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Synthesis of Zero-ValentIron Nanoparticles using Camellia Sinensis Leaf Extract

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ABSTRACT

This study focuses on the synthesis of cost-effective and highly stableZero-valent iron nanoparticles using Camellia Sinensis leaf extract in an eco-friendly way. It is observed that green tea extract in Camellia Sinensis leaf act as a reducing agent for iron(Fe) ions to form iron nanoparticles. This type of process can replace the traditionally used physical and chemical methods which are harmful to the environment. Zero-valent iron nanoparticles have a wide range of applications so, this eco-friendly process can be beneficial.

KEYWORDS: Iron Nanoparticles, camellia Sinensis, Particle size, Centrifugation, Zero valent.

INTRODUCTION

Nanotechnology refers to a branch of engineering which involves the manipulation of matter such as atoms and molecules at the nanoscale through certain physical or chemical processes to enhance its properties. They have important features like large surface area and volume ratio, which are responsible for wide applications of these nanoparticles. Currently, physical, and chemical processes are widely used for the production of metals and oxides. In the case of nanoparticle production, they need highly reactive and toxic reducing agents which have harmful effects on the environment and other living organisms.

Synthesis of ion nanoparticles using green tea extract provides an advancement over physical and chemical methods and also, it provides cost-effective, highly stable, and environment friendly without any use of energy, high temperature, and toxic chemicals. This implies that this process is advantageous to our environment.

Zero-valent iron nanoparticles have been successfully used as a remediation for various environmental issues such as soil and groundwater contamination. The applications of zero-valent iron nanoparticles have been increased as a highly effective process due to their stability

and high surface area. Further, these types of nanoparticles can be developed through the advanced research with the help of nanotechnology.

Nowadays, research in nanotechnology is an important aspect due to its vast number of applications. Nanotechnology already has a wide range of applications in industrial sectors such as medical products, food technologies, energy technology, and also in the information and communication industries. The most important aspect of nanotechnology is it may provide new opportunities for the eradication of pollution in our environment.

MATERIAL AND METHODS

RAW MATERIALS

Chemicals required are camellia Sinensis (green tea powder), 0.1M ferric chloride ($FeCl_3$), and distilled water.

Equipment required are a hot plate heater, laboratory centrifuge, hot air oven, and weighing machine.

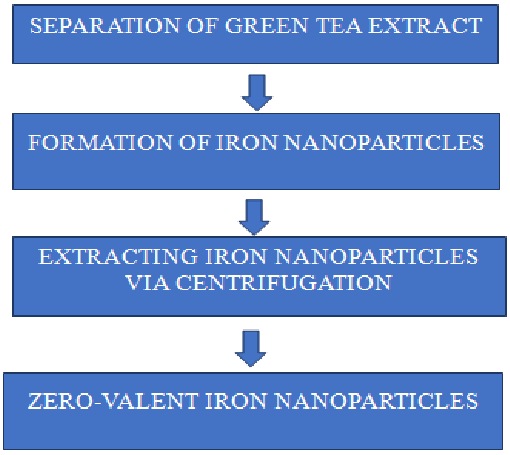
Additional materials required are a laboratory thermometer, filter paper, funnel, tripod stand, glassrod, centrifugal vials, and laboratory spatula.

SYNTHESIS OF IRONNANOPARTICLES

The green tea extract reacts with 0.1M Fecl3 solution which results in the formation of highly stable and cost-effective iron nanoparticles. The polyphenols present in the green tea extract act as the reducing agent over the $FeCl_3$ solution and zero-valent iron nanoparticles are produced.

METHOD:

Four steps involved in the synthesizing of zero-valent iron nanoparticles is shown below



SEPARATION OF GREEN TEA EXTRACT

The first step of the process after getting all the required raw material and equipment is the separation of green tea extract from Camellia sinensis.

At first 1:20 ratio of green tea powder and DI water i.e., 5 grams of 100 percent Camellia sinensis(green tea) powder is taken and weighed, and 100 ml of distilled water is taken in a beaker. The beaker is placed on a hot plate and heated up to 80 degrees Celsius. The temperature is adjusted to be around 80 degrees Celsius. Check the temperature of the distilled water with the help of a laboratory thermometer, andonce the solution attains 80 °C, thenCamellia sinensis green tea powder is added to the water andstir the solution slowly using a glass rod. The solution is heated for 20 minutes until the solution turnsgreen. After the solution turns green thatimplies the complete dissolution of powder in water.

After 20 minutes the hot plate is turned off and the beaker containing the solution is carefully put aside. Let the solution to be cooled for 5-10 minutes. After the solution cooled and it is filtered using filter paper with the help of a funnel. The resulting product after filtration is shown in figure 3.

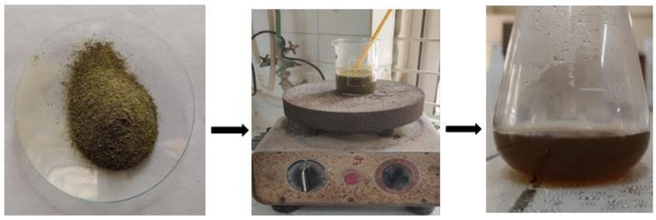


Figure 1 Camellia sinensis Green Tea Powder　*Figure 2 Heating on Hot Plate*　*Figure 3 Filtered Solution After Heating*

FORMATION OF IRON NANOPARTICLES

In this step, 1:2 ratio i.e., 50 ml of Laboratory prepared 0.1 M ferric chloride ($FeCl_3$) is mixed with 100ml of filtered solution. Once the Camellia sinensis filtered solution is added to 0.1M ferric chloride the yellow-colored solution turns black immediately which shows the formation of iron Nanoparticles as shown in figure 6.

The iron Nanoparticles are formed when the polyphenols that are present in Camellia sinensis act as reducing and capping agents which reduce the ferric chloride iron salt to iron Nanoparticles. The black solution shows that iron nanoparticles are formed by the reduction of $FeCl_3$ by polyphenols present in the green tea powder.

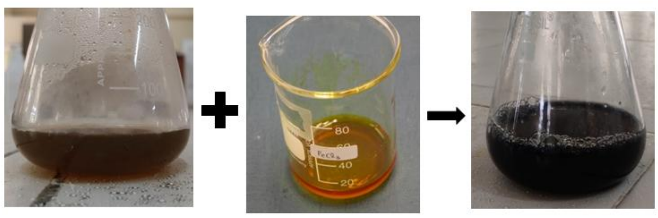


Figure 4 Filtered Solution　*Figure 5 0.1 M FeCl3 Solution*　*Figure 6 Formation of Iron Nanoparticles*

EXTRACTING IRON NANOPARTICLES VIA CENTRIFUGATION

The black solution has nanoparticlesthat are dispersed so to extract the nanoparticles we use a centrifuge.The centrifugation process helps to separate the particles at the nano level which are mixed in a solution. The solution is uniformly poured into the centrifuge vials of 30 ml each. Six centrifuge vials are filled, and the centrifuge is done for about 20 minutes at 8000 rpm. Once the centrifuge is done thenanoparticle are separated.

Slowly pour out the excess water and centrifuge again by adding double distilled water to the vales to clean the separated iron nanoparticles. The before step has been repeated twice to getpure iron nanoparticles.

Figure 7 Iron nanoparticles solution in centrifuge vials

Figure 8 Centrifugation at 8000 rpm for 20 min

Figure 9 Particles separated after Centrifugation

ZERO-VALENT IRON NANOPARTICLES

After centrifugation, carefully remove the separated nanoparticles from vials with the help of a laboratory spatula and separate the excess moisture present in them by using a drier. After drying small black color particles free of moisture and the obtained product are zero-valent iron nanoparticles. These zero-valent iron nanoparticles have a high specific surface area, and they are highly stable. Further, the resultant product zero-valent iron nanoparticles sent for characterization.

Figure 10 zero-valent iron nanoparticles

RESULTS AND DISCUSSION

Table-1Combinations Used during Experiment Run

Green tea and solvent ratio (w/v)	$FeCl_3$ and green tea extract ratio (v/v)
1:16	1:1
1:18	1:2
1:20	1:3

Three different ratios of green tea powder and solvent have been taken to separate the green tea extract and three different ratios of $FeCl_3$ solution and green tea extract have been

taken to check the parameters wherethe maximum yield of iron nanoparticles is obtained.

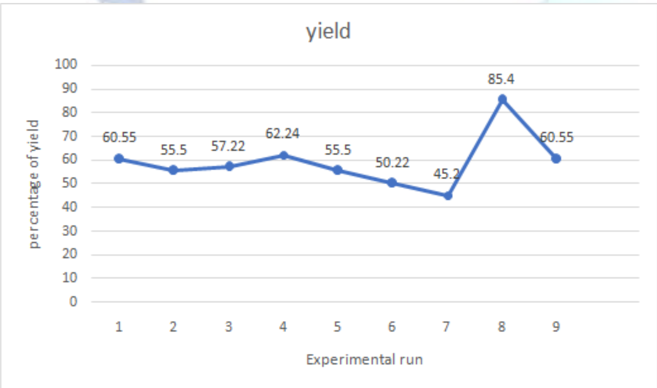
Table-2 Series of Different Experiment Runs

Experiment runs	Green tea and solvent ratio (w/v)	$FeCl_3$ and green tea extract ratio (v/v)	Percentage of Yield (w/w)	Average particle size (nm)
1.	1:16	1:1	58.66	15.04
2.	1:16	1:2	55.50	10.46
3.	1:16	1:3	57.22	9.82
4.	1:18	1:1	62.24	17.04
5.	1:18	1:2	55.50	16.46
6.	1:18	1:3	50.22	8.82
7.	1:20	1:1	45.2	18.86
8.	1:20	1:2	85.40	13.07
9.	1:20	1:3	60.55	9.70

It can be observed that the amount of the solvent and green tea extractratios influencesthe percentage of yield. The desired amount of solvent is required for the separation of green tea extract, but the less proportion of the solvent gives a low recovery. The conditions that gave the least diameter of particle size can be seen in experiment run 6, whereas the conditions which gave the highest diameter of the particle size in experiment number 7 from table 2.

The ratio of $FeCl_3$ and green tea extract as a reducing agent plays an important role in the synthesis of zero-valent iron nanoparticles. Further, the yield is increased with the increase of the reducing agent ratio of 1:2 and the green tea and solvent ratio of 1:20, but a further increase in the proportion of the green tea extract resultinga decrease in the yield percentage. Therefore, this implies excessive input of reducing agent will affect particle production.

Graphical Representation of The Different Experiment Runs



From the above graph, it is clearly shown that the yield percentage of nanoparticles synthesized is high in experiment run number 8i.e., the ratio of green tea and solvent is 1:20, and $FeCl_3$ and green tea extract ratio is 1:2.

Scanning Electron Microscopic (SEM) Image of Iron Nanoparticles

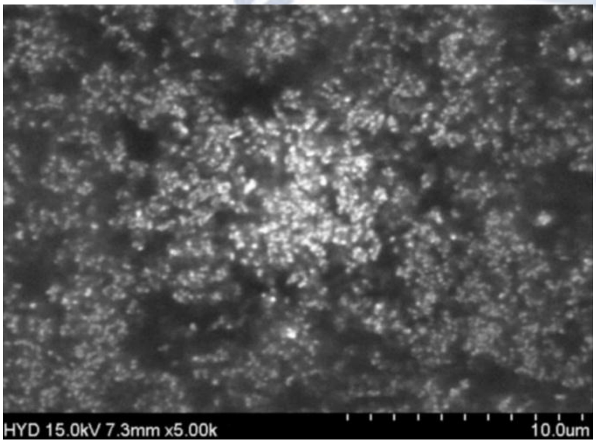
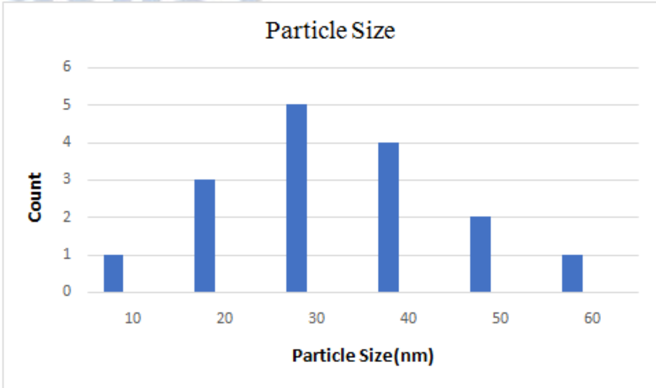


Figure 11: SEM image of iron nanoparticles

1. Iron nanoparticles are successfully synthesized and sent for SEM characterization.
2. Figure 11 shows the SEM image of the iron nanoparticlesas the result of experiment run number 8 which gave good yields
3. The diameter of the nanoparticles is found in the range of 10nm to 45nm.

Graphical representation Of Different Particle Sizes



- Different particle sizes from the SEM image of the iron nanoparticles are compared and represented graphically.
- It can be seen that the diameter of the particles is more in between 20nm to 30nm.

Applications of Zero-Valent Iron Nanoparticles

Stabilized zero-valent iron nanoparticles have a wide range of applications.

1. Iron nanoparticles have been widely used as remediation of both organic and inorganic contaminants in groundwater as well as soil like fertilizers, pesticides etc.
2. They are also used for treating industrially contaminated water with different toxic compounds such as chlorine, arsenic, fluoride etc.
3. The most promising use of these iron nanoparticles in medical purposesis they are used as drug carriers for the specific area in the human bodywith the help of an external magnetic field.
4. Zero-valent iron nanoparticles can be used as a catalyst in electrolysis to improve the efficiency of the electrodes. These iron nanoparticles reduce the loss of electrons and improve the conductivity of the electrodes.

5. They are also used as a catalyst in the production of alloys and primary coloring agent for glass and ceramic products.

CONCLUSIONS

1. The current research work has confirmed that zero-valent iron nanoparticles can be synthesized using Camellia sinensis extract in an eco-friendly wayand cost-effectively.
2. Polyphenols present in the Camellia sinensis (green tea extract) has played a crucial role as a reducing agent over $FeCl_3$ solution to extract iron nanoparticles.
3. The conditions in which the highest yield is obtained are 1:20 ratio of green tea and solvent, and $FeCl_3$ and green tea extract ratio is 1:2.
4. The average particle size observed through the series of experiments was about 15nm to 25nm.
5. Synthesis of zero-valent iron nanoparticles through this process is beneficial to the environment as the process is done without any use of toxic chemicals.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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