Chapter 2
Conversion of CO_2 to High Value Products

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ABSTRACT

Due to human activities and rapid industrialization, the amount of CO_2 emitted into the atmosphere increases by the day. It is an environmental pollutant and is indirectly responsible for causing climate change and global warming. Thus, research has been carried out for the conversion of CO_2 into value added chemicals. However, CO_2 is a chemically-inert and thermodynamically-stable molecule; thus, external energy should be supplied or a suitable catalyst should be designed for their conversion into useful chemical. Methanol, dimethyl ether, higher alcohols, methyl, formic acid, formaldehyde, organic carbonates, etc. are the different chemicals that are prepared from CO_2. CO_2 is an environmentally friendly raw material as it is nontoxic, abundant, and economical. A lot of research has been carried out on the reaction using CO_2 as a raw material. This chapter mainly focused on synthesis of various chemicals from CO_2 as a raw material.

INTRODUCTION

CO_2 is the main greenhouse gases (GHGs) which is responsible for global warming and climate change. With increasing emission of CO_2 climate change is one of the serious issues for the development of future energy systems. The concentration of atmospheric CO_2 have been increasing from 280 parts per million (ppm) to 400 ppm in 2014 due to population growth, deforestation, rapid industrialization and intensive agriculture (the guardian.com). From the Greenhouse Gas Bulletin & the

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UN weather agency's annual flagship report. "Globally averaged concentrations of CO_2 is 400.00 ppm in 2015 while it is 403.3 ppm in 2016 due to this the average global temperature is increasing (ElMekawy, et.al.,2016). The average temperature of land and ocean on February 2017 is 0.98°C above the temperature of February 2016. It was reported that 30 Gton of CO_2 is emitted per year which is responsible for increase in atmospheric concentration of CO_2 and global warming. CO_2 emission drastically increased from 15 Gton in 1971 to 30 Gton in 2007. According to United States Energy Information Agency (EIA 2014) that till 2030, the energy consumption is increased by 57%, and if the primary source of energy is coal then till 2030, the expected emission of CO_2 is 40.2 Gton (Johnson, et.al.,2014).

This increase in the concentration of CO_2 in the atmosphere has negative impact on our climate, environment, society and future generations (Johnson, et.al., 2014, Field, et.al., 2014, Lagarde, 2013, Nichols Roth, 2015). Therefore, the conversion of CO_2 into value-added chemicals is one of the main challenges for the 21st century. On increasing population, the demand of carbon based plastics to medicines will also be increasing and to fulfill the demand CO_2 will have to be recycle. Carbon capture and recycling will capture CO_2 from source, and using any alternative energy source converted it to useful materials and fuels.

Conversion of CO_2 An Overview

The utilization of CO_2 in Industrial processes was developed earlier in 1880–1893s, for the synthesis of urea (Bazarov, 1870), hydrogen carbonates (Steinhauser, 2008), and the production of salicylic acid (Kolbe, 1874). Since the late 1800s the chemistry of CO from fossil carbon has been developed for the synthesis of chemicals and fuels that had its golden era in the 1900–1970s, and still it plays an important role in the production of value added chemicals and fuels. In 1970s CO_2 was used as additive for synthesis of methanol with CO (Liu et. al., 2003) and used as a co-monomer for the synthesis of organic carbonates from epoxides (Tsuda, et.al., 1976). In 2013 Aresta and his co-worker describe the utilizaton of CO_2 in the synthesis of value added chemicals and its perspective use at 2030, on considering the market growth for the chemicals and the new technologies (Aresta, et. al., 2013).

CO_2 is one of the easily available feedstock used as a raw material for the production of many value-added chemicals and fuels, which provides a solution to reducing CO_2 emission and energy supply challenges (Markewitz, et.al. 2012). The CO_2 capture, utilization, and sequestration (CCUS) is a promising approach to reduce the emission of CO_2. The Carbon capture and storage (CCS) is a technology which