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Metal-organic framework as a template to form Co nanoparticles in porous carbon matrix for CO2 methanation

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PURPOSE OF THE ABSTRACT

CO2 emission represents serious environmental issues since it is one of the greenhouse gases leading to climate change [1, 2]. Hydrogenation of CO2 captured at point sources, towards methane, is considered an effective way to reduce net CO2 emissions [3]. In this regard, several metal oxides- supported metals have been implemented. While noble metal-based catalysts are very active for this reaction at low temperatures, their high cost and limited availability led to a shift in the focus towards non-noble metals such as Ni and Co [4, 5]. In the field of heterogeneous catalysts, the number of organic reactions in which metal-organic frameworks (MOFs) and MOFs?derived materials have been employed is rocketing. MOFs-derived carbon (obtained by thermal treatments under inert atmosphere) have attracted significant attention because this strategy gives access to highly dispersed metal nanoparticles in a porous carbon matrix with high stability at high temperatures. Interestingly, MOFs-derived carbon has found their merits in CO2 methanation reaction as well [6, 7].

Here, we disclose carbon-based Co catalyst obtained by the controlled thermal decomposition of 2D MOF: Co-ZIF-L. The latter is compared to the more conventional ZIF-67, which was already studied for CO2 methanation[7]. Here, Co(NO3)2 and 2-methylimidazol are applied to synthesize the MOFs via ultrasonication (Co-ZIF-L) and at room temperature (ZIF-67). The resultant powders after drying, are carbonized at 800°C under Ar to form Co nanoparticles dispersed in porous carbon (CoNP-C). CO2 methanation is performed in a fixed bed flow reactor with 100 mg of the catalyst while the molar ration H2/CO2= 4/1, the GHSV=24000 ml/gcat.s and P=0.1MPa . Importantly, with this catalyst, the reduction step with hydrogen is skipped since CoNP are formed during the carbonization. Interestingly, at 400ºC Co-ZIF-L-derived CoNP-C (C-Co-1) reaches CO2 conversion as high as 62% with 53% selectivity towards methane. By comparison, ZIF-67-derived CoNP-C (C-Co-2) demonstrates 49% CO2 conversion with 35% methane selectivity (Fig.1). We surmise that much higher performance exhibited by catalyst C-Co-1 is assigned to the basic sites.

FIGURES

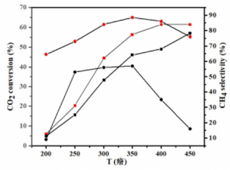

FIGURE 1

Fig. 1

Fig. 1. Square=CO2 conversion, Circle= CH4 selectivity. Red= results for C-Co-1 catalyst and Black= results for C-Co-2 catalyst.

FIGURE 2

KEYWORDS

CO2 methanation | Co nano-particles | MOF-derived carbon

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