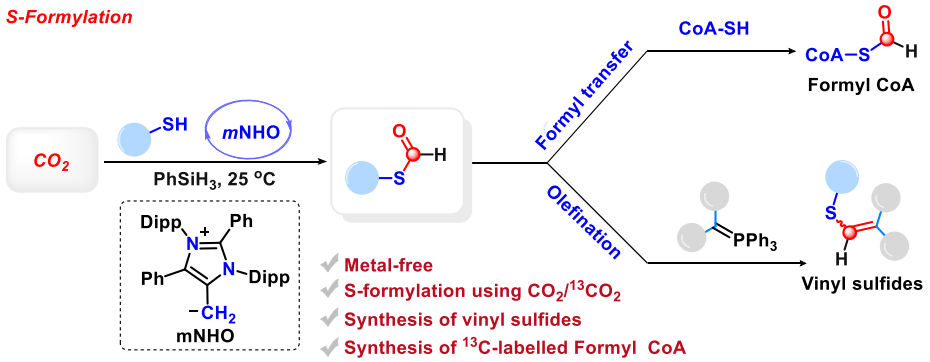
A sustainable way to transform CO_2 into olefins

Carbon dioxide (CO_2) is a significant greenhouse gas present in the atmosphere, and its emission is steadily rising on an annual basis. The escalating concentrations of atmospheric CO_2 have resulted in a rise in global temperatures, culminating in 2023 being identified as the warmest year ever documented. To tackle this worldwide problem, a comprehensive strategy is necessary, which includes the implementation of carbon capture and storage (CCS) and carbon capture and utilization (CCU) methods. Currently, we lack any sustainable technology capable of achieving NET ZERO emissions. For instance, with our existing technological capabilities, even if we can achieve Carbon Capture and Utilization (CCU) with its highest level of efficiency, it cannot consume more than 5% of total emitted CO_2. Therefore, the discovery of various new CO_2 utilisation processes is highly desirable. Nevertheless, the activation of carbon dioxide, whether through chemical or biological means, presents significant difficulties due to its highly oxidized state, thermodynamic stability, and kinetic inertness. This often necessitates the utilization of catalysts based on transition metals. These transition metals are both costly and environmentally hazardous. To achieve sustainability, it is necessary to substitute costly transition metals with catalysts that do not contain any metals and can operate effectively under gentle conditions. We have successfully achieved a novel CO_2 reaction known as S-formylation followed by olefination to produce olefins in one step, in which we utilized CO_2 as a source of carbon (C1) without the use of any metals.

S-formylated thiols and S-formylation are crucial components of several vital biological activities. Such biological process represents S-formylation from thiols utilizing CO_2. However, the chemical process of catalytic S-formylation remains unknown. Hence, accomplishing S-formylation from thiols utilizing CO_2 remains a formidable challenge to tackle. Inspired by nature, recently, we accomplished a catalytic approach, to directly produce S-formylated molecules from CO_2 in the laboratory via a chemical method. The late-stage functionalization of various natural products and pharmaceutically active molecules was performed using both CO_2/$^{13}CO_2$ under metal-free conditions. This procedure was utilized to synthesize the ^{13}C-labelled formyl coenzyme A, which holds significance in terms of enhancing our understanding of its biological function at a molecular level. In addition, we have employed S-formylation of thiols to create a one-pot S-formylation-olefination method for producing various olefins (vinyl sulfides). These olefins are significant in the fields of material and polymer science and are commonly present in pharmaceuticals, natural products, and biologically active substances. One of the carbon atoms in these olefins is harvested directly from the CO_2. This finding will simplify the process of converting CO_2 into valuable compounds without needing any metal catalyst.



Refs: **Subir Maji**, Arpan Das, Madhur Mahesh Bhatt, **Swadhin K. Mandal***, "Metal-free organocatalytic S-formylation of thiols using CO_2" *Nature Catalysis*, **2024**, 10.1038/s41929-024-01114-7, *ASAP*.