



Review Article

A review on photochemical, biochemical and electrochemical transformation of CO₂ into value-added productsP.R. Yaashikaa^a, P. Senthil Kumar^{a,b,*}, Sunita J. Varjani^{c,**}, A. Saravanan^d^a Department of Chemical Engineering, SSN College of Engineering, Chennai 603 110, India^b SSN-Centre for Radiation, Environmental Science and Technology (SSN-CREST), SSN College of Engineering, Chennai 603110, India^c Gujarat Pollution Control Board, Gandhinagar, Gujarat 382010, India^d Department of Biotechnology, Rajalakshmi Engineering College, Chennai 603110, India

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ABSTRACT

Carbon dioxide (CO₂), a greenhouse gas is considered to contribute significantly to climate change and global warming. Environmental changes require to minimize the measure of CO₂ in air. The capture, storage and utilization of carbon based on photochemical, biochemical and electrochemical processes are the innovative proposed methods to decrease utilization of nonrenewables such as coal and oil. CO₂ can be reduced chemically through either homogeneous or heterogeneous pathway. In general, photochemical transformation of CO₂ involves formation of carrier charges followed by its separation, transportation and finally reduction of CO₂ using generated photoelectrons. Photocatalytic reduction of carbon dioxide is a rising territory of research. Beginning from the premise of photocatalytic reduction, the investigations about different semiconducting frameworks like oxides, sulfides, and phosphides are considered in this review. Biochemical transformation deals with enzymatic conversion of CO₂ and electrochemical reduction uses electrical energy for converting CO₂ into its reduced form. The enzyme catalytic carbon dioxide change gives an eco-accommodating approach to make carbon-based chemical products. A few favorable circumstances related with enzymatic change incorporate high selectivity, high return, less quantity of waste, less response conditions however certain downsides, for example, staggering expense of catalysts and cofactors, and longer response times as contrasted and normal strategies. Some products obtained as a result of CO₂ reduction includes methanol, formic acid, CO, methane, ethylene and gasoline. In this review, a overview on inalienably associated methodologies is given and ongoing advancement on the improvement, designing, and comprehension of CO₂ reduction using photochemical, biochemical and electrochemical is outlined.

1. Introduction

The ultimate goal of present scientists and researchers is to convert the carbon dioxide, greenhouse gases into value-added products such as fuels or chemicals in order to minimize their negative effect. Climatic change and global warming are the major threats that make policy makers, environmental researchers and officials to focus [1–3]. As per recent reports the measure of carbon dioxide content in the atmosphere is increasing due to the vast growth in industrialization during mid 19th century resulting in changes in climatic conditions. The climatic condition of 2019 was described by abnormally warm conditions crosswise over a great part of the world's territory and sea surface. The most outstanding warm temperature takeoffs from normal conditions were available crosswise over northwestern and north-focal locale, where

temperatures were in any event 4.0 °C (7.2 °F) higher than the 1981–2010 normal. This has now become a major threat to mankind. Carbon dioxide thus has become a center of attraction for all the researchers and experts [4]. The impact of climatic change can be responded either by adjusting to the implications or by taking necessary steps for controlling the emissions of greenhouse gases. Another effective way to handle these situations is finding the better way to capture and convert these emitted gases and carbon dioxide into valuable products that are helpful to human. Human and industrial activities can be altered such that the influence on environment is less [5]. Few measures are proper utilization of resources such as water and fossil fuels, promoting the growth of water and disaster resistant crops. There are many problems related to the execution of these measures like time-period, financial or technical issues. On the other side, a strategy

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