

Optimization of 3%AgCuMn₈O_x loading on γ -Al₂O₃ support

9. General

The success of Cu₁Mn₈ catalyst has encouraged a big deal of simple work dedicated to useful the role played by each element and the nature of active sites. The novel redox method permitted for the preparation of amorphous Cu₁Mn₈ catalyst with high surface areas and high activity for CO oxidation at a low temperature [Njagi *et al.*, 2010]. In the CO oxidation process, the oxygen is initially adsorbed on Cu₁Mn₈ catalyst surface with the energy of activation [Kondrat *et al.*, 2011]. When the temperature is reach sufficient amount so that the adsorption of oxygen reaches enough proportions, therefore the CO passing over the catalyst surfaces either reacts openly with the adsorbed oxygen or else is primary adsorbed and then reacts, after which the CO produced being desorbed [Lee *et al.*, 2016; Solsona *et al.*, 2004]. The support has a strong influence on the activity of resulting catalysts. The main idea of this study to obtain more information about γ -Al₂O₃ supported 3%AgCuMn₈O_x catalyst and evaluates the possibility of their practical application in CO oxidation. It is recognized that the phase composition and reduction properties of mixed 3%AgCuMn₈ Ox / γ -Al₂O₃ catalysts depended on the Cu/Mn molar ratio.

The 3%AgCuMn₈O_x catalyst has shows a good performance for CO oxidation and cheaper than the precious metal catalysts, it could be made more cheaper using gamma-alumina (γ -Al₂O₃) support without sacrifice their performance in the reaction [Jones *et al.*, 2006]. The presence of abundant large pores and large surface area in γ -Al₂O₃ support, it has to make a great potential to further improving their performance for CO

oxidation. The adding of γ -Al₂O₃ support into the 3%AgCuMn₈Ox catalyst has improved to enhance their dispersion capacity and makes the 3%AgCuMn₈Ox/ γ -Al₂O₃ catalyst different from the unsupported 3%AgCuMn₈Ox catalysts. It indicates that there exists strong interaction between the copper, manganese, silver oxide and γ -Al₂O₃ support.

The effect of γ -Al₂O₃ dispersion on the active states and reduction behavior of surface supported 3%AgCuMn₈Ox catalysts have been investigated by the XRD, FTIR, SEM-EDX and BET analysis. The characterization results confirmed that the Cu⁺, Mn²⁺, Ag and Al mostly existed on the effective surface sites of the 3%AgCuMn₈Ox/ γ -Al₂O₃ catalysts. These results indicate that there is a synergistic interface between the copper, manganese, silver and aluminum oxide, which is responsible for the high catalytic activity of CO oxidation. The alumina wash-coated monolith has been widely used in a TWC converter. However, a little attention has been paid on the alumina supported Cu₁Mn₈ catalyst for CO oxidation [Rattan *et al.*, 2012]. Further, it is recognize that the method of preparation of catalysts determines the dispersion and size distribution of metal crystallites. The spatial division of support effect on the homogeneity of components and the morphology, etc. which in turn strongly affect the catalyst activity [Qin *et al.*, 2010]. The present work was undertaken to search the significance of preparation methods on the morphology and the performance of gama-alumina (γ -Al₂O₃) supported 3%AgCuMn₈Ox catalyst for CO oxidation.

9.1 Experimental

9.1.1 Catalyst preparation

Gamma alumina (γ -Al₂O₃) support was prepared via hydrothermal synthesis in to two steps (Figure 9.1). Initially, the bohemite is prepared by precipitation of Al(NO₃)₃.9H₂O solution with aqueous 12.5% NH₃ solution at pH 8.5. Later, the precipitates were

directly transported to an autoclave at 121°C and 15 psig for 6 hours. After autoclave the precipitate washed free of anions. The washed precipitates (bohemite) AlOOH were thermally decomposed at 600°C calcined for 24 hours to form γ -Al₂O₃. The following reactions (9.1-9.3) occur in the preparation of γ -Al₂O₃:



Figure 9.1: Steps involved in support synthesis

The prepared γ -Al₂O₃ supported Cu-Mn system was synthesized by co-precipitation deposition method. The γ -Al₂O₃ of fraction size (0.6-1.0mm) was used as a support. Different, 10-50% loading of 3%AgCuMn₈Ox over γ -Al₂O₃ was prepared.

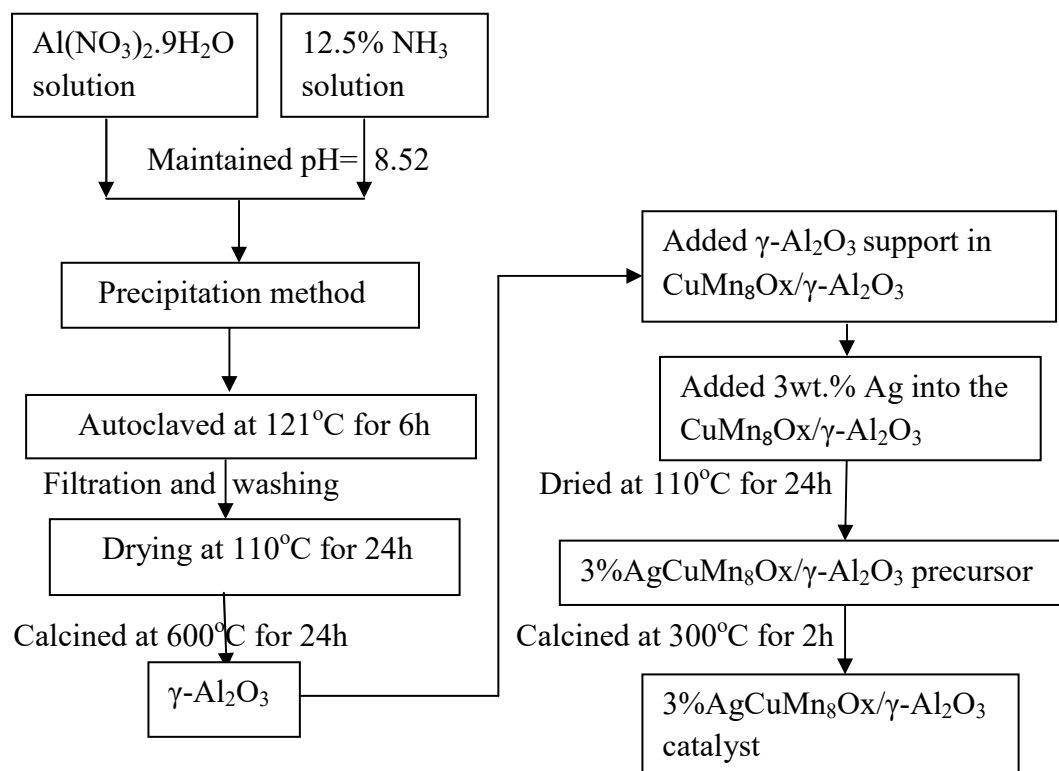
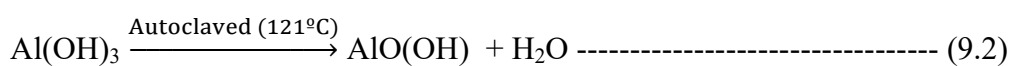
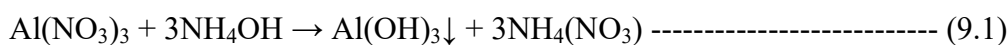


Figure 9.2: Preparation of γ -Al₂O₃ supported 3%AgCuMn₈Ox catalysts

The required amount of γ -Al₂O₃ was suspended in the KMnO₄ solution and co-precipitation deposition was carried out by adding drop wise mixed solutions of copper nitrate and manganese acetate in molar ratio of 1:8 with constant stirring for 2hr. The precipitate was filtered and washed times with hot distilled water to remove all the anions. The solid obtained was dried at 110°C for 24h into an oven. 3%Ag using required amount of silver nitrate solution was sprayed mixed thoroughly in the dried solid followed by calcination by FA method. The nomenclature of the 3%AgCuMn₈Ox/ γ -Al₂O₃ catalysts thus obtained after calcination process was given in Table 9.1.



Bohemite

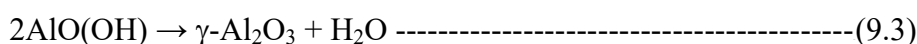


Table 9.1: Nomenclature of prepared catalysts

Catalyst Name	Nomenclature
3%AgCuMn ₈ Ox supported 90% γ -Al ₂ O ₃	3%AgCuMn ₈ Ox/90% γ -Al ₂ O ₃
3%AgCuMn ₈ Ox supported 80% γ -Al ₂ O ₃	3%AgCuMn ₈ Ox/80% γ -Al ₂ O ₃
3%AgCuMn ₈ Ox supported 70% γ -Al ₂ O ₃	3%AgCuMn ₈ Ox/70% γ -Al ₂ O ₃
3%AgCuMn ₈ Ox supported 60% γ -Al ₂ O ₃	3%AgCuMn ₈ Ox/60% γ -Al ₂ O ₃
3%AgCuMn ₈ Ox supported 50% γ -Al ₂ O ₃	3%AgCuMn ₈ Ox/50% γ -Al ₂ O ₃

9.2 Catalyst Characterization

Characterization of the supported and unsupported 3%AgCuMn₈Ox catalyst reveals the morphology, surface structure, phase identification, material identification and surface area etc. All the catalysts prepared in flowing air calcination (FAC) conditions were done by the different techniques was discussed below.

9.2.1 Morphological analysis

The textural property of the supported and unsupported 3%AgCuMn₈Ox catalyst was analyzed by the scanning electron microscopy (SEM) technique. All the catalysts were prepared under flowing air calcination conditions (Figure 9.3) shows clearly large differences in the microstructure and morphology of the resulting catalysts. As seen in the SEM micrograph the particles presence in a catalyst samples were comprised, of coarse, fine and finest size grains resulted by flowing air calcination of γ -Al₂O₃, 3%AgCuMn₈Ox/60% γ -Al₂O₃ and 3%AgCuMn₈Ox catalyst respectively.

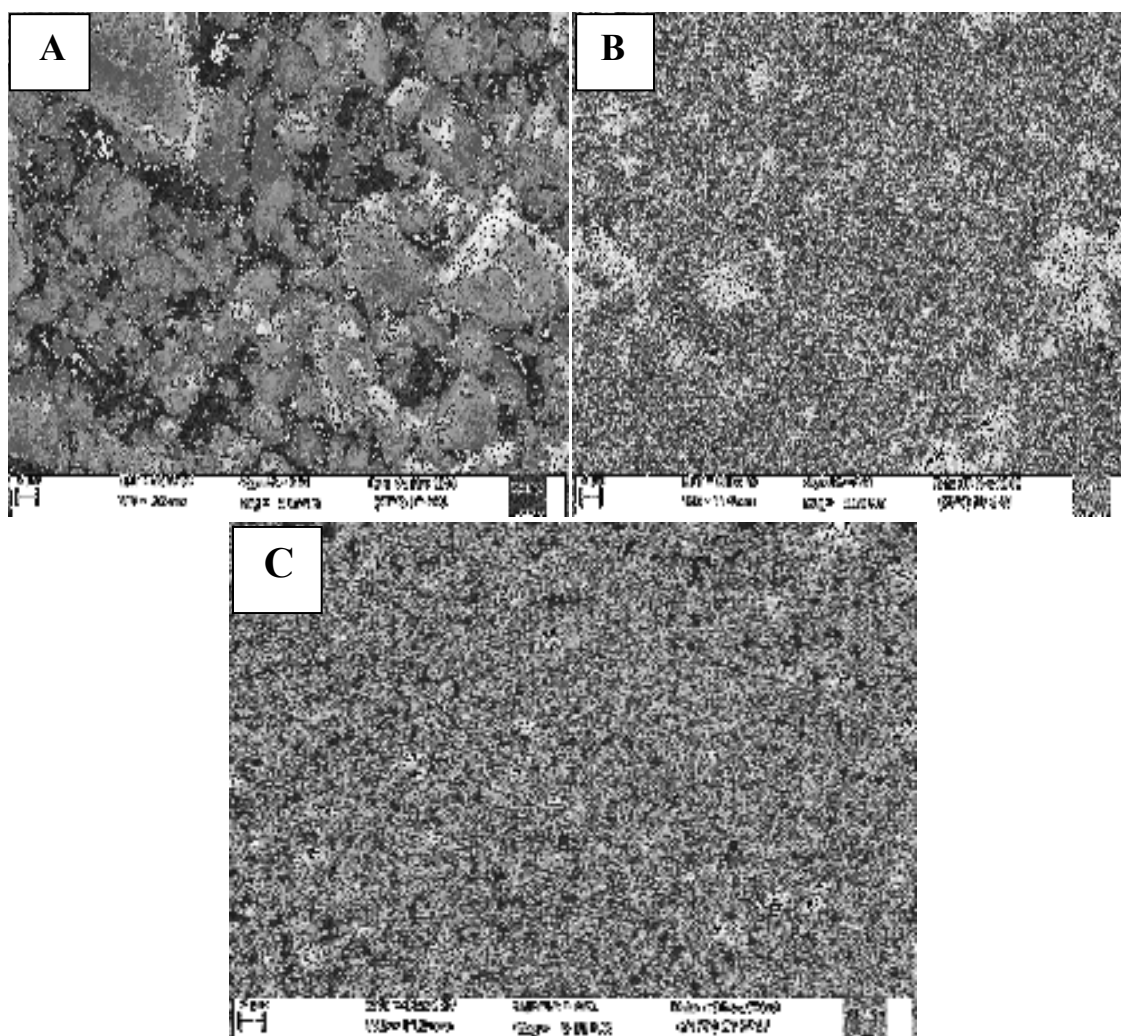


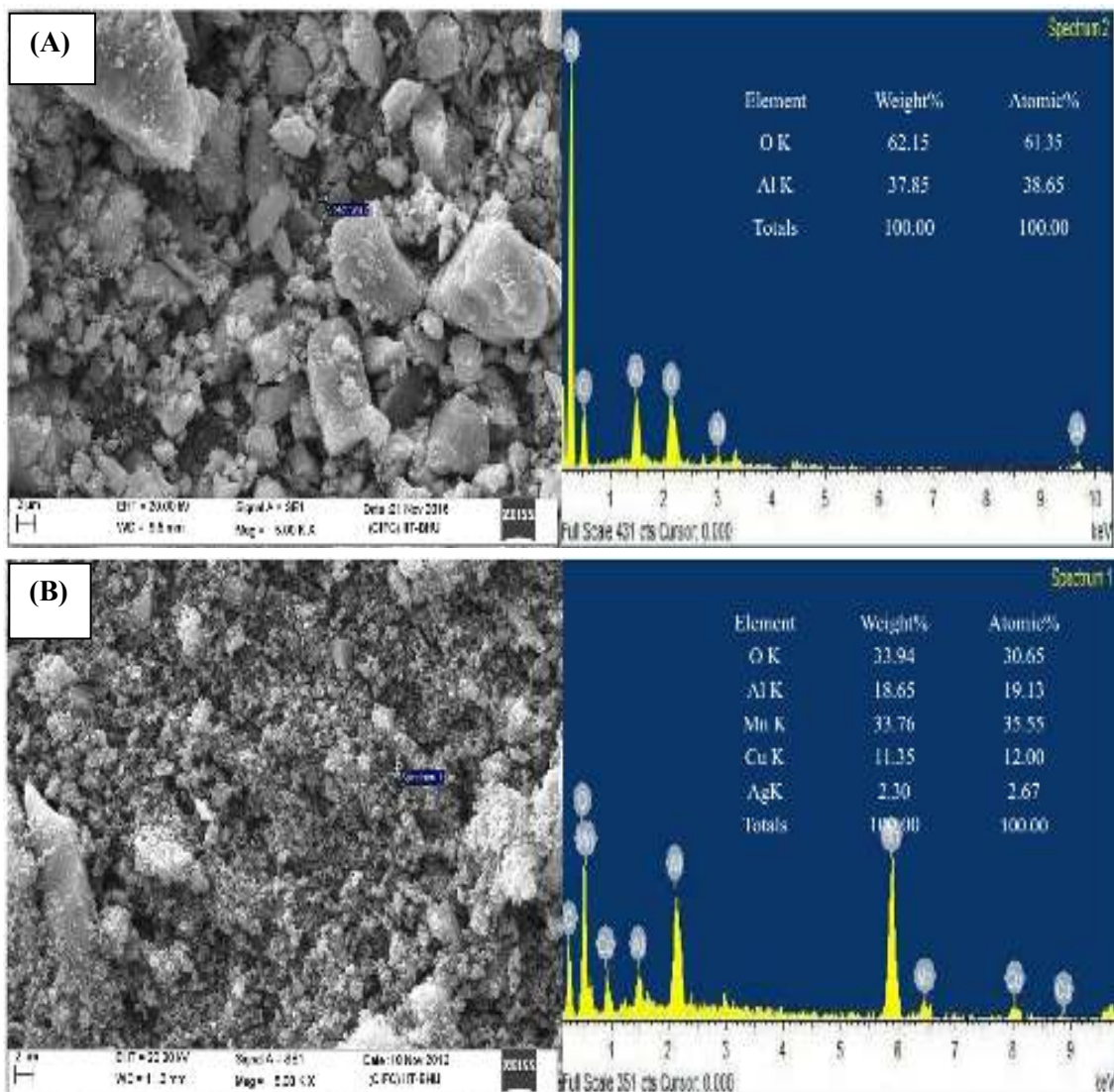
Figure 9.3: SEM image of (A) γ -Al₂O₃, (B) 3%AgCuMn₈Ox/60% γ -Al₂O₃ and (C) 3%AgCuMn₈Ox

Particles of 3%AgCuMn₈Ox catalyst has least agglomerated, more porous, high surface area and uniformly distributed. The smaller size particles present in a 3%AgCuMn₈Ox catalyst has more efficient for CO dispersed on their surfaces. The surface reform behavior of different size of particles present in a 3%AgCuMn₈Ox/60% γ -Al₂O₃ and 3%AgCuMn₈Ox catalyst surfaces during the prolong exposure of CO gas. The size of particles present in γ -Al₂O₃ support was relatively larger, agglomerated and irregular shape as compared to those in 3%AgCuMn₈Ox/60% γ -Al₂O₃ and 3%AgCuMn₈Ox catalysts. The fine white and grey crystals clearly indicated that the γ -Al₂O₃ support was present in the metallic and oxide form at a higher magnification. The SEM results were also in good agreement with that of the XRD findings. In the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst, the synergetic effect depends on the catalyst composition and the nature of oxidized compound.

9.2.2 Elemental analysis

In the 3%AgCuMn₈Ox, γ -Al₂O₃ and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst samples, the percentages of different elements were present analysis by the energy dispersive X-ray (EDX) analysis. The results of energy dispersive X-ray analysis (EDX) has showed that all the samples of γ -Al₂O₃, 3%AgCuMn₈Ox/60% γ -Al₂O₃ and 3%AgCuMn₈Ox were pure due to the presence of their relative element peaks only as illustrated in Figure 9.4. To understand the influence of γ -Al₂O₃ support on the activity and stability of the promoted 3%AgCuMn₈Ox catalysts towards CO oxidation, by EDX characterization technique have been carried out. It was clear from the EDX analysis that the atomic percentage of Mn was also higher than the Cu, Al, and O in the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst. The γ -Al₂O₃ support was associated with 3%AgCuMn₈Ox catalyst promotes the oxygen storage, release and enhanced the oxygen mobility. The oxygen content of the 3%AgCuMn₈Ox catalyst was least as comparison to the other catalyst

samples. This indicates the presence of oxygen deficiency in the 3%AgCuMn₈Ox catalyst which makes the high density of active sites so that it was oxidized more CO into CO₂. The atomic ratio of Cu/Mn in 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst was approximately 0.253 and 0.337 respectively, and the weight ratio of Cu/Mn in 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst was approximately 0.220 and 0.336 respectively.



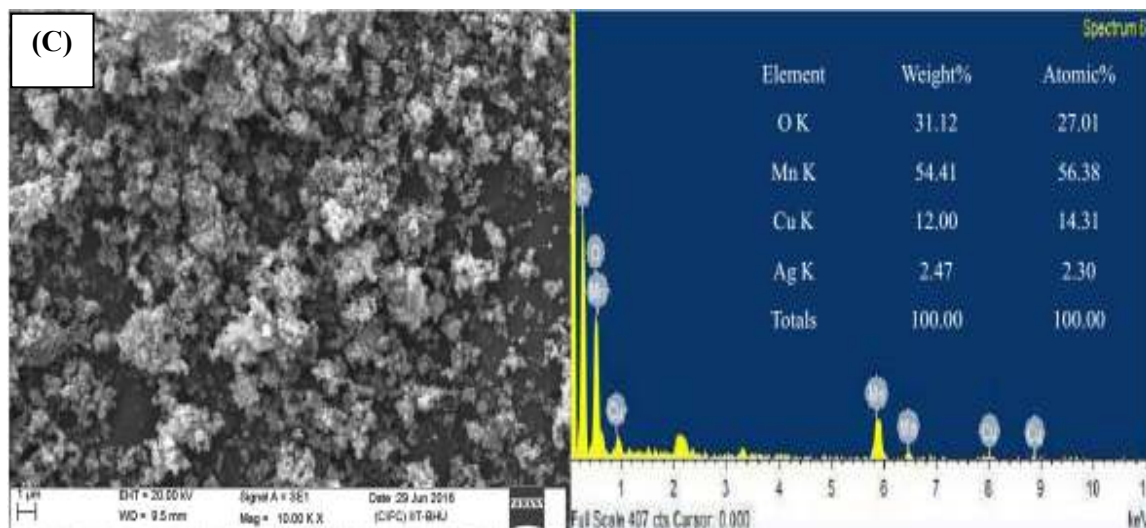


Figure 9.4: SEM-EDX image of (A) γ -Al₂O₃, (B) 3%AgCuMn₈Ox/60% γ -Al₂O₃ and (C) 3%AgCuMn₈Ox

The γ -Al₂O₃ support has a high surface area and produced during the calcination process. It also exhibits the high thermal stability and possesses too high cation vacancy which assists the interactions of 3%AgCuMn₈Ox catalyst. It was an important redox property of 3%AgCuMn₈Ox catalyst, which highly influenced by their interactions with the support.

9.2.3 Phase identification and cell dimensions

X-ray diffraction (XRD) study was carried out to identify the phases and crystallite size present in the catalysts. The XRD peak of γ -Al₂O₃, 3%AgCuMn₈Ox/60% γ -Al₂O₃ and 3%AgCuMn₈Ox samples prepared under flowing air calcination conditions as shown in the Figure 9.5. XRD pattern of the 3%AgCuMn₈Ox catalyst diffraction peak at 2θ was 37.20 corresponds to its lattice plane (110) of face-centered cubic. The main phase was found to be CuMn(AgO) form with the crystallite size of the catalyst was 2.423 nm. The γ -Al₂O₃ support structure was found to be cubic in nature, was called a defect cubic spinel structure with vacancies on Al (III) positions with the crystallite size in the range 5.0–10.0nm. Each cell unit contains 32 oxygen and 64/3 Al(III) to fulfill the

stoichiometry. Al (III) ions occupy both the octahedral and tetrahedral positions by the relative partial occupancy in each position. XRD pattern of the 3%AgCuMn₈Ox/ 60% γ -Al₂O₃ catalyst diffraction peak at 2θ was 36.50 corresponds to face-centered cubic Cu_{1.5}Mn_{1.5}O₄ and γ -Al₂O₃ support (PDF-24-0735 JCPDS file). The crystallite size of the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts was 4-6.5 nm. The sharpness of the peaks also indicates that the CuO particles were highly crystalline and broadness of the peaks showed poor crystallization of Mn₂O₃ with the presence of defects in the crystal structure.

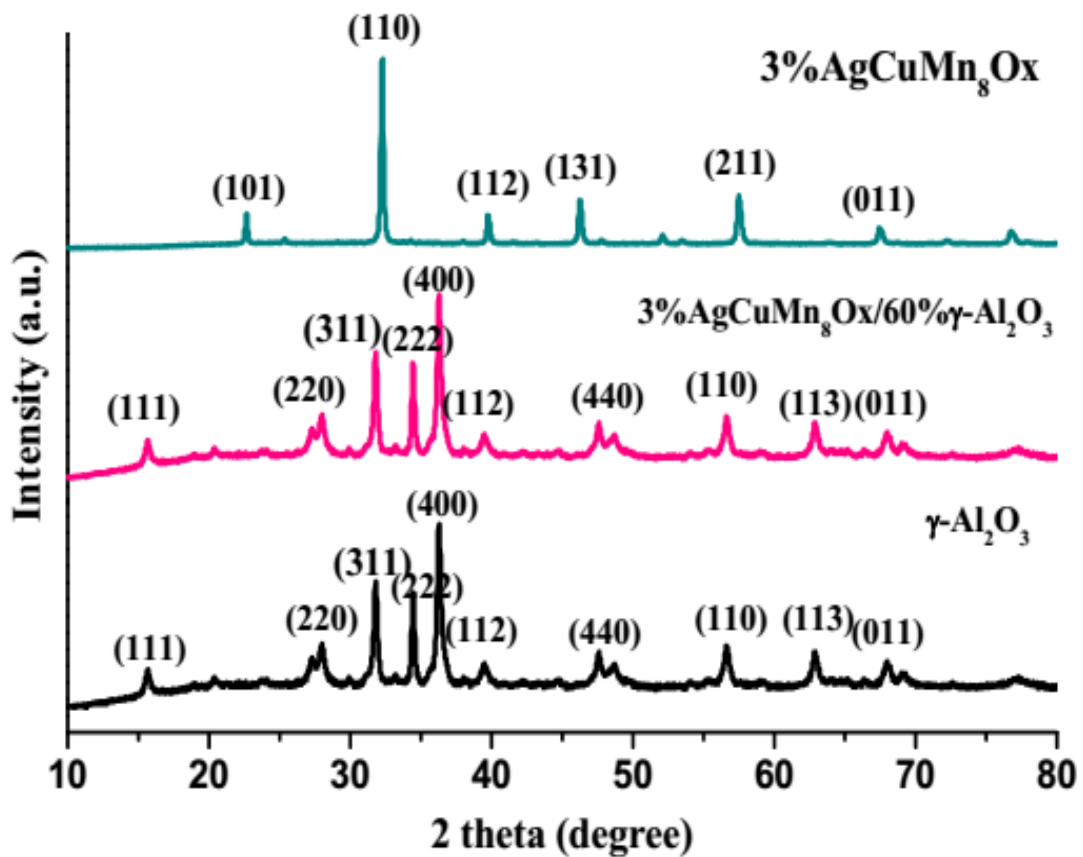


Figure 9.5: XRD analysis of γ -Al₂O₃, 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃

There were no crystalline MnOx phase was observed in 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst, implying that MnOx species may be single layer dispersive on γ -Al₂O₃ surfaces or may be created small clusters with a high amount of dispersion, which

cannot be detected by XRD. The poor crystalline structure of MnOx may favor structural defects formation, in particular, oxygen vacancies giving the best activity for CO oxidation.

9.2.4 Identification of the materials presence in a Catalyst

Identification of the metal-oxygen bonds present in the 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst was made by the Fourier transform infrared spectroscopy (FTIR) analysis. The different peaks were shown, various types of chemical groups present in the 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts at the invested region (4000–400cm⁻¹).

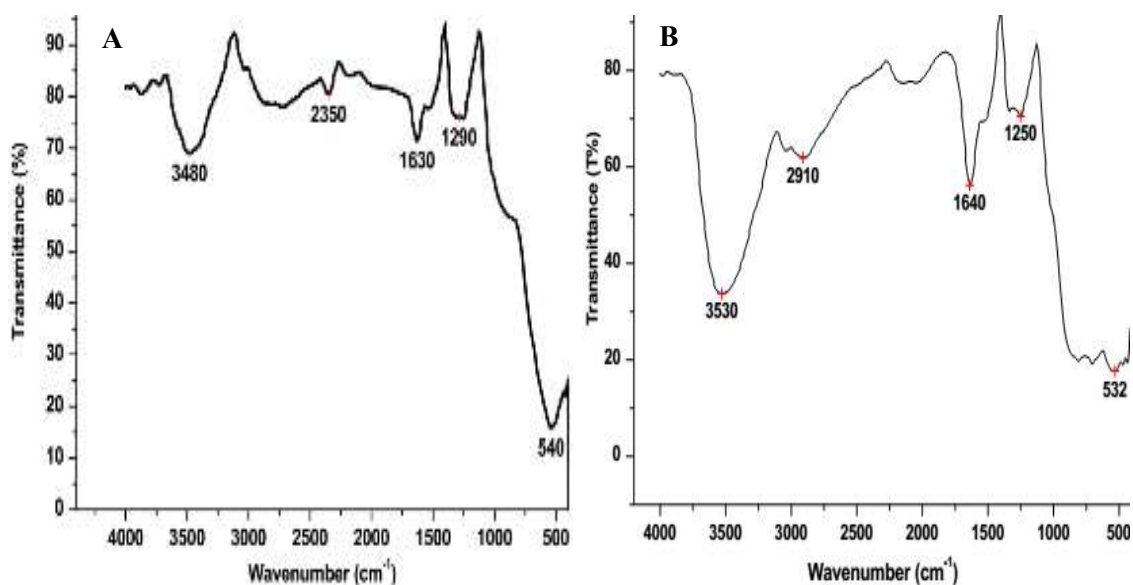


Figure 9.6: FTIR analysis of (A) 3%AgCuMn₈Ox/60% γ -Al₂O₃ and (B) 3%AgCuMn₈Ox catalysts

FTIR spectra of the catalyst prepared under flowing air calcination conditions were shown in Figure 9.6. In the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst (3530cm⁻¹) peak represent the presence of –OH group, (2910cm⁻¹) CuO group, (1250cm⁻¹) CO₃²⁻ group, (532cm⁻¹) AlO₂ group and (1640cm⁻¹) Mn₂O₃ group. In the flowing air calcination prepared 3%AgCuMn₈Ox catalysts; which originate from the stretching vibrations of

the metal-oxygen bond and confirms the presence of CuO and Mn₂O₃ phases. The 3%AgCuMn₈Ox catalyst at the transmittance conditions, there were total five peaks we obtained, the IR band (1630cm⁻¹) has shown the presence of Mn₂O₃ group, (3480cm⁻¹) -OH group, (540cm⁻¹ and 2350cm⁻¹) CuO group and (1290cm⁻¹) AgO₂ group. The spectra of impurities like hydroxyl (-OH) group at (3530cm⁻¹) decreases in the following order: 3%AgCuMn₈Ox/60% γ -Al₂O₃ > 3%AgCuMn₈Ox. Thus, the 3%AgCuMn₈Ox catalyst was highly pure as compared to the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst.

9.2.5 Surface area measurement

The surface area of supported and un-supported 3%AgCuMn₈Ox catalyst sample was analysis by the Brunauer Emmett Teller Analysis (BET) technique. The surface area, pore volume and pore size of 3%AgCuMn₈Ox, γ -Al₂O₃ and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts were presented in the Figure 9.7 and mentioned in the Table 9.2.

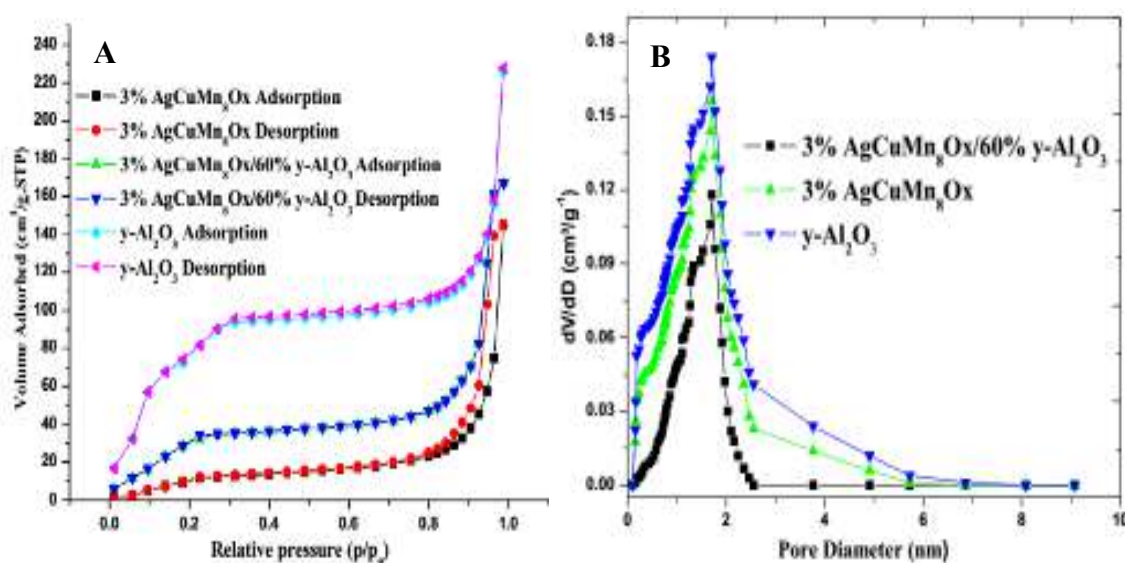


Figure 9.7: Textural properties of (A) N₂ adsorption-desorption isotherms and (B) Pore size distributions curves

The average pore volume and pore size of the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst was 0.695cm³/g and 60.65Å respectively. All the catalysts were prepared in flowing air calcination conditions. It can be visualized from the Table 9.2 that the pore volume and

pore size of γ -Al₂O₃ support was higher than the other catalysts. The slope and height of the steps were clear indications of very well definite mesopores with narrow size pore distribution. Total pore volume and specific surface area which were two major factors which can affect the catalytic activity for CO oxidation. The surface area was a key parameter in determining the catalyst activity for CO oxidation. Average pore diameter of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst has also increased with the increasing of γ -Al₂O₃ support in the 3%AgCuMn₈Ox catalyst. Clearly, the textural property of 3%AgCuMn₈Ox catalyst was also highly active for CO oxidation at a low temperature.

Table 9.2: The surface area, pore volume and pore size of the catalysts

Catalyst Name	Surface Area (m ² /g)	Pore Volume (cm ³ /g)	Pore Size (Å)
γ -Al ₂ O ₃	212.76	0.730	51.70
3%AgCuMn ₈ Ox/ 60% γ -Al ₂ O ₃	171.76	0.695	60.65
3%AgCuMn ₈ Ox	129.76	0.676	68.45

Considering the close similarity values of pore volume and pore diameter for both the 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts, the results can be interpreted as affirmation that the specific surface area of the catalysts was not only the main factor in the CO oxidation on γ -alumina supported 3%AgCuMn₈Ox catalysts, mainly in the outline of our experiments. The specific surface area was measured by BET analysis and it was also follows the SEM and XRD results. Typical nitrogen adsorption/desorption isotherms of these catalysts with hysteresis loop showing catalysts were mesoporous according to De-Boer classification. The 3%AgCuMn₈Ox catalyst surface areas of similar magnitude regardless of the preparation atmosphere; however, there was a general increase in surface area as a result of increased γ -Al₂O₃

percentages. From this BET characterization we have confirmed that the synthesized, of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst by the deposition-precipitation method was an appropriate approach for the development of catalysts with enhanced catalytic activity toward CO oxidation.

9.3 Catalyst performance and activity measurement

Activity measurement of the catalyst was carried out to evaluate the effectiveness of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts as a function of temperature. It was evaluated in flowing air calcination conditions. The improved catalytic activity of the catalysts can be ascribed to the unique structural, textural characteristics and the smallest crystallite size.

9.3.1 Optimization of metals loading on γ -Al₂O₃

The γ -Al₂O₃ support has a strongly influence on the activity of resulting catalyst. Effect of different percentages of γ -Al₂O₃ support into the 3%AgCuMn₈Ox catalysts has also measured for CO oxidation. The γ -Al₂O₃ support was not chemically inactive, and the metal-support interactions can promote or retard the catalytic processes. The co-precipitation involves dissolving both the support and the active phase salts in the same solution, via a pH control. Also, the active phase presence in materials may be precipitated inside the support. For this reason, this method was used for γ -Al₂O₃ support with a metal loading up to 10% or higher. The metals loading on γ -Al₂O₃ were carried out by the deposition-precipitation method to prepare 3%AgCuMn₈Ox/Z% γ -Al₂O₃ catalysts (Z=0, 10, 20, 30, 40, 50). Figure 9.8 shows that the activity test of various 3%AgCuMn₈Ox/Z% γ -Al₂O₃ catalysts prepared in flowing air calcination conditions.

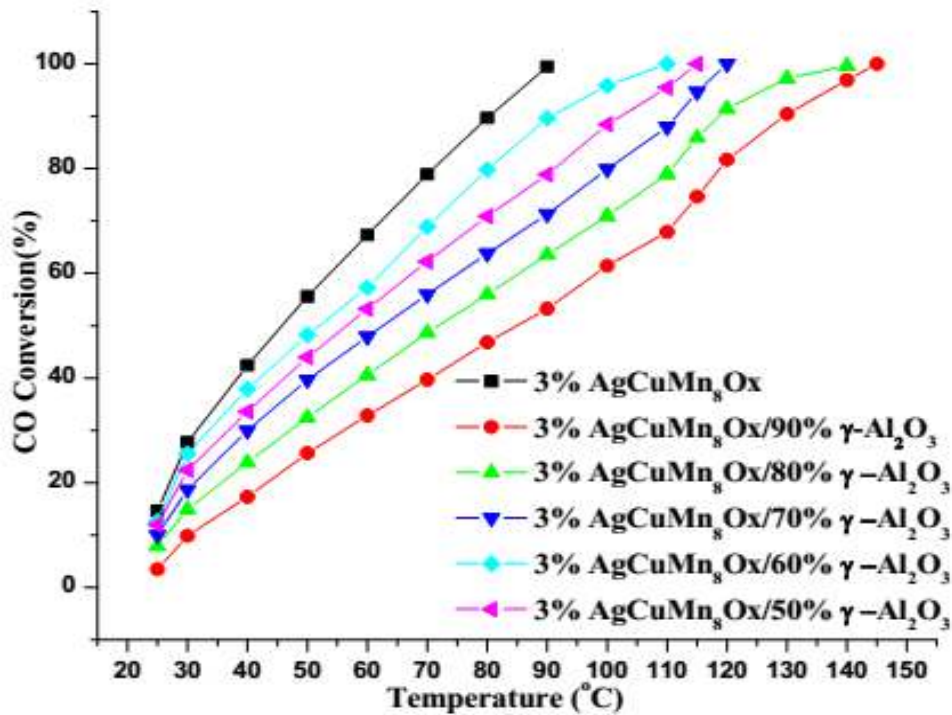


Figure 9.8: Effect of metal loading on γ -Al₂O₃ support for oxidation of CO

The oxidation of CO was initiated below 25°C overall all the catalysts. The complete oxidation temperature of CO was 88°C for 3%AgCuMn₈Ox catalyst, which was less by 57°C, 44°C, 33°C, 13°C and 27°C over than that of 3%AgCuMn₈Ox/90% γ -Al₂O₃, 3%AgCuMn₈Ox/80% γ -Al₂O₃, 3%AgCuMn₈Ox/70% γ -Al₂O₃, 3%AgCuMn₈Ox/60% γ -Al₂O₃ and 3%AgCuMn₈Ox/50% γ -Al₂O₃ respectively. It was evident from the Figure 9.8 that the activity of catalyst increased with increasing of metal loading upto 40% of 3%AgCuMn₈Ox on γ -Al₂O₃ support, with further increase of metal loading the activity was decreased. Thus, the optimum metal loading and support ratio of 3%AgCuMn₈Ox/Z% γ -Al₂O₃ catalyst was (3%AgCuMn₈Ox: γ -Al₂O₃=40:60). The γ -Al₂O₃ support has strongly influence on the activity of resulting 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst. The large pores size and surface area present in a γ -Al₂O₃ supported 3%AgCuMn₈Ox catalyst has a huge potential to improve their performance for CO oxidation.

Table 9.3: Activity test of supported and unsupported 3%AgCuMn₈Ox/ γ -Al₂O₃ catalysts

Catalyst	T ₁₀	T ₅₀	T ₁₀₀
3%AgCuMn ₈ Ox	<25°C	52°C	88°C
3%AgCuMn ₈ Ox/90% γ -Al ₂ O ₃	30°C	88°C	145°C
3%AgCuMn ₈ Ox/80% γ -Al ₂ O ₃	<25°C	82°C	132°C
3%AgCuMn ₈ Ox/70% γ -Al ₂ O ₃	<25°C	64°C	121°C
3%AgCuMn ₈ Ox/60% γ -Al ₂ O ₃	<25°C	51°C	101°C
3%AgCuMn ₈ Ox/50% γ -Al ₂ O ₃	<25°C	62°C	115°C

The light off characteristics for different percentage of γ -Al₂O₃ supported into 3%AgCuMn₈Ox catalyst used to evaluate the activity of resulting catalysts was tabulated in Table 9.3. The rising temperature was enlarge the specific surface area and pore volume of the 3%AgCuMn₈Ox/ γ -Al₂O₃ catalyst, and their activity for CO oxidation has been increased. These results showed that the nature of both 3%AgCuMn₈Ox catalyst and γ -Al₂O₃ support has a strongly influenced on the catalytic activity of 3%AgCuMn₈Ox/ γ -Al₂O₃ catalyst(s) for CO oxidation. In the beginning, the local rise in the temperature of the precursor's crystallites due to very slow exothermic oxidation which ensures very slow decomposition of the precursor then after, slightly faster CO oxidation has been observed. The γ -Al₂O₃ support was thermally very stable and withstands processes required to activate pre-catalysts.

9.3.2 Optimum percentage of metal loading on γ -Al₂O₃ support

The effect of metal loading on CO conversion at 101°C is shown in Figure 9.9. It is clear from the Figure 9.9 that the activity order of different catalysts for CO oxidation

was as follows: 3%AgCuMn₈Ox/60% γ -Al₂O₃ > 3%AgCuMn₈Ox/50% γ -Al₂O₃ > 3%AgCuMn₈Ox/70% γ -Al₂O₃ > 3%AgCuMn₈Ox/80% γ -Al₂O₃ > 3%AgCuMn₈Ox/90% γ -Al₂O₃. The higher catalytic activity of 3%AgCuMn₈Ox/60% γ -Al₂O₃ may open new avenues in searching for CO oxidation at an economical cost. The reason behind the excellent activity of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst for CO oxidation may be due to the presence of (Cu⁺, Mn²⁺ and Ag⁺) metal ions in the 3%AgCuMn₈Ox catalyst over γ -Al₂O₃ support. Due to the low reactivity with γ -Al₂O₃ support, the 3%AgCuMn₈Ox catalyst was comparatively very stable over γ -Al₂O₃ supports.

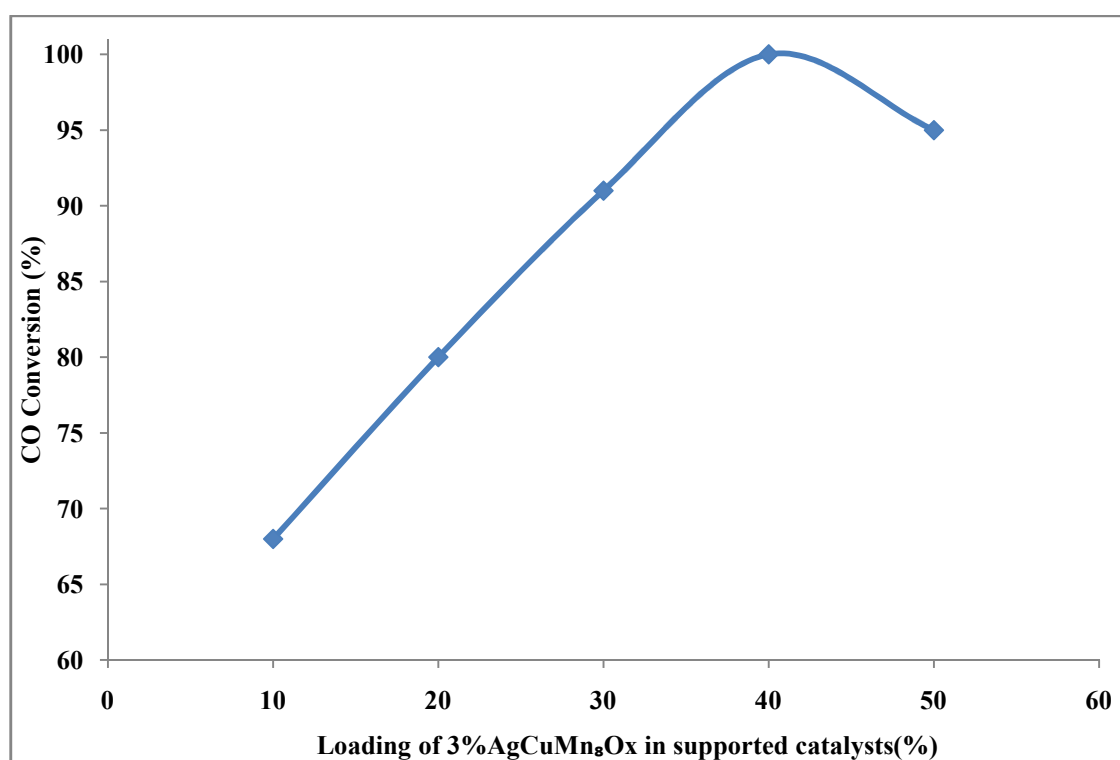


Figure 9.9: Optimization of 3%AgCuMn₈Ox in γ -Al₂O₃ supported catalysts

The nature of 3%AgCuMn₈Ox catalyst, a key parameter governing the conversion seems to be the geometrical make contact with the 3%AgCuMn₈Ox catalyst and supporting γ -Al₂O₃ material, which was preferential by a highly corrugated catalyst surface. This was the reason why the more corrugated 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst ensured the best performance under real operating conditions. The performance

of catalysts was accordance with their characterization. The interactions between the adsorbing molecules and the catalyst can be characterized quantitatively in terms of adsorption/desorption properties.

9.3.3 Comparison of 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst

The comparative study of 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts for total oxidation of CO has been shown in the Figure 9.10. The oxidation of CO has been initiated near around the room temperature \sim 25°C and the 50% conversion of CO has occurred at 50°C over 3%AgCuMn₈Ox catalyst which was lowered by 2°C over than that of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst. The acceleration of CO oxidation was strongly depends upon the 3%AgCuMn₈Ox catalyst composition and their effect on γ -Al₂O₃ support. The complete oxidation of CO has been achieved at 90°C over 3%AgCuMn₈Ox catalyst, which was less by 11°C over than that of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst. The obtained results confirmed that the highly active 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts for CO oxidation was represented in the Table 9.4. Considering the close similarity values of the BET specific surface area, pore volume and average pore diameter for both 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst. The characterization work has been shows that the confirmation of specific surface area of the catalysts was the principal factor for the CO oxidation.

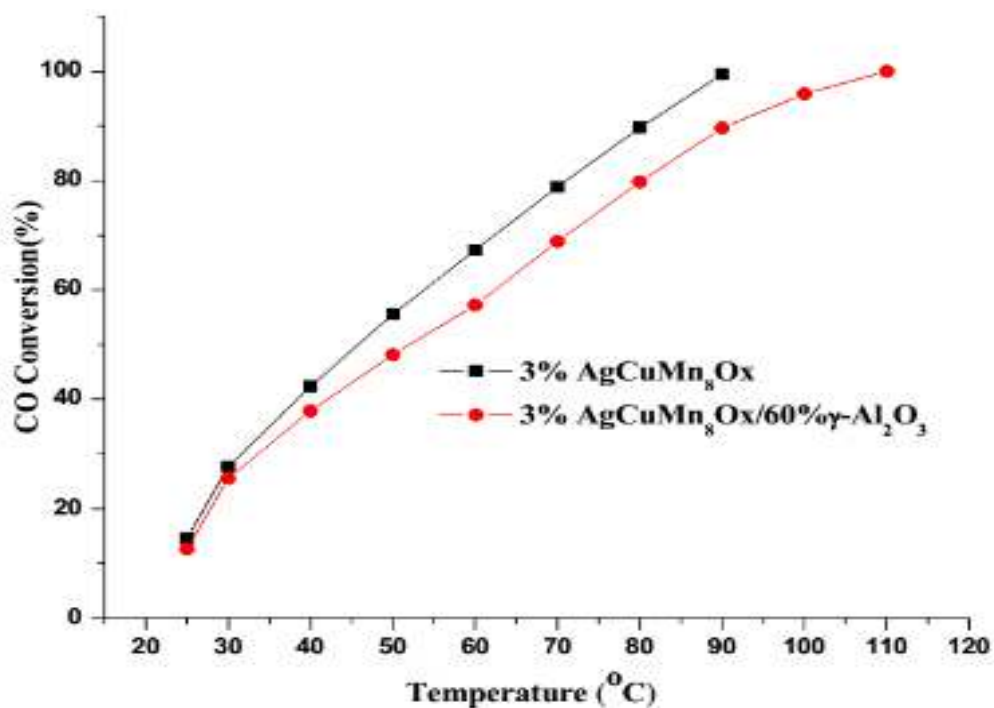


Figure 9.10: Comparison of 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts

The surface area measurements confirmed that the activity behaviors of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts seems to be due to the most active catalyst, which was derived from 3%AgCuMn₈Ox + γ -Al₂O₃ catalyst, has the highest specific surface area.

Table 9.4: Comparison of 3%AgCuMn₈Ox and 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts

Catalyst	T ₁₀	T ₅₀	T ₁₀₀
3%AgCuMn ₈ Ox	>25°C	50°C	90°C
3%AgCuMn ₈ Ox/60% γ -Al ₂ O ₃	25°C	52°C	101°C

In addition to high catalytic activity, the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts must also comprised significant features like high stability in different conditions, ability to be reuse several times and should have a great forbearance against deactivation. The γ -Al₂O₃ support was not very active, but the presence of 3%AgCuMn₈Ox can promote the CO oxidation.

9.4 Concluding Remarks

Synthesis of supported 3%AgCuMn₈Ox/Z% γ -Al₂O₃ catalyst by the precipitation-deposition method is an appropriate method for the development of highly active catalysts for CO oxidation. It is recognized that the phase composition and reduction properties of mixed 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalysts have strongly depended on the catalyst and support ratio. The optimum metals loading on γ -Al₂O₃ support is 40%. The optimum catalyst formulation is 3%AgCuMn₈Ox/60% γ -Al₂O₃ for CO oxidation. The application of γ -Al₂O₃ support in 3%AgCuMn₈Ox improves performance of the catalyst as well as reduces the cost. The performance of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst has followed the characterization results. The crystalline nature of 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst sample is favor on the structural defects formation, in particular, oxygen vacancies giving the best performance for CO oxidation. The using of γ -Al₂O₃ support in 3%AgCuMn₈Ox catalyst could be made cheaper the 3%AgCuMn₈Ox/60% γ -Al₂O₃ catalyst without sacrificing their performance for CO oxidation. Therefore, we used γ -Al₂O₃ support in 3%AgCuMn₈Ox catalyst for improving their performance and reducing their cost.