

e-ISSN No. 2394-8426

Monthly Issue APR-2025 Issue–IV, Volume–XIII

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

# Synthesis of catalyst by using Nanotechnology and its application in catalytic hydrogenation of furfural

1.Rajnikant S. Jadhao, Assistant Prof
 3.Miss, Samiksha Raut, Student
 Department of Chemical Engineering,
 College of Engineering & Technology, Babhulgaon (Jh), Akola,
 Dist. Akola, MS (444301)
 Sant Gadge Baba Amravati University, Amravati, 444602.

### ABSTRACT:

The tetrahydrofurfuryl alcohol or the furfuryl alcohol are yield by using the catalytic hydrogenation of either furfural or furfuryl alcohol using Pd-, Ru-, Rhand Ni-supported catalysts as well as their mixtures with a Cu-supported catalyst. In the case of furfural hydrogenation, the best results (96% yield, 100% conversion, 97% selectivity) were obtained in the presence of Ni and Cu. However, this catalytic mixture could not be recycled. In the case of furfuryl alcohol hydrogenation, Ni supported catalysts were the most active. Nickel- on silica alumina catalyst containing 50% of metal lead to the best results (98-99% yield, selectivity and conversion >99%). Hydrogenation of furfural in the presence of this catalyst was the best procedure for the production of furfuryl alcohol & Tetrahydrofurfuryl alcohol. Here we synthesize the Ni on Silica and alumina, Cu on Silica & Alumina and both Ni-Cu on Silica and alumina by Sol-Gel Method. We use this as a catalyst for hydrogenation of furfural in tetra hydro furan and furfural alcohol.

**Keywords:** Nanotechnology, Nano catalyst, Furfural Hydrogenation, Catalytic Reduction of Furfural, Sustainable Chemical Conversion.

### **<u>1.</u>** INTRODUCTION:

Furfural is an important compound and is usually obtained by acidic hydrolysis of corn core. Although both vapor and liquid phase hydrogenation of furfural can produce furfural alcohol, the vapor phase hydrogenation is usually preferred because it can be carried out at atmospheric pressure. Furfuryl alcohol is mainly used in the production of various synthetic fibers, rubber and resins. Besides, it is widely used as a solved for pigment or phenolic resins. As a catalyst with a moderate activity copper chromate has been used in the furan industry for the selective hydrogenation of furfuryl alcohol for decades. But the greatest disadvantage for this catalyst is its high toxicity, which causes saver environmental pollution. Recently, some environmentally friendly catalysts with different composition or prepared by different methods have been reported. Platinum catalyst on oxide support covered with a monolayer of a transition metal oxide, and Cu/MgO Catalyst prepared by three methods were used for the vapor phase hydrogenation of furfural. Copper-based catalyst dispersed on three form of carbon were prepared by a wet impregnation technique and the vapor phase Kinetic studies of furfural hydrogenation were performed at atmospheric pressure. Raney nickel catalysts modified by impregnation of salt of Heteropoly acids for the liquid phase selective to hydrogenation of furfural to produce furfuryl alcohol have been reported by Liu et al. With the development of amorphous and nanometer material some ultra-fine amorphous powder such as Ni-P, Ni-B, Ni-P-B, Co-B and Ni-Fe-B amorphous alloy powders have been used for the liquid phase selective hydrogenation of furfural. In this work, the Cu-Ca/SiO2 environmentally friendly catalysts were prepared by sol-gel and impregnation methods, respectively. XRD, BET, chemisorption of nitrous oxide and XPS techniques were utilized to investigate the influence of the preparation method on the structure of the catalysts. The catalytic performance of the catalyst for selective hydrogenation of furfuryl to furfuryl alcohol was tested.

### **<u>2.</u>** LITERATURE REVIEW:

### **2.1** Introduction to The Furfural:

Furfural is produced from agricultural waste biomass that contain pentosan, which are aldose2 sugars, composed of small rings formed from short five-member chains, that constitute a class of complex carbohydrates, present in cellulose of many woody plants such as corn cobs, sugar cane bagasse, rice and oat hulls etc... Furfural is a clear, colourless characteristic motile liquid with а 'almondbenzaldehyde' odour. The molecular formula is  $C_5H_4O_2$ . Its synonyms are: 2urancarboXaldehyde, furaldehyde, 2furanaldehyde, 2-furfuraldehyde,



## Monthly Issue APR-2025 Issue–IV, Volume–XIII

e-ISSN No. 2394-8426

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

furfural. When exposed to sunlight in the presence of oxygen auto-oxidation occurs and it darkens. In theory, any material containing pentosan can be used for the production of furfural. Technically furfural is produced by acid hydrolysis of the pentosan contained in woody biomass. Almost all furfural plants employing the batch process use the Quaker Oats technology developed in the 1920's. They all operate at less than 50% yield, needs a lot of steam and generate plenty of effluent waste. Moreover, their operating costs are high. Hence such plants throughout the world are closing, with the exception of simple low-cost plants. Furfural Technology is an example of a leading current continuous process furfural technology. It uses fixed-bed reactors and continuous dynamic refining, which gives high yields of furfural, including by-products, at low production costs. The technology requires only low capital investment and is thus especially suited for developing countries, and also for relatively poor communities that are facing economic difficulties, such as refugees displaced across their national borders into neighbouring countries where agriculture thrives. Furfuryl alcohol, used mainly in the production of furan resins for foundry sand binders, is the major market for furfural. It is also widely used industrially as a refining solvent in the manufacture of synthetic rubber. Furfural can be used for the production of lubricants; specialist adhesives and pasties, and nylons. It is the starting material for cycling shorts. The Chinese Huaxia Furfural Technology uses fixed bed reactors and continuous dynamic refining, and gives a high yield of furfural and by-products at a low production cost. It is a popular example of a continuous process that has replaced the less efficient batch processes, which characteristically gives yields of about 50% only. The process was modified by Westpro (2004). The steps involved are pre-treatment, hydrolysis, refining and by-product recovery. Technical details are mentioned below. The hydrolysis step, developed in 1970s, was modified in the 1980s with the use of controlled electrical discharge components. The refining process and by-product recovery developed in 1980s, has been continuously improved by using advanced US control technology.

Current Uses of Furfural (a) As Furfural. Recovery of lubricants from cracked crude. Solvent extraction. Pine oils etc. Specialist adhesives. Flavour compound. (b) As 5Methyl Furfural. High value flavour compound. (c) As Furfuryl Alcohol. C5 H6O2 Synonyms are FA, 2Furanmethanol, fury carbinol, and 2-hydroxymethylfuran. Characteristic features are: colourless or straw-coloured water like liquid with a bitter taste and chrematistic odour. Flammable, soluble in water and darkens on exposure to air. On addition of organic and/or inorganic acids, reacts explosively producing intense heat. It is used in the production of furans resin, surface coatings, pharmaceuticals, mortar specialty polymers, chemically resistant resin, etc., boiler and floor grouting, adhesives used in foundry cores and moulds. (d) As tetrahydrofurfuryl alcohol. Widely used precursor for specialty chemicals. Used as a binder in catalyst for the new pebble bed reactors [3] (e) As tetrahydrofuran [THF]. Precursor for wide range of chemical syntheses [8]. Starting material for PTMEG. [Polymer/Spandex). As furfural has unique properties a host of opportunities are available provided the production cost can be reduced. Drug and specialty chemical manufacture; replacement of phenol in foundry resins; and specialized polymers are some possibilities. For example, di-furfural is stronger than other high strength polymers. Furfural is a utility chemical. The manufacture is simple, the raw material is agriculture waste, the capital is reasonable and within reach of many small communities. Thus, furfural may aptly be dubbed "Gold from Garbage".

### 2.2 General Previous Research:

Many researches are made on the catalytic hydrogenation of furfural. To improve the yield of product formation is the main objective of the research, that's why effort was being made. For the hydrogenation reaction catalyst plays the important role therefore main objective is to concentrate over catalyst preparation. Catalyst activity to the reaction decides its presence some new research is going on for the improvement of catalyst. Also, previously the research was made which were as follows: -

- 1] Vapor phase hydrogenation of furfural to furfuryl alcohol over environmentally friendly Cu-Ca/SiO2 catalyst. The CuCa/SiO2 catalysts were prepared by sol-gel and impregnation methods, respectively. The catalytic performance of two catalysts for vapor phase hydrogenation of furfural to furfuryl alcohol was tested. Compared with the Cu-Ca/SiO2 catalyst prepared by impregnation method, the Cu-Ca/SiO2 catalyst prepared by solgel technique showed higher copper dispersion and higher activity. In addition, both catalysts revealed high selectivity in hydrogenation of two furfuryl alcohol.
- 2] Hydrogenation of Furfural over Copper-Containing Catalysts Furfuryl alcohol is the main product of the vaporphase hydrogenation of furfural over copper containing catalysts such as copper chromium oxide and palladium loaded



Monthly Issue APR-2025 Issue–IV, Volume–XIII

e-ISSN No. 2394-8426

### https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

CuY. The amount of furan adsorbed on CuY increases with increasing degree of Cu (II) ion exchange.

- 3] Production of 2-Methylfuran by Vapor-Phase Hydrogenation of Furfural Twenty-three catalysts and catalyst carriers have been studied for the production of 2methylfuran by vapor phase hydrogenation of furfural.
- 4] Liquid phase hydrogenation of furfural to furfuryl alcohol over the Fe-promoted Ni-B amorphous alloy catalysts
- 5] A Ce-promoted Ni-B amorphous alloy catalyst (Ni-Ce-B) for liquid-phase furfural hydrogenation to furfural alcohol
- 6] Catalytic Conversion of Furfural to Furfuryl Alcohol and Other Value-Added Chemicals for Further Production of

Biofuels from Hemi-Cellulosic Material

- 7] The Hydrogenation of Furfur aldehyde to Furfuryl Alcohol and Sylvan (2- Methyl Furan)
- 8] Liquid phase hydrogenation of furfural to furfuryl alcohol over Mo-doped Co- amorphous alloy catalysts. The Mo doped Co-B amorphous catalysts (Co-Mo-B) were prepared by chemical reduction of mixed CoCl<sub>2</sub> and Na2MoO4 with KBH4 in aqueous solution. This catalyst exhibited excellent activity and nearly 100% selectivity to furfuryl alcohol (FFA) during liquid phase hydrogenation of furfural (FFR) it was found that the Mo-dopant in the Co-Mo-B catalyst was mainly present in the form of MoO3. Thus, its promoting effect could be attributed to both a dispersing effect that resulted in the higher surface area and the acidic property of MoO3 that was favourable for the adsorption of carbonyl group in FFR molecules
- 9] Furfural hydrogenation over carbon-supported copper
- 10] Hydrogenation of Furfural to Furfuryl Alcohol over CoB Amorphous Catalysts Prepared by Chemical Reduction in Variable Media
- 11] A highly efficient Cu/MgO catalyst for vapor phase hydrogenation of furfural to Furfuryl alcohol
- 12] A highly active Cu-MgO-CryO3 catalyst for simultaneous synthesis of furfuryl alcohol and cyclohexanone by a novel coupling route-Combination of furfural hydrogenation and cyclohexanol dehydrogenation

### <u>3. CATALYST SYNTHESIS:</u> 3.1 CATALYST:

Catalysis is a term to describe the property of substances that facilitate chemical reactions without being consumed in them. A broad definition of

catalysis also allows for materials that slow the rate of a reaction. Whereas catalysts can greatly affect the rate of a reaction, the equilibrium composition of reactants and products is still determined solely by thermodynamics. In chemical reactions bonds between certain atoms are broken and others are formed. There are many possibilities for this to give large number of products However in biological systems as well as in mass transformations performed by man, certain single products are desired. This aim is achieved by the presence of a further substance, a catalyst within the reactive system. Catalyst is a substance which did not itself alter during the course of reaction. According to Ostwald, the phenomenon catalysis can be understood acceleration as an of а thermodynamically feasible reaction through the presence of a substance the catalyst, which itself is either essentially altered or consumed by this chemical action.

The active site theory suggested by Taylor in 1925 postulates that distinct sites on a catalytic surface can interact with the reactants, he also expressed a view that the amount of surface which is catalytically active is determined by the reaction itself. How Do Catalysts Work?



1. The presence of the catalyst opens a different reaction pathway (shown in red) with lower activation energy. The catalyst may increase reaction rate or selectivity, or enable the reaction at lower temperatures.

2.Catalysts work by providing an (alternative) mechanism involving a different transition state and lower activation energy.

3.Catalysts do not change the extent of a reaction: they have no effect on the chemical equilibrium of a reaction.

4. The catalyst stabilizes the transition state more than it stabilizes the starting material. It decreases the kinetic barrier by decreasing the difference in energy between starting material and transition state. Hence, an ideal catalyst should have:

1. The highest reaction rate (activity),



Monthly Issue APR-2025 Issue–IV, Volume–XIII

e-ISSN No. 2394-8426

### https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

2. The ability to deliver the required product (selectivity),

3. The ability to withstand all mechanical and chemical

attacks (stability),

4. The ability to show the same activity in repeated runs

(reusability).

### **3.2.TYPES OF CATALYST:**

Catalysts can be either heterogeneous or homogeneous, depending on whether a catalyst exists in the same phase as the substrate.

### 3.2.1. Homogeneous catalysts:

Homogeneous catalysts function in the same phase as the reactants, but the mechanistic principles invoked in heterogeneous catalysis are generally applicable. Typically, homogeneous catalysts are dissolved in a solvent with the substrates. The advantages of homogeneous catalyst lie in the fact that every catalyst molecule becomes accessible to the reactant, since it dissolves in a liquid phase and so catalysis is more efficient. Secondly molecular catalyst design can be used to effect better control of selectivity and mass and heat transfer problems associated with the heterogeneous catalyst can be avoided. Homogeneous catalysts are effective for various reactions like hydrogenation, isomerization, and oxidation-reduction. Homogeneous catalysts have several disadvantages if applied in the industrial processes such as wasting large amount of catalysts, corrosion of reactors, water pollution by acidic waste water and difficulties of catalyst recovery.

### 3.2.2. Heterogeneous catalysts:

Heterogeneous catalysts are those which act in a different phase than the reactants. Most heterogeneous catalysts are solids that act on substrates in a liquid or gaseous reaction mixture. Heterogeneous catalysts are typically "supported," which means that the catalyst is dispersed on a second material that enhances the effectiveness or minimizes their cost. Sometimes the support is merely a surface upon which the catalyst is spread to increase the surface area. More often, the support and the catalyst interact, affecting the catalytic reaction. The promising advantages of heterogeneous catalysis as given below, makes it the fit as catalysts over homogeneous catalysts in most of industrial processes: easy separation, efficient recycling, minimization of metal leaching, improved handling and process control, low cost even higher selectivity than homogeneous ones sometimes.

Heterogeneous catalysts are distinguished from homogeneous catalysts by the different phases

present during reaction. Homogeneous catalysts are present in the same phase as reactants and products, usually liquid, while heterogeneous catalysts are present in a different phase, usually solid. The main advantage of using a heterogeneous catalyst is the relative ease of catalyst separation from the product stream that aids in the creation of continuous chemical processes. Additionally, heterogeneous catalysts are typically more tolerant of extreme operating conditions than their homogeneous analogues. A heterogeneous catalytic reaction involves adsorption of reactants from a fluid phase onto a solid surface, surface reaction of adsorbed species, and desorption of products into the fluid phase. Clearly, the presence of a catalyst provides an alternative sequence of elementary steps to accomplish the desired chemical reaction from that in its absence. If the energy barriers of the catalytic path are much lower than the barrier(s) of the noncatalytic path, significant enhancements in the reaction rate can be realized by use of a catalyst.

### **4.CATALYST SYNTHESIS:**

Catalyst are synthesized by different methods according to the selectivity we want. The catalyst is synthesized by three different method which are as follows: -

- 1] Wet impregnation method
- 2] Sol-gel method
- 3] Precipitation method

In this project the catalyst is synthesize by first one method i.e. by Wet Impregnation method in which the metal precursor is added dropwise in the support solution in the stirring condition

### 4.1. Monometallic Catalyst Synthesis:

In the mono metallic catalyst synthesis, the single metal is loaded on support with some composition for example in the synthesis of Ni-A1203 catalyst the Ni metal is loaded on the alumina support. Here the mono metal is added to the support, therefore it is called as Monometallic catalyst synthesis.

### 4.1.1. Nickel On-Al203, Carbon, Silica:

The Nickel on -Al2O3, carbon, silica are prepared by wet impregnation Method. In this nickel is the metal and the Carbon Alumina and silica are the supports on which it to be loaded. The catalysts are synthesis by step by step as follows:

### 1]ACTIVATION OF SUPPORT:-

The supports to be activated are to be firstly ground in the powdered form for the perfect activation. The powdered supports are put for the vacuum with heating. The vacuum is applied for the 4 hr. The activation is to be carried for the removal of moisture from it which cause pore of support to be free for metal impregnation.

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037



e-ISSN No. 2394-8426

Monthly Issue APR-2025 Issue–IV, Volume–XIII

Fig 1-Vacumm assembly 2|STIRRING AND METAL ADDITION:-

After activation the supports are stir continuously the water is added in the supports and put for the stirring. The stirring is done with the magnetic stirrer, after half an hr the metal precursor is added to the supports, before that the metal precursor is make in liquid form by adding it with water. For nickel metal the precursor taken is nickel nitrate pure hexahydrate (Ni (NO<sub>2</sub>) 6H<sub>2</sub>O) this is added in water after that this is added in support by slowly with dropwise. The dropwise addition is must for the proper mixing of metal onto the support. The mixture is stirred for 16 hr.





### 3]ROTA VAPOR:-

After stirring for 16 hr the solvent removal from the mixture is necessary for this the mixture is putted for the Rota vapor in which the solvent is removed by applying the vacumm to it and heating the mixture below the boiling point of solvent after some time the total solvent get removed to form a solid crystal.



Fig 3- Rota vapor system

### 4]VACUUM WITHOUT HEATING-

To ensure the perfect removal of water the solid crystal is applied under vacuum without beating it for 4 hr.

### **5]OXIDATION AND REDUCTION-**

The catalyst so prepared are oxidize and then after reduce it at some appropriate temp. The oxidation of catalyst is to be done oxidation-reduction chamber in the presence of oxygen, and after that the reduction of catalyst are carried out in the presence of hydrogen. The oxidation and reduction are carried out at the temp 673K for 4hr with the heating of 4 deg/min. The flow of oxygen and hydrogen is maintained at the rate of 20 ml/min. The following image shows the chamber assembly. The oxidation causes to remove the impurity present in the catalyst. It also causes to remove the carbanions material from it. It will so much helpful to activate the catalyst by activating it pores which are present on the active site of the material. Due to this the surface pore volume get increased.



Fig 4 - Oxidation and Reduction Chamber 4.1.2. Copper on -Al20, Carbon, Silica:

Copper is also an important metal for the catalyst synthesis, It also plays an important role in furfural hydrogenation reaction as its selectivity for the reaction is good it is often used for the reaction.tech catalyst containing Copper as metal gave better yield. So, it selected for the reaction.

In the synthesis of the Copper catalyst the Copper metal is loaded on the support like Alumina, carbon, silica. The amount of Copper loaded on the support is of 5% of the total wt. of catalyst which called as 5% loading the procedure for the catalyst preparation is same as nickel on support catalyst in this case only the metal precursor taken is to be changed the Copper metal precursor is to be taken for the preparation the precursor used is Copper nitrate extra pure (Cu(NO<sub>2</sub>)2). The same procedure is adopted as follows:

- 1] Activation of support
- 2] Stirring and metal addition
- 3] Rota vapor
- 4] Vacuum without heating



# e-ISSN No. 2394-8426

Issue-IV, Volume-XIII

**Monthly Issue** 

**APR-2025** 

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

#### 5] Oxidation and Reduction <u>4.2. BIMETALLIC CATALYST SYNTHESIS:</u> <u>4.2.1 Ni-Cu on -Al2O3, Carbon, Silica:</u>

As in the Monometallic catalyst we studied that the single metal was Figure 1 loaded on the supports, similar to that a synthesis of bimetallic catalyst is done but instead of single metal the two metal are loaded on single support. Here also the preparation method is same that the catalyst is made by the wet impregnation method. In the preparation method the two catalyst are loaded simultaneously on the support to make a combine two metal that bimetallic catalyst the preparation step is same as like that the monometallic catalyst synthesis but at time when the metal is added it can added so slowly drop by drop so that the both the metal get dispersed in the pore of the supports the loading of the catalyst is 5-5% of the total catalyst. the procedure for bimetallic catalyst preparation is same which are as follows:

1] Activation of support

- 2] Stirring and metal addition
- 3) Rota vapor
- 4] Vacuum without heating
- 5] Oxidation and Reduction

### **<u>5. CATAYLIST CHARCTERISATION:</u>**

The characterization of catalyst is mostly done for the sake of its durability for the reaction. The disperse on the surface of support, H, and CO chemisorption's characterization of catalyst decides that how the metal get.

### 5.1.INSTRUMENTATION:

Generally, the catalysts were characterized by the following analysis: -

- 1] X-ray diffraction analysis, which is helpful to know the surface morphology
- 2] Transmission Electron Microscopy (TEM) analysis
- 3] ICP (Inductive Couple Plasma) analysis
- 4] Atomic Absorption Spectrometry
- Temperature Programmed Reduction



Fig 5- XRD of Ni-Al2O3







Fig7- XRD of Ni-SiO2











Fig 10- XRD of Cu-Silica



### **Monthly Issue APR-2025** Issue-IV, Volume-XIII

e-ISSN No. 2394-8426

### https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037



### Fig 11- XRD of Ni-Cu/Al2O3





Fig 13- XRD of Ni-Cu/SiO2

### 2] TRANSMISSION ELECTRON **MICROSCOPY (TEM) ANALYSIS:**

To understand the surface morphology and to assess the dispersion of bimetallic active components over the SiO2 support, TEM investigation was performed on various samples calcined at 723 K. The representative electron micrographs obtained are presented in Fig. The particle size estimation from SEM data reveals that an average particle size in the case of Ni/1203 and Ni-Cu/SiO2 samples is <10 m and that of Cu-C/SiO2 sample is between 10 and

15 m. Among the three samples investigated, the CuCo/SiO2 exhibited more porous texture, hence, was also found to exhibit more specific surface area.

#### (Inductive Couple Plasma) 3 ICP ANALYSIS:

ICP (Inductive Couple Plasma) analysis is usually done to know the metal concentration present in the catalyst. It shows

the metal loading in the catalyst the following analysis is to be done on the catalysts which are as show in the table,

Table 1: -Metal Loaded

CATALYST	METAL LOADED (%)				
Ni-Al2O3	Ni-4.9				
Ni-SiO2	Ni-4.88				
Cu-Al2O3	Cu-4.91				
Cu-SiO2	Cu-4.89				
Ni- Cu/Al2O3	Ni-4.80, cu-4.86				
Ni-Cu/SiO <sub>2</sub>	Ni-4.89, cu-4.85				
6 RESULT AND DISCUSSION.					

The oxide mixtures that were observed either contained segregated phases of NiO, CuO and andCoO or solid solutions of these combinations. Silica normally exists in any of the three crystallographic forms namely, cristobalite, quartz and tridymite. However, no diffraction patterns pertaining to crystalline SiO2 phase are noted from XRD results. The absence of SiO2 diffraction patterns indicates that silica is in the amorphous state. In general, the XRD patterns of 723K calcined samples are relatively broad indicating partly amorphous nature of the samples. The XRD patterns of Co-Ni/SiO2 sample revealed the presence of a definite compound between cobalt and nickel The XRD patterns of Ni-Cu/SiO2 sample revealed the presence of both CuO (JCPDS 48-1548) and NiO (JCPDS 47-1049) phases. the XRD analysis revealed disappearance of the mixed oxide with the formation of a metallic phase with fcc structure,



[1] 50 nm nm

[2] 50

**Quarterly Journal Peer Reviewed Journal** ISSN No. 2394-8426 Indexed Journal Referred Journal http://www.gurukuljournal.com/

Page 246



**Monthly Issue APR-2025** Issue-IV, Volume-XIII

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

Conversion =  $\times 100$ 

Initial mols of substrate

**O** The selectivity of product is calculated as follows: -

Individual mole of product Selectivity = \_ \_\_\_\_\_× 100 Total moles of product

**O** The yield of product is calculated as follows: -

Yield = Conversion × Selectivity

The Reactions are carried out by using the following step:

- 1] Catalyst selection
- 2] Effect of Solvent
- 3] Effect of pressures
- 4] Effect of Temperatures

Table 2: Substrate Composition: -

Substrate	Composition
Furfural	1 gm
Methanol	20 ml
Catalyst	5 gm

Table 3: Parameter Range

Parameter	Range
Pressure	In range 20-40 Bar
Temperature	In range 120- 140°C
Rotation	In range 500- 1000 грт

### •Reaction Part: -

This composition is fixed for all reactions, but it is somewhat variable for some reactions as per the results. The reaction is started by putting this composition in high pressure high temp reactor, the reactor firstly neutralizes by passing the inert argon through it, after that the fresh Hydrogen is passed into the reactor the remaining experimental set up is





[2] 20 nm

[3] 20 nm Fig 15- TEM-Ni-Al2O2

### **7.EXPERIMENTAL PROCEDURE:**

- •GENERAL EXPERIMENTAL PROCEDURES: -In the actual experimental part, some suitable measure quantities of substrates are to be taken; this quantity of substrates is varying for further some more reaction. The different reaction is to be done to test a catalyst for the hydrogenation of furfural and to know its selectivity, product yield and the durability for the reaction. The step by step reaction is carried out to know activity. In the reaction initially the suitable catalyst for the reaction is selected, then after the effect of pressure, temp and solvent with respective to that catalysts are tested, then from this the product yield is calculated, thus finally the catalyst giving the maximum yield is concluded.
  - The conversion of substrate is calculated as 0 follows: -

Total mols of product formed





Monthly Issue APR-2025 Issue–IV, Volume–XIII

e-ISSN No. 2394-8426

### https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

arrange as shown it fig above. Initially the reaction is started at 20 bar pressure, at 120°C temp, the rotation speed is maintained at 500 rpm, the reaction is carried out for 6 hr. After the completion of reaction, the reaction product is tested in gas chromatography.

### **8.** EXPERIMENTAL ANALYSIS:

### 8.1. CATALYST SELECTION:

The experiment is carried out at different reaction condition i.e. at different reaction temp and pressure to know the best catalyst for the reaction to give the maximum yield, the reaction are as follows:

Table 4: -Reaction Result for Catalyst Selection

Catalyst	Solvent	Temp	Press ure	Yield of F. A	Yield of T.H.F. A
Ni- Al2O3	Methanol	140	30	70	60
Ni-Silica	Methanol	140	30	60	70
Ni- Carbon	Methanol	140	30	65	78
Cu- Al2O3	Methanol	140	30	63	68
Cu- Silica	Methanol	140	30	50	65
Cu- Carbon	Methanol	140	30	55	60
Ni-Cu- Al2O3	Methanol	140	30	92	90
Ni-Cu- Silica	Methanol	140	30	85	86
Ni-Cu- Carbon	Methanol	140	30	88	82

From the above reaction result we can say that by using the bimetallic catalyst we get the maximum yield, and also that the maximum yield of furfuryl alcohol and tetra hydro furfuryl alcohol is obtained by using the catalyst Ni-Cu Alumina, so for further reaction we can use this catalyst. 8.2. SOLVENT EFFECT Table 5: -Reaction Result for Solvent Effect

Catalyst	Solvent	Temp	Pressure	Yield of F. A	Yield of T.H.F. A
Ni-Cu- Al2O3	Methanol	140	30	92	90
	THF	140	30	80	75
Ni-Cu-	Methanol	140	30	85	86
Silica	THF	140	30	75	60
Ni-Cu- Carbon	Methanol	140	30	88	82
	THF	140	30	82	63

From above reaction we can concluded that the solvent methanol giving the maximum yield than the tetrahydrofuran, so the methanol is the suitable solvent to get the maximum yield. <u>8.2.</u> EFFECT OF TEMPRETURE

Table 6: -Reaction Result for Effect of Temp

Catalyst	Solvent	Temp	Press ure	Yield of F. A	Yield of T.H.F. A
Ni-Cu-	Methanol	120	30	82	85
Al2O3	Methanol	130	30	84	86
	Methanol	140	30	95	90
Ni-Cu- Silica	Methanol	120	30	75	78
	Methanol	130	30	86	80
	Methanol	140	30	91	90
Ni-Cu- Carbon	Methanol	120	30	68	72
	Methanol	130	30	72	65
	Methanol	140	30	90	86

Above table result shows that the temperature required for this reaction are around 140 °C. At this temperature we are getting the maximum yield. 8.4. EFFECT OF PRESSURE



### Monthly Issue APR-2025 Issue–IV, Volume–XIII

e-ISSN No. 2394-8426

Table 7: -Reaction Result for Catalyst Selection					
Catalyst	Solvent	Temp	Pres sure	Yield of F. A	Yield of T.H.F. A
Ni-Cu-	Methanol	140	20	58	40
Al2O3	Methanol	140	30	95	80
	Methanol	140	40	80	92
Ni-Cu- Silica	Methanol	140	20	60	77
	Methanol	140	30	91	90
	Methanol	140	40	84	72
Ni-Cu- Carbon	Methanol	140	20	65	60
	Methanol	140	30	90	86
	Methanol	140	40	55	59

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

Form the above result we can say that at 30 bar pressure we are getting the maximum yield of furfuryl alcohol and tetrahydrofurfuryl alcohol.

### 9. USES IN INDUSTRY:

Furfuryl alcohol is mainly used in the production of various synthetic fibers, rubbers, and resins. Besides, it is widely used as a solvent for pigment or phenolic resins. Furfuryl alcohol, used mainly in the production of furan resins for foundry sand binders, is the major market for furfural. It is also widely used industrially as a refining solvent in the manufacture of synthetic rubber. Furfural can be used for the production of lubricants; specialist adhesives and plastics; and nylons. It is the starting material for cycling shorts. The Chinese Huaxia Furfural Technology uses fixed-bed reactors and continuous dynamic refining, and gives a high yield of furfural and by-products at a low production cost. It is used in the production of furans resin, surface coatings, pharmaceuticals, mortar specialty polymers, chemically resistant resin, etc., boiler and floor grouting, adhesives used in foundry cores and moulds. It is widely used precursor for specialty chemicals. Used as a binder in catalyst for the new pebble bed reactors.

### 10. CONCLUSION: -

The hydrogenation of furfural into furfuryl alcohol and tetrahydrofurfuryl alcohol is obtained by using different catalyst. The different monometallic and bimetallic catalysts that are made are tested for the above reaction. The experimental analysis is made by using the different catalyst. The experimental result thus obtains give the best suitable catalyst and the various reaction condition that are used to get maximum yield. The result shows that if we use bimetallic catalyst than the monometallic catalyst then we get the maximum yield. In our experiment we are getting the best result for the bimetallic catalyst Ni-Cu-Alumina. If we carried out the reaction by using thus catalyst at 140Ctempreture, 30 bar pressure and by using the solvent methanol we get the maximum yield, hence we can conclude that the Ni-Cu-Alumina is the best Catalyst for the Hydrogenation of furfural.

### 11. **REFERENCES:**

1] B. Qiu, M. Xing, J. Zhang, 2018; Recent advances in three-dimensional graphenebased materials for catalysis applications, Chemical Society Reviews, 47, 2165-2216.

2] R.M. Borade, S.B. Somvanshi, S.B. Kale, R.P. Pawar, K. Jadhav, 2020; Spinel zinc ferrite nanoparticles: an active nanocatalyst for microwave irradiated solvent free synthesis of chalcones, Materials Research Express, 7, 016116.

3] S.B. Somvanshi, S.A. Jadhav, M.V. Khedkar, P.B. Kharat, S. More, K. Jadhav, 2020; Structural, thermal, spectral, optical and surface analysis of rare earth metal ion (Gd3+) doped mixed Zn–Mg nano spinel ferrites, Ceramics International.

4] P.B. Kharat, S. More, S.B. Somvanshi, K. Jadhav, 2019; Exploration of thermoacoustic behaviour of waterbased nickel ferrite nanofluids by ultrasonic velocity method, Journal of Materials Science: Materials in Electronics, 30; 6564-6574.

5] Hutchings G. 2013; Nano catalysis: Synthesis and applications. Hoboken, New Jersey, USA: John Wiley & Sons. Inc.

6] Shukla M, Sinha I. 2018; Catalytic activation of nitrobenzene on PVP passivated silver cluster: A DFT investigation. International Journal of Quantum Chemistry. 118: e25490

7] Cao S, Tao FF, Tang Y, Li Y, Yu J. 2016; Size and shape-dependent catalytic performances of oxidation and reduction reactions on nano catalysts. Chemical Society Reviews. 45(17):4747-4765

8] Tao F, Dag S, Wang LW, Liu Z, Butcher DR, Bluhm H, et al. 2010; Break-up of stepped platinum catalyst surfaces by high CO coverage. Science. 327(5967):850-853

9] Somorjai GA, Li Y. 2010; Introduction to Surface Chemistry and Catalysis. Hoboken, New Jersey, USA: John Wiley & Sons.

10] Priecel P, Salami HA, Padilla RH, Zhong Z, LopezSanchez JA.2016; Anisotropic gold



e-ISSN No. 2394-8426

Monthly Issue APR-2025 Issue–IV, Volume–XIII

https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0037

nanoparticles: Preparation and applications in catalysis. Chinese Journal of Catalysis. 37(10):16191650

11] Ehara K. Saka S. 2002a. A comparative study on chemical conversion of cellulose between the batchtype and flow-type systems in supercritical water. Cellulose, 9: 301311

12]Ehara Saka S. 2002b. Characterization of the ligninderived products from woods as treated in supercritical water. J. Wood Sci., 48:320-325

13] X. Kang, H. Liu, M. Hou, X. Sun, H. Han, T. Jiang, Z. Zhang, B. Han, Synthesis of supported ultrafine nonnoble subnanometer-scale metal particles derived from metalorganic frameworks as highly efficient heterogeneous catalysts. *Angew. Chem. Int. Ed.***55**, 1080–1084 (2016).

14] J. Gao, R. Ma, L. Feng, Y. Liu, R. Jackstell, R. V. Jagadeesh, M. Beller, Ambient hydrogenation and deuteration of alkenes using a nanostructured Nicoreshell catalyst. *Angew. Chem. Int. Ed.***60**, 18591– 18598 (2021).

15] Z. Yuan, X. Li, G. Wang, Z. Zhu, Y. Liao, Z. Zhang, B. Liu, Efficient hydrogenation of *N*heteroarenes into Nheterocycles over MOF-derived CeO<sub>2</sub> supported nickel nanoparticles. *Mol. Catal.***540**, 113052 (2023).

16] F. Alonso, P. Riente, M. Yus, Nickel nanoparticles in hydrogen transfer reactions. *Acc. Chem. Res.***44**, 379–391 (2011).

17] A. Pérez Alonso, S. Mauriés, J. B. Ledeuil, L. Madec, D. Pham Minh, D. Pla, M. Gómez, Nickel nanoparticles immobilized on pristine halloysite: An outstanding catalyst for hydrogenation processes. *ChemCatChem***14**, e202200775 (2022).

J. H. Advani, K. Ravi, D. R. Naikwadi, H. C. Bajaj, M. B. Gawande, A. V. Biradar, Biowaste chitosanderived N-doped CNT-supported Ni nanoparticles for selective hydrogenation of nitroarenes. *Dalton Trans.* 49, 10431–10440 (2020).
M. Klarner, S. Bieger, M. Drechsler, R. Kummer, Characterization and the selection of the selectio

Kempe, Chemoselective hydrogenation of olefins using a nanostructured nickel catalyst. Z. Anorg. Allg. Chem. 647, 2157–2161 (2021).

20] G. Hahn, J.-K. Ewert, C. Denner, D. Tilgner, R. Kempe, A reusable mesoporous nickel nanocomposite catalyst for the selective hydrogenation of nitroarenes in the presence of sensitive functional groups. *ChemCatChem***8**, 2461– 2465 (2016).