced in any form as long as the original work is properly attributed. A normal calcination step in catalyst synthesis is avoided from this process. A platinum nanoparticle nanocomposite was discovered using transmission electron microscopy (TEM) with an average particle size of 2.2 nm–0.6 nm. It was found that 63% of the Pt and 37% of the PtO were found in the XPS investigations.

***Keywords*---**characterization, nanoparticles, catalysts, platinum.

Introduction

We can utilize natural resources more effectively and decrease pollution in chemical production by using catalysis. Catalysis has been the backbone of large-scale chemical and petroleum production in the past century. [1] Some issues remain unresolved, though. Catalysis has faced new problems and possibilities as a result of nanotechnology's growth. Metal nanoparticles as heterogeneous catalysts have made some progress in the last several years. Selectivity and strong catalytic activity characterize these catalysts. Oxidation, reduction, coupling, and electrochemical processes are all examples of nanocatalysts that may be used in chemical reactions. [2] They've become more popular with employees. As a bridge between matter and non-matter, non-materials have been the subject of significant study. Aside from this, Consideration must also be given to surface and interface effects, impacts of scale reduction, and effects of quantum size. [3]

A recent study in our research examined using noble metal nanoparticles in organic processes and electrocatalysis as heterogonous catalysts with the

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objective of discovering chemical syntheses that are both environmentally friendly and cost-effective are possible thanks to novel catalysts." [4] This "atom economy" in catalytic organic reactions, based on new nanomaterials, is not only possible, but it is also possible to reduce energy consumption and pollution. Fuel cell systems that are both environmentally friendly and efficient may benefit from the use of nanomaterials produced for direct oxidation of methanol and formic acid. [5]

Literature Review

KHALIL UR REHMAN,(2022) A feasible alternative to chemically available technologies in food, medical, biotechnology, and textile sectors is the use of noble metal nanoparticles (NMNPs). A total of four temperatures were used in this work to synthesis PtNPs: More dispersed PtNPs were formed at 100 °C, which resulted in smaller spheres with a high dispersion. We used several kinds of physical and chemical tests to examine the properties of PtNPs such as their composition, size, crystal structure, and surface morphology. The photodegradation of methylene blue (MB) by the biosynthesized PtNPs was examined using visible light irradiations. PtNPs shown excellent photocatalytic activity destroying 98% of MB in only 40 minutes according to the data PtNPs mediated by acid phosphatase inhibited S. aureus and E. coli bacteria very well. Against 1,1-diphenyl-2-picrylhydrazil, it has an antioxidant activity of 88%. This research offered an overview of these uses. That is why food microbiology, biomedicine, and the environment might all employ it as a new method. [6]

MD. ABU RAYHANKHANA (2021)as a result, nanotechnology has become a crucial and cutting-edge area of technological research and development. The term "nano" refers to particles that are less than a millimeter in diameter and have a broad variety of uses. Nowadays, several types of nanoparticles may be made synthetically in various ways. Physicochemical characteristics of metallic nanoparticles, such as noble metals, are utilized in a variety of industries. Pt nanoparticles are the most useful in biological, biosensor, electroanalytical, and analytical applications, as well as catalysis, when compared to the other metallic nanoparticles. Pt nanoparticles are created using a variety of processes, including physical, chemical, and biological synthesis. Biological methods are more efficient and ecologically friendly when it comes to producing Pt nanoparticles. The major objective of this study was to investigate the production, characterization, and diverse uses of Pt nanoparticles, including catalytic activity, antibacterial activity, antifungal activity, and electro analytical analysis. [7]

LEONARDO C. MORAES (2020) As a result, we observed that N-Heterocyclic Thrones (NHT) were excellent stabilisers for platinum nanoparticles generated from [Pt(dba)2] in the presence of varying substoichiometric amounts of NHT in an H2 environment. According to certain NHT legends, the imidazole fragment's double bond C C double bond binds with the metal and provides further stability to nanoparticles. Alkynes have been hydro borated using platinum nanoparticles as a catalyst. The system with the least surface area covered by the CC double bond is the most active. The monoborylated anti-Markovnikov product is hydroborated with high selectivity by this catalyst using one equivalent of borane (vinyl-boronate) A second hydroborylation results in diboroylated alkynes, which are 1,1- and 1,2-difosburov, respectively, after the initial hydroborylation. [8]

S. A. GAMA-LARA (2018) The calcination phase is eliminated in this approach, allowing for a more efficient catalyst manufacturing process. The nanocomposite included platinum nanoparticles with an average particle size of 2.2 nm - 0.6 micrometres in diameter, as revealed by transmission electron microscopy. According to the XPS results, there was 63% Pt° and 37% PtO present. 2-Butyne-1,4-diol was hydrogenated using the catalytic activity. [9]

KHWAJA SALAHUDDIN SIDDIQI (2016)Biogenic production of palladium and platinum nanoparticles from microorganism and plant sources has attracted the interest of many scientists due to its low cost, long-term viability, and environmental friendliness. Metabolites found in plants and their components are known to convert metal salts into metal nanoparticles. When it comes to Pd and Pt nanoparticle properties like size, shape, and stability, variables like pH, incubation period, concentrations of plant extract, and metal salt concentration all have a role. In addition to being used as catalysts, Pd and Pt nanoparticles may also be used to cure cancer. Size and form have been found to influence their ability to be both specific and selective in the treatment of various medical conditions. Nanoparticles made from Pd/Pt alloys may be used in a variety of industries including catalysts, biosensors and diagnostic and medicinal products. [10]

Methodology

Pt/Bovine-Bone SynthesisPtCl4 was employed as a precursor salt to generate the Pt NPs. There was no need to modify the pH of this solution, which had exactly 0.01 M NaBH4 after being dissolved in only 50 ml of water. The bovine femur was employed as a support. Afterward, the bone was rinsed and cleaned, and then submerged in a solution of 0.01 M hydrochloric acid. It was chopped into tiny pieces and powdered by a tungsten spinning component that was attached to an electric motor after immersion. Sieved 150-mesh powder was then obtained. Solution 2 was used to reduce Pt(IV) ions for 30 minutes before the experiment was stopped. An overnight air drying process at room temperature produced the final powder. Note that the reduction agent NaBH4 was used to generate Pt NPs, hence a calcinations step was not required. A micelle activity may also be predicted because to the volume of powder that was treated (about 1 g), as sepia cartilage collagen solutions have previously been shown to form micelles.

CharacterizationJEOL JSM-6510LV equipment was used to conduct the SEM observations. The carbon-conductive double-stick tape was used to connect the nanocomposite to the aluminium stub. To characterise the elements, we employed an INCA X-Sight Oxford and a scanning electron microscope. At 200 kV, a JEOL JEM-2100 microscope was used to conduct transmission electronic microscopy (TEM) research and SAED techniques. A solution of 2-propanol and ultrasonically dispersed platinum-impregnated bovine bone powders was prepared at room temperature. In the middle of a Cu-grid coated in a holey carbon layer, this suspension was dropped. STEM method was used to examine the supported Pt nanoparticles as well. It was decided to use XPS to examine the samples, and this was accomplished by using for all samples. The findings of the experiment were analyzed with the help of the programmed Te Spec Surf. Based on the 285.5 EV C1s signal, the charge adjustment was applied. Gauss-Lorentz was employed for curve fitting, whereas Shirley was utilized for background correction.

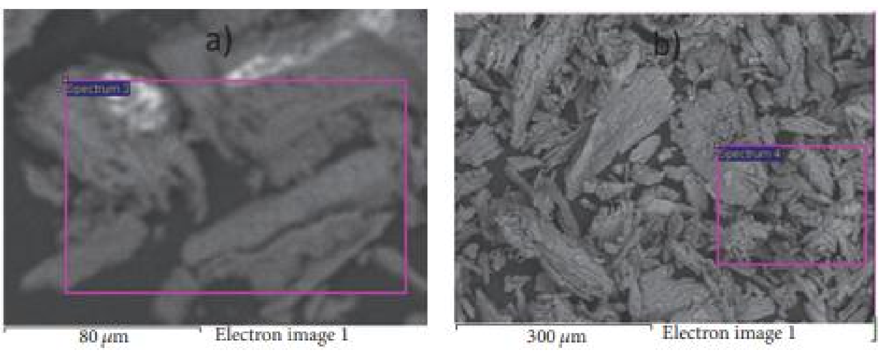
Hydrogenation Of 2-Butyne-1, 4-DiolThe reactor was supplied with hydrogen at a constant pressure via a reservoir and a constant pressure regulator.A VARIAN CP3800GC with helium as carrier gas was used to analyze the liquid samples that were taken. This was done in accordance with previously reported analysis methods, which used a fame ionization detector and a fame ionization detector. The following settings were used for the GC analysis of reaction samples. The oven temperature was raised to 493 K at a rate of 10 (K/min) It was decided to keep the oven at a constant temperature for the last three minutes.

Data Analysis

Sintering was avoided and nanoparticle size and form were controlled by using a bovine bone as a novel substrate for Pt nanoparticle synthesis (NPs) in this work. When NaBH4 reduces Pt(IV) ions, the solution is transformed into a metallic platinum phase:

$$2Pt^{4+} + BH_4^{-} + 4H_2O \rightarrow 2Pt + B(OH)_4^{-} + 8H^{+} \quad (1)$$

It is possible to entirely transform Pt ions into metallic Pt with the help of the potent reducing agent sodium borohydride (SbH). It is possible to adjust the size of Pt (IV) NPs by altering the period that bovine bone is immersed in the Pt solution. As a study variable, immersion duration of 30 seconds was found to be ideal. Pt NPs were shown to shrink in size over a shorter period of time. Furthermore, increasing the support area resulted in a significant increase in particle size.



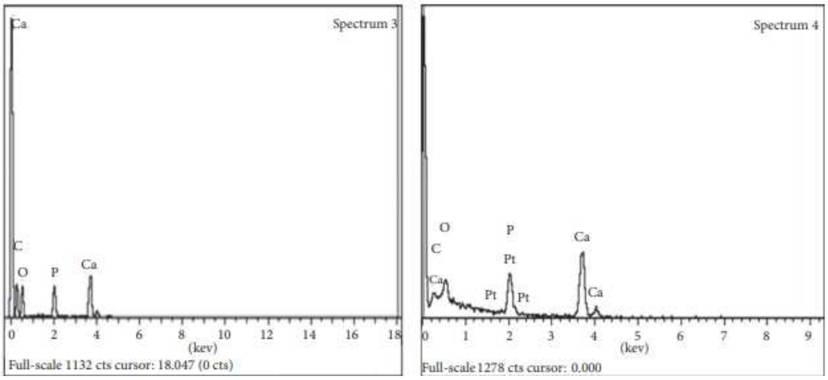


Figure 1. SEM image of bovine-bone powder, 20 kV

Pt particles of micrometric rather than nanometric size were produced when bone was employed in bulk. Bone powder's capacity to resist platinum ion aggregation due to the vast distance between metal ions might account for this finding. The high porosity (200–900 m) and large superficial area of bovine-bone powder make it a suitable platform for the production of nanoparticles. OH and PO4 3 groups in bone tissue's chemical makeup give it a high electrical density. Bovine bone hydroxyapatite has the following elements: calcium, magnesium, phosphorus, and zinc. EDS spectra and SEM micrograph of bovine powder without treatment are shown in Figures 1(a) and 1(c). After being impregnated with Pt NPs, bovine bone powder is shown in Figure 1(b). Hydroxyapatite elements and platinum are also seen in the EDS spectra shown in Figure 1(d). STEM was able to confirm the presence of Te-supported Pt NPs. Porcelain nanoparticles (Pt NPs) were used to coat bovine bone powder, which may be electrostatically connected to the support (hydroxyapatite, OH) through Pt (+). Figures 2a, 2b, 2c, and 2g demonstrate the incorporation of Pt NPs with low size polydispersity (see Table 1) into the bovine bone surface. The size and shape of the particles on the substrate may be approximated using Tese images.

Table 1
EDS elemental analysis

Element	Elemental weight% of bone	Elemental weight% of bone/Pt NPs
C K	15.78	15.18
O K	42.98	41.15
P K	13.08	12.41
C K	28.16	27.56
PTM	……	3.71

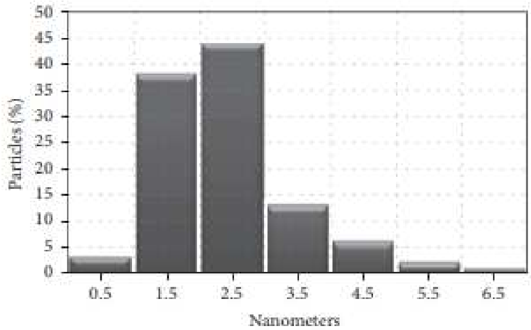


Figure 2. Size distribution of platinum nanoparticles

Fig. 2 depicts the size distribution of particles. There was an average diameter of 2.2 0.6 nm for the nanoparticles that were produced. Platinum nanoparticles and bovine-bone powder were analysed using XPS to detect their oxidation states. A platinum oxidation state diagram and its narrow spectra in the Pt 4f region demonstrate two distinct oxidation states for platinum. At 70.9 and 74.1 electron volts (4f7/2) respectively, metallic platinum accounts for about 63% of the total platinum at 4f7/2 and 75.4 eV (4f5/2), platinum oxide accounts for 37% of the total platinum signal. It is envisaged that the Pt nanoparticles/bovine-bone combination would be able to catalyse hydrogenation processes because of the aforementioned. As a result, the hydrogenation of an alkyne was chosen as a test case. The 2-butyne-1,4-diol conversion took 3.5 hours to complete. The higher the concentration of Pt metallic particles, the more active the Te catalyst is. However, when the concentration of PtO nanoparticles rises, so does the catalytic activity. 2-Butene's highest-ever selectivity After three hours of reaction, -1,4-diol had reached 83 percent. As demonstrated, Crotyl alcohol and -butanol may be to blame for the lack of selectivity in the alkane.

Conclusion

Platinum nanoparticles may be effectively and affordably supported by bovine-bone powder. Direct reduction of the metallic salt allows for the creation of this unique bionanocomposite, which yields platinum nanoparticles with a diameter of 2.2 0.6 nm. For example, the waste material used as the support is recycled, and water serves as the solvent. The calcination stage has also been eliminated. For hydrogenation operations, platinum NPs in the bovine-bone powder system exhibit great activity and selectivity. Two-butyne-1,4-diol had an almost complete conversion. High conversions resulted in a selectivity of 83% for 2-butene-1, 4-diol, the maximum possible. To a large extent, alkane content influences Tis selectivity.

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