Study of catalyst synthesizing using gas phase deposition of active metal on g-C3N4 Nano sheets support for furfural hydrogenation

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INTRODUCTION or ABSTRACT

Biomass is one of the most abundant and cost-effective non-fossil carbon sources and is referred to as a sustainable carbon source. Furfural with the chemical formula of $C_5H_4O_2$ is produced from agricultural biomass containing cellulose and lingenine by using various solvents and catalysts. The high amount of oxygen in furfural causes instability and undesirable storage properties in it. Furfural hydrogenation to furfuryl alcohol is one way to prevent this undesirable instability. Although the use of copper-chromium catalyst has been widely used in the past, the high toxicity of chromium and the resulting environmental problems prevent the widespread use of this metal and make finding a new metal a major challenge. In this research, Ni/g-C_3N_4 catalysts have been synthesized by using a novel method of activate-metal gas-deposition. In this synthesis method, first, the CO gas passes through a 15% Ni/SiO_2 substrate (synthesized by the impregnation method) and leads to the production of $Ni(CO)_4$ gas. The generated nickel carbonyl gas, after production in the first part of the reactor, is transferred to the next reactor bed and passed through the g-C_3N_4 and the Ni/g-C_3N_4 catalyst is produced by depositing the nickel gas phase. Obtaining the best amount of nickel loading on the catalyst support and finding the optimum temperature of the second region of the reactor was determined by ICP analysis of the synthesized catalysts. The results indicate that the optimum temperature leads to 9.3% nickel loading. Properties and structure of catalytic samples were evaluated using X-ray diffraction (XRD) analysis. The activity of these catalysts for the furfural hydrogenation reaction in the gas phase was evaluated. 4hr-Ni/g-C_3N_4 catalyst has the best performance with the conversion of 80.2% and selectivity of 99.9% at the temperature of 230℃, atmospheric pressure, feed with the concentration of 5 volume% furfural in isopropanol solvent and inlet flow rate of 3.8 ml/h.

OBJECTIVES

The aim of this study is to first fabricate an active and selective catalyst for the selective furfural hydrogenation process to produce furfuryl alcohol. Also the study of the effect of catalyst synthesis method and the support structure of the catalyst and the effect of nickel metal loading on the activity and selectivity of the catalyst is one of the main objectives of this research.

MATERIALS & METHODS

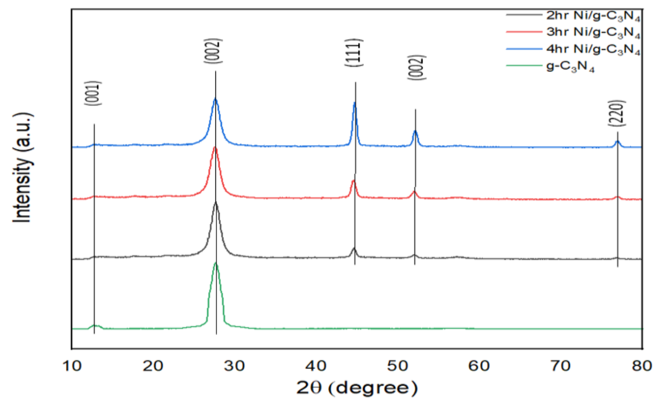
Urea (Merk) for g-C3N4 synthesis by thermal method.

Silica (Merk), Ni(NO3)2.6H2O (Merk) for Ni/SiO2 synthesis by dry impregnation method.

RESULTS

The nickel index peaks at 2ɵ 44.6, 51.9, and 76.4 ° correspond to the crystal plates (111), (200), (220), respectively. The low intensity peak at 76.4 ° is according to ICCD 00-004-0850 code and has FCC structure. The peak at 44.6 and 51.9 ° is according to JCPDS 085-04 code. As the loading amount of nickel metal increases, the intensity of nickel-related peaks increases.

Also, after the addition of nickel, the peak intensity of tri-s-traizin decreases and the peak in the 27.57 region also decreases.



figur1. XRD for g-C_3N_4 2hr Ni/ g-C_3N_4 3hr Ni/ g-C_3N_4 4hr Ni/ g-C_3N_4

In order to evaluate the performance of the synthesized catalysts, after performing the conversion test, the collected samples were injected into the gas chromatography device, the results of which are given in Table 1.

Table 1

Selectivity (%)	Conversion (%)	sample
≈99	2	g-C_3N_4
≈99	54.54	2hr Ni/ g-C_3N_4
≈99	74.76	3hr Ni/ g-C_3N_4
≈99	80.2	4hr Ni/ g-C_3N_4

As can be seen in the table above, bulk support has almost no activity without metal loading, so the loading of metal is active and the catalytic conversion is affected by this factor in advancing the reaction.

CONCLUSIONS

- **By using this method, a catalyst was synthesized that could perform well in the furfural hydrogenation process.**
- **The best temperature for catalyst fabrication was 175℃.**
- **The best performance of the catalyst was at 230℃.**
- **The best performance was shown by 4hr Ni / g-C3N4 catalyst with 80.2% efficiency and 99% selectivity.**

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