NEW IRON OXIDE NANOMATERIALS FOR USE IN THE ENVIRONMENT: MAKING AND STUDYING.

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ABSTRACT

This research looks at making and studying unique nanomaterials formed of iron oxide, as well as how these nanomaterials could be used in environmental systems. This study primarily examines the correlation between the reaction conditions index during the synthesis process and the use of these nanomaterials in environmental systems. The catalytic activity and environmental stability metric show that research into nanomaterials and the reaction conditions index and particle size show that the fabrication of nanomaterials are two separate things. The dependent variable is how nanomaterials are used in the environment. The researcher may find out how well iron oxide nanomaterials can adapt to different environments by looking at how changes in the synthesis parameters affect the structure, shape, and surface characteristics of these particles. This helps to figure out whether these particles can change to fit in with their environment. The research employs a simple random sampling method with quantitative methodologies. The reaction conditions index is a very important portion that has a big impact on how well particles get rid of contaminants and fix damaged areas. This is because the index may change the surface area, crystallinity, and homogeneity of particles. This index considers a variety of elements, including temperature, pH, time, and the rate at which stirring happens. When looking at long-term performance, stability and catalytic activity are both equally important. However, the findings show that nanomaterials work better in real-world situations when the reaction circumstances are just right. Even if each of these things are equally vital, this is the case. The results of this research shed insight on how controlled synthesis approaches may help improve the link between making nanomaterials and using them in real-world situations. The study was conducted to analyse the relationship between the two entities.

Keywords: reaction conditions index, particle size, iron oxide nanomaterials, crystallinity, synthesis approaches.

INTRODUCTION

Iron oxide nanomaterials are becoming increasingly useful for cleaning up pollution, purifying water, and cleaning up pollution because they have very well magnetic, catalytic, and adsorption capabilities (Patiño-Ruiz et al., 2021). There are several factors that affect the structure and function of these nanoparticles, as well as their possible uses in environmental

systems. The study of nanomaterials, as shown by metrics for catalytic activity and environmental stability, and the creation of iron oxide nanomaterials, as shown by the reaction conditions index and particle size, are examples of this idea (Abdullah et al., 2023). The reaction conditions index, which was connected to the reactions that happened while creating iron oxide nanoparticles, was an essential factor that impacted the end product of the synthesis. The process that was going on had a direct effect on the nanomaterials' surfaces, crystallinity, and form. This happened because of the way that pH, reaction temperature, duration, and stirring speed all worked together. By making modest changes to the conditions under which nanoparticles are made, it was possible to change the size, surface characteristics, and phase purity of the particles. After the conditions were made more stable, both adsorption and catalysis worked better. Stability began to decrease and application was restricted when conditions were not fully optimum. The reaction conditions index was the main measure utilised to find out what iron oxide nanomaterials may be used for in the environment. (Chaudhari et al., 2024).

BACKGROUND OF THE STUDY

Nanotechnology has made it possible to make high-tech materials that might help solve important environmental problems. Iron oxide nanoparticles have showed a lot of potential in various areas, such as removing heavy metals, breaking down pollutants, and cleaning up wastewater. The way these nanoparticles are manufactured and analysed influences their structure, chemistry, and function, which in turn affects how they interact with their surroundings (Patil et al., 2019). The size of the particles and the Reaction Conditions Index are two of the most essential things that affect how iron oxide nanoparticles are made. The Reaction Conditions Index includes things like pH, precursor concentration, temperature, and reaction time. These things have a big effect on the form, surface properties, and crystallinity of the nanomaterials. When things aren't handled well, they become less stable and don't utilise their skills to their maximum potential. On the other hand, optimising them makes them more responsive and helpful to the things around them. The link between particle size and surface area is another thing that impacts how the material acts. Smaller particles are more likely to work better in processes like adsorption and catalysis (Zhou et al., 2023).

PURPOSE OF THE STUDY

Researchers did this investigation wanted to learn all they could about the Reaction Conditions Index. They also wanted to know whether the index had anything to do with making new iron oxide nanoparticles. The circumstances that were present throughout the synthesis process have a big impact on how well the final applications work. Iron oxide nanoparticles have been known to scientists for a long time because they can get rid of contaminants and mend ecosystems that have been harmed. This study seeks to investigate the influence of varying values of the Reaction Conditions Index on the performance, environmental adaptability, and utility of nanomaterials. To reach this aim, a lot of different things need to be taken into account,

such the concentration of the precursor, the pH level, the temperature, and the time of the reaction. The researcher may investigate the influence of the aforementioned factors on the reaction time. The objective of this work is to demonstrate that iron oxide nanoparticles may achieve greater efficiency via regulated synthesis.

LITERATURE REVIEW

Researchers in environmental remediation are very interested in iron oxide nanoparticles since they may be used in a lot of various ways. In the future, these nanoparticles could be able to aid with environmental issues. They are expected to do very well at getting rid of heavy metals, adsorbing pollutants, and catalysing organic pollutants. Making nanoparticles out of iron oxide molecules is one of the most important phases in figuring out how useful they are for protecting the environment. The way these nanoparticles were made and the circumstances under which they were made have a direct effect on their structure and function. The Reaction Conditions Index is made up of several different sections that work together. The temperature, pH, length, and quantity of precursor molecules in the reaction are all variables that affect it. Researchers that have examined the features of these materials concerning environmental concerns have shown that modifying the reaction conditions may enhance their efficiency. For each individual particle, the amount of reactivity is directly related to its size. Smaller particles are more reactive than bigger ones. This is because smaller particles have a larger surface-to-volume ratio (Gupta C Bhattacharya, 2022). Scientists are focussing on making iron oxide nanoparticles so they can find out how well they work as catalysts and how stable they are in the environment. Nanoparticles are stable, which means that they are continue do what they are supposed to do no matter what the environment is like. Nanoparticles, on the other hand, have a catalytic activity that decides how much they may speed up the breakdown of compounds. Because of these traits, it seems like nanoparticles might be employed all across the world, not only in research labs (Gupta C Bhattacharya, 2022). The researchers think that the Reaction Conditions Index is the most important of these contributing factors since it affects how well the nanomaterials work as a whole. This is not the case since each of these things is important. The study showed that poorly regulated synthesis leads to structures that are less efficient at eliminating contaminants and have strange shapes. However, the best circumstances produce materials that are beneficial for the environment. This is why it is so important to make a clear link between the synthesis method's parameters and how well it works in different situations (Zhang et al., 2021).

RESEARCH QUESTION

What is the influence of Reaction Conditions Index on Usage of New Iron Oxide Nanomaterials in The Environment?

METHODOLOGY

Research design: Quantitative data were analysed with SPSS version 25. The odds ratio and 95% confidence interval were used to evaluate the direction and size of the statistical association. The researchers established a statistically significant criteria of $p < 0.05$. A descriptive analysis elucidated the principal facets of the data. Quantitative approaches are often used for mathematical, numerical, or statistical analysis of data acquired by surveys, polls, and questionnaires, or by modifying existing statistical data using computing tools.

Sampling: Research participants completed questionnaires to provide information. Utilising the Rao-soft software, researchers identified a study population of 875 individuals, resulting in the dissemination of 962 questionnaires. The researchers received 945 responses, but discarded 27 due to incompleteness. This resulted in a conclusive sample size of 918.

Data and Measurement: A questionnaire was the major tool used to gather data for this investigation. There were two parts to the survey: (A) a basic demographic part and (B) a part where people rated various aspects of both online and offline channels on a 5-point Likert scale. It got secondary data from a number of places, but mostly from databases on the internet.

Statistical software: SPSS 25 and MS-Excel were used to do the statistical analysis.

Statistical tools: Descriptive analysis was used to comprehend the essential attributes of the data. The researcher must analyse the data with ANOVA.

CONCEPTUAL FRAMEWORK
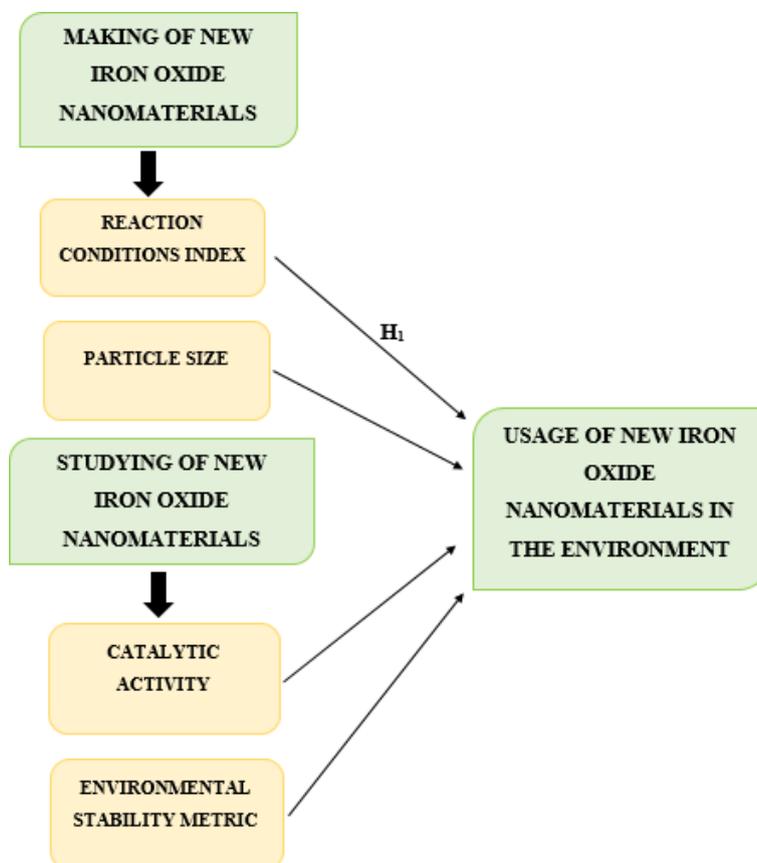
RESULT

Factor Analysis: Assessing the fundamental component structure of a set of measurement items is a prevalent use of Factor Analysis (FA). The scores of the observed variables are believed to be influenced by hidden factors that are not easily discernible. The accuracy analysis (FA) method is a model-driven methodology. This research primarily focuses on constructing causal pathways between observable events, hidden causes, and measurement errors. The appropriateness of the data for factor analysis may be assessed using the Kaiser-Meyer-Olkin (KMO) approach. The adequacy of the sample for each individual model variable and the overall model is assessed. The statistics quantify the extent of possible common variation across many variables. Data with lower percentages is often more suitable for factor analysis. KMO yields integers ranging from zero to one. Sampling is considered sufficient if the KMO value is between 0.8 and 1. Remedial action is required if the KMO is below 0.6, indicating insufficient sampling. Exercise researcher best judgment; some writers utilize 0.5 for this purpose, hence the range is 0.5 to 0.6.

A KMO value around 0 indicates that the partial correlations are substantial relative to the overall correlations. Component analysis is significantly impeded by substantial correlations. Kaiser's thresholds for acceptability are delineated as follows:

A bleak 0.050 to 0.059.

0.60 - 0.69 subpar

Standard range for middle grade: 0.70 to 0.79. A quality point value ranging from 0.80 to 0.89. The interval from 0.90 to 1.00 is quite impressive.

Table 1. KMO and Bartlett's Test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.890
Bartlett's Test of Sphericity	Approx. Chi-Square	3252.968
	df	190
	Sig.	.000

Bartlett's Test of Sphericity further validated the importance of the correlation matrices. The Kaiser-Meyer-Olkin metric of sampling adequacy is 0.890. Utilising Bartlett's sphericity test, researchers obtained a p-value of 0.00. The results of Bartlett's sphericity test indicated that the correlation matrix is erroneous.

INDEPENDENT VARIABLE

Making of New Iron Oxide Nanomaterials: To make new iron oxide nanomaterials, it is vital to make iron oxide structures on the nanoscale and put them together appropriately. This is something that has to happen before the manufacturing stage (Akhtar et al., 2021). These things change the material's surface chemistry, reactivity, crystallinity, and the size and shape of its particles, which in turn changes that material. These factors have a big effect on how the system nucleates and grows. The manufacturing approach uses well-known methods such as co-precipitation, sol-gel processing, micro emulsion, and hydrothermal synthesis (Chen et al., 2022). In environmental contexts, the synthesis of iron oxide nanoparticles is getting a lot of attention. When these compounds are put in reaction circumstances that have been carefully prepared, they may remove heavy metals, break down photocatalytically, and adsorb pollutants to a greater level. By controlling the synthesis at this level, it is possible to make nanoparticles that are not only stable but also reproducible and can be made in larger amounts (Wang et al., 2023).

FACTOR

Reaction Conditions Index: By using the reaction conditions index, nanoparticles of iron oxide may be characterised in terms of their structural, morphological, and functional characteristics. The presence of surfactants or stabilisers, the type of solvent, temperature, pH, concentration of precursors, reaction time, and reaction time are all important factors to take into consideration. The nucleation and growth processes are influenced by these factors, which change the surface area, crystallinity, size, and magnetic or catalytic properties of the particles (Gupta et al., 2020). According to the reaction conditions index, iron oxide nanoparticles are not only favourable to the environment but also extremely adaptable material. It is possible that synthetic research carried out in a laboratory might be effective in resolving problems that occur in the real world, such as the elimination of pollution (Li et al., 2022).

DEPENDENT VARIABLE

Usage of New Iron Oxide Nanomaterials in the Environment: The phrase "environmental usage" of iron oxide nanoparticles has changed lately to signify something other than it did before. This brand-new term is used to talk about how these nanostructures may be utilised to clean up polluted air, water, and soil systems, among other things. Iron oxide nanoparticles are employed to gather, break down, or change contaminants into forms that are less harmful to people. This shows that they can be used for more than just cleaning. The quantity of these compounds used is dependent on their manufacturing process, particularly the parameters governing their reactions. This is because the crystallinity, morphology, and surface chemistry of these molecules all have a big influence on how well they work in the environment. Both of these things are closely related to how these compounds work in the environment (Bakshi, 2024). Iron oxide nanoparticles have a lot of promise for environmentally friendly management because they are safe for the environment, can be used again, and can be combined with other materials, like carbon-based supports or polymers, to make them more stable. Environmental

safety problems are intimately linked to the use of nanoparticles since it is important to know how they are released and how long they stay in ecosystems. Some of the things that are looked at include how stable they are, how well they work, how they interact with the environment, and the regulations they have to follow. Researchers are currently looking at the best methods to use iron oxide nanoparticles in environmental protection strategies (Ansari et al., 2024).

Relationship Between Reaction Conditions Index and Usage of New Iron Oxide Nanomaterials in the Environment: The reaction conditions index is an important aspect of figuring out what iron oxide nanoparticles are like and how they may be used in the environment. The size, crystallinity, surface chemistry, and porosity of the particles are all affected by the temperature, pH, concentration of the precursor, the amount of time it takes for the reaction to happen, and the atmosphere around the reaction. These physicochemical characteristics influence several parameters, including the adsorption capability of iron oxide nanoparticles. The careful control of the pH and temperature settings is linked to the making of particles that have a consistent form and a better surface reactivity. These traits are particularly important when it comes to getting rid of heavy metals and breaking down pollutants in a way that works (Chen et al., 2021). To make it feasible for iron oxide nanoparticles to be utilised in the environment, such as cleaning water, fixing soil, and cleaning air, it is very important to change the reaction conditions index. This is due to the connection between the two. When iron oxide nanoparticles are used in real-world environmental systems, they need to be very stable, efficient, and long-lasting. Also, improving the reaction conditions index is a key part of making green nanotechnology (Liu et al., 2022). Following the above debate, the researcher developed the following hypothesis to examine the correlation between Reaction Conditions Index and Usage of New Iron Oxide Nanomaterials in the Environment.

H_{01}: *"There is no significant relationship between Reaction Conditions Index and Usage of New Iron Oxide Nanomaterials in the Environment"*.

H_1: *"There is a significant relationship between Reaction Conditions Index and Usage of New Iron Oxide Nanomaterials in the Environment"*.

Table 2. H1 ANOVA Test.

ANOVA					
Sum					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	39588.620	384	5655.546	1,063.672	.000
Within Groups	492.770	533	5.317		
Total	40081.390	917			

This inquiry has yielded a significant discovery. The F value is 1063.672, indicating significance with a p-value of 0.000, which is below the alpha threshold of 0.05. This denotes the *"H₁: There is a significant relationship between Reaction Conditions Index and Usage of New Iron*

Oxide Nanomaterials in the Environment" the alternative hypothesis is accepted while the null hypothesis is rejected.

DISCUSSION

Production of new nanoparticles of iron oxide is one of the most promising routes for the development of environmentally friendly technologies. This is because nanoparticles are very small. The synthesis process not only affects the chemical and structural characteristics of the nanomaterials, but it also decides the potential uses of these materials in environmental systems since it takes into account the nanoparticles' properties. In the context of this conversation, the reaction conditions index has been an important component in determining the physicochemical characteristics of nanomaterials that are made up of iron oxide from the beginning of this debate. Surface area, crystallinity, particle shape, and the availability of functional groups are all areas that are influenced by a wide range of properties. The kind of precursor, the pH level, the temperature, and the amount of time that the reaction is carried out are all examples of these factors. The effectiveness of nanomaterials in environmental applications such as catalysis, the removal of pollutants, and the restoration of ecosystems that have been damaged is directly tied to the features and attributes that are discussed below. Due to the fact that they have a high capacity for adsorption, are highly effective chemical catalysts, and are environmentally benign, iron oxide nanoparticles have shown a great lot of promise for use in environmental applications. This is because of the fact that they are environmentally friendly. In the case of iron oxide nanoparticles, for example, they have shown a substantial level of effectiveness in the removal of organic pollutants, heavy metals, and colours when they are synthesised under circumstances that are optimal. The degree to which the reaction conditions index was managed throughout the production process is a significant factor that plays a significant role in determining their efficiency. It is likely that nanoparticles interact with environmental pollutants in a stronger way under circumstances when the surface reactivity of the nanomaterials is high and their particle size is both very small and consistent. In order to achieve this effect, the production parameters need to be fine-tuned in a very specific way. In spite of this, it is of the highest significance to carefully manage reactions since, in the event that the circumstances are not appropriately optimised, it is possible for particles to agglomerate, surface activity to decrease, and environmental performance to degrade. Thus, it is essential to carefully regulate responses.

When it comes to environmental systems, the utilisation of iron oxide nanoparticles and the reaction conditions index are extremely dependent on one another when it comes to the relationship between the two. In light of the fact that it is the phase that is accountable for deciding the functionality that implemented in following stages, the synthesis phase is very significant. The capacity of nanomaterials to maintain their stability, activity, and flexibility is contingent upon the effective setting of the reaction conditions index. Even when the nanomaterials are subjected to fluctuating environmental conditions, such as pH, salinity, or organic load, this remains the case. There exists a connection between the two, and if there are

interested in enhancing the effects that nanomaterials have on the environment, ones need to place a significant emphasis on optimising the synthesis process in the design of future nanomaterials.

CONCLUSION

It is ultimately the reaction conditions index that is responsible for determining the process by which iron oxide nanoparticles are produced. This index, in turn, provides us with information on the potential applications of these particles within the realm of environmental protection technologies. The ability to make quick adjustments to the parameters of the synthesis results in improved pollution control and environmental repair of the environment. With regard to the development of nanomaterials, there is still another reason why the index is of such fundamental significance.

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