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Effect of gas dilution on synthesis of carbon nanotubes in a chemical vapor deposition over Cobalt Ferrite catalyst

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***Abstract*— This study investigates the effect of carbonous gas dilution on the production of carbon nanotubes in a chemical vapor deposition process. Carbon nanotubes have been prepared when the ratio of the CH_4 to N_2 is 3:1, However when the N_2 dilution is increased and the ratio of the CH_4 to N_2 is equal ,3:3 , Carbon nano tubes isn't formed and only some carbon chunk is deposited on the $CoFe_2o_4$ catalysts.**

***Index Terms*— CNTs, gas ratio, chemical vapor deposition, cobalt ferrite**

I. INTRODUCTION

Carbon Nano Tubes were discovered by Iijima [1] in 1991, they discovered multi-walled carbon nanotubes (MWCNT) in 1991.Among the forms of nano carbons, multi walled , singled walled and recently graphene are popular materials[2]. Carbon nanotubes are considered as wonderful materials due to their unique electrical, mechanical, and chemical properties[3]. Numerous methods have been carried out to produce carbon nano tubes, such as arc discharge, Plasma enhanced chemical vapor deposition, laser ablation, chemical vapor deposition, and High-Pressure CO Conversion production[4] and also CO_2 decomposition[5] . In a CVD method CNTs are produced from the carbonous gaseous source as it decomposes at elevated temperature and passes over a transition metal catalyst [6]. Transition metals such Fe, Co, Ni in form of their mono metallic or bi and tri metallic are usually used for production of carbon nanotubes[7]. Different factors affect the production of carbon nanotubes, such catalyst size[8], and use of support[9], calcination of the catalyst[10] and also gas composition and ratios[11].
In this work we report production of carbon nanotubes by different ratio of CH_4:N_2 gas on $CoFe_2O_4$ catalyst.

II. METHODOLOGY

The methodology of catalyst preparation is modification of work by Allaedini et al[12], (Co $(NO_3)26H_2O$), ferric nitrate nano-hydrate (Fe $(NO_3)_39H_2O$), and NaOH were used as precursors and dissolved in deionized water with a molar proportion of Fe/Co = 2 (50 ml). An aqueous solution of 1 M NaOH was used as the precipitating agent. The as prepared metal nitrate solutions were added to the boiling solution of 2 M NaOH (25 ml) at 150 C. The obtained solution was stirred for 2 h while at 150 C. They were transferred to centrifuge and then washed 3 times with ethanol and after that dried at 200 C. In order to obtain CNTs, 2 g of the obtained catalysts were placed in the CVD reactor and heated in the presence of N2 up to 500 °C, then purged with H_2 and maintained for 2 hour at 600 °C. The reactor was then heated up again to 1000 °C in the presence of N_2. Once the temperature was stabilized at 900 °C, the methane gas was introduced with a flow rate of 600 ml/min for 3 hours. At this step the dilution was done in order to see the effect of dilution. In one experiment the ration of CH_4 to N_2 was 3:1 and in the other one 3:3. The reactor was then cooled down while passing N_2 gas for 1 hour. The samples were collected and sent for analysis.

III. CHARACTERIZATION

The SEM Image of the FeCo3 has been shown in figure 1. As can be seen the morphology of the catalyst is spherical illustrating the presence of cobalt and iron sphere.

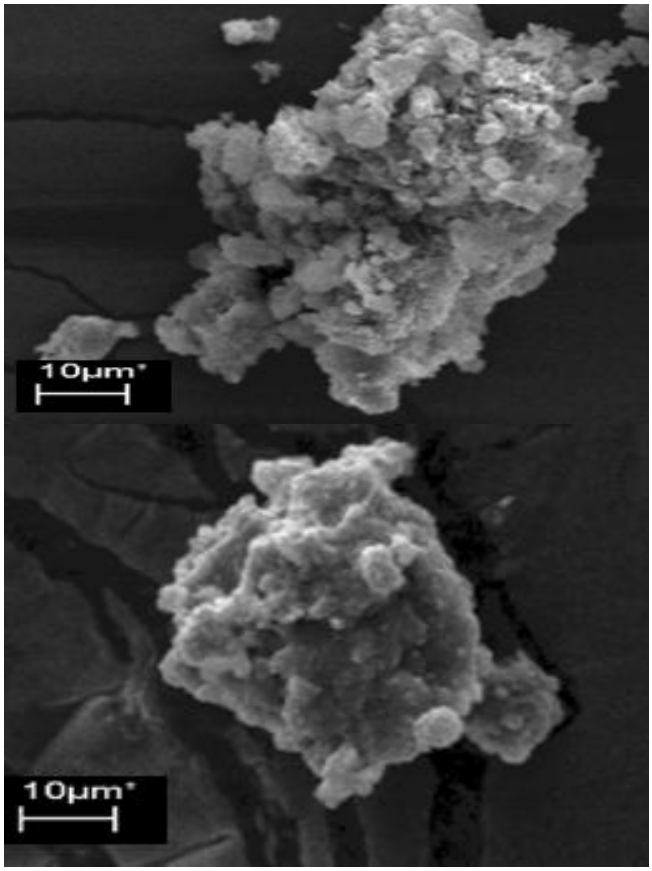

Figure 1- SEM images of the Cobalt Ferrite Catalysts

The XRD image of the catalyst is shown in figure 2. The XRD calculated crystalline size was 46 nm by Scherer formula:

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$D = K\lambda/\beta\cos\theta$, -Equation 1

Where D is the crystalline size (nm), K is the Scherrer constant equal to 0.89, λ is the radiation wavelength (nm), β is the observed peak width, and θ is the diffraction angle.

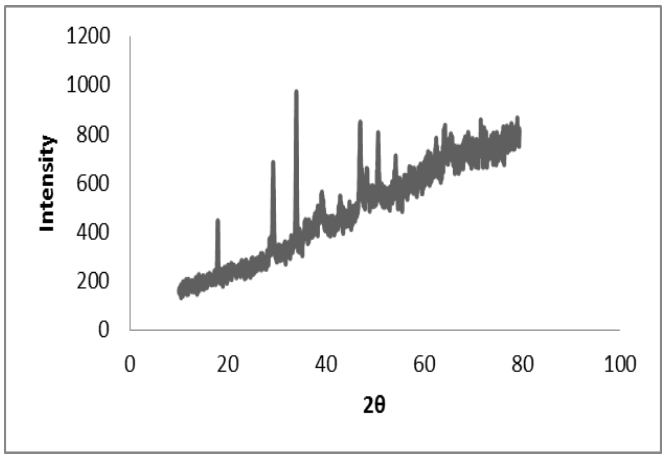

Figure 2-XRD result of cobalt ferrite catalysts

Figure 3 shows the obtained carbon chunk and carbon nano tubes after the reaction for the ratio of 3:3 and 3:1 respectively. When the ratio of the N_2 and CH_4 is equal no carbon nanotube is formed and only some carbon is deposited as form of chunk , however when the ratio of the CH_4 is higher than N_2 , carbon formed in the nano tubes morphology.

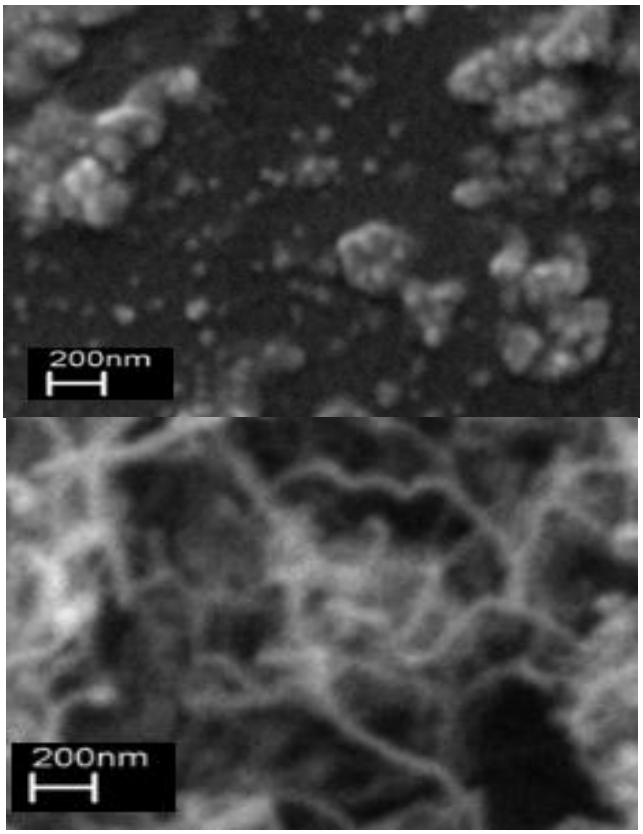

Figure 3- SEM images of the carbon chunk (on the left) and carbon nano tubes (on the right)

IV. Conclusion

In this work cobalt ferrite catalyst were synthesized and characterized for synthesis of carbon nano tubes. The crystallinity of the catalyst and their morphology were examined as spherical. The effect of methane to nitrogen ration was observed and it was found that if the ratio of these two gases are equal no carbon nanostructure forms, however when methane gas ratio to nitrogen is higher carbon nano tubes forms. This result confirms that methane flow rate plays a vital role in production of carbon nano tubes.

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