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Synthesis and Characterization of Nanomaterials: Catalytic Application

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ABSTRACT

These days, the world is undergoing major economic development, which is generating strong growth in energy demand. The use of fossil fuels leads to high emissions of greenhouse gases, in particular CO_2, which is harmful to the environment and to humanity, hence the idea of harnessing the latter to produce clean, sustainable energy. In this context, catalysts based on copper and zinc metal oxides (CuO and ZnO) supported on aluminium oxide Al_2O_3 and titanium oxide TiO_2 were synthesised at different calcinations temperatures of 350°C and 450°C in order to activate the CO_2 hydrogenation reaction to form methanol.

Keywords: Carbon dioxide, hydrogenation, methanol.

1. Introduction

Since the beginning of recording of atmospheric measurements around the globe, the annual average of CO_2 concentrations has increased continuously starting from 6.8 Pg C/year in 2000 and reaching a maximum of 10.1 Pg C/year in 2019 (1 Petagram of carbon is equivalent to 1015 g C, or 1 billion metric tons of C, or 3.67 billion metric tons of CO_2). It is estimated that fossil fuel emissions would need to be reduced by around 80% to stop the growth of atmospheric pollution.

In Algeria, CO_2 emissions have reached more than 160 million tons in 2020 (figure 1). For this reason, it is committed to reduce its emissions by 7% by 2030 with its own resources and by 22% if the country benefits from international financing. Stressing that 75% of CO_2 emissions come from the energy sector, and 20% from the processing of hydrocarbons, hence the need to treat the CO_2 emitted in order to meet environmental requirements and limit global warming.

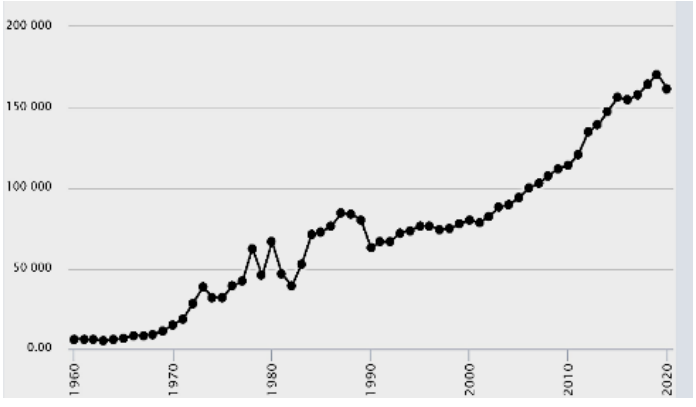

Figure 1: CO_2 emission (kt), Algeria *(Source: world Bank)*

The transformation of CO_2 into other reusable substances has the advantage of reducing the carbon footprint of new products developed and therefore being able to move away from fossil resources. One of the applications of CO_2 conversion is its transformation into methanol. The latter is of great industrial interest:

1- Produce olefins,

2- Used in fuels, to improve their octane numbers [1].

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3- Application in fuel cells called direct methanol fuel cells (DMFC) to produce hydrogen [2].
4- Used as a hydrogen vector, because it allows efficient and secure storage (53 g/L of H_2 at ordinary temperature and pressure, or approximately twice the capacity of dihydrogen at 350 bar) [3].

2. Experimental

Metal oxide catalysts based on zinc and copper were synthesized by the co-precipitation method. The CuO-ZnO/Al_2O_3 and CuO-ZnO/TiO_2 catalysts were synthesized from aqueous solutions of copper nitrates $Cu(NO_3)_2$, 2.5 H_2O and zinc nitrates $Zn(NO_3)_2.6H_2O$ with a mass ratio (Cu/Zn/ Al_2O_3) = (40/40/20), (Cu/Zn/ TiO_2) = (40/40/20) under reflux heating at 80°C/3h. The precipitate obtained was filtered, washed, dried at 100°C/overnight then calcined at 350°C and 450°C for 4 hours.

3. Results and Discussion

- Thermo gravimetric analysis confirms the degradation of the various species present before calcination of the CuO-ZnO/Al_2O_3 catalyst, such as nitrates, carbonates and hydroxylated groups (Figure 2).
- X-ray diffraction (XRD) analysis of the CuO-ZnO/Al_2O_3 catalyst confirms the formation of the ZnO and CuO phases in the synthesised catalyst (Figure 3).

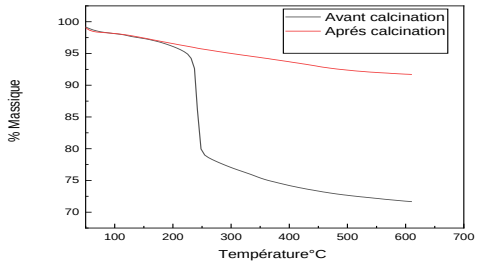

Figure 2: ATG curve

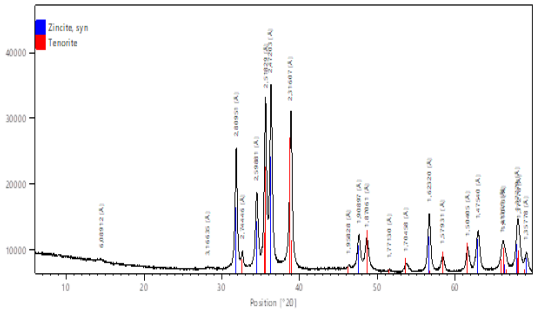

Figure 3: XRD curve of the catalyst CuO-ZnO/Al_2O_3

4. Conclusions

The aim of this work is to develop metal catalysts based on zinc oxide and copper oxide for use in the hydrogenation reaction of CO_2 to form methanol. XRD analysis confirms the formation of the ZnO and CuO phases and thermo gravimetric analysis shows that the chemical species are degraded after calcination for 3h.

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