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Press Release

Global CO2 Emissions Drive Breakthrough Study by Prof. Sumanta Kumar Padhi of IIT (ISM) Dhanbad to Explore Novel Methods of Converting CO2 into Valuable Fuels and Chemical Feedstocks; Study Prominently Features in the Cover of Chemistry; A European Journal.

Global CO2 emissions have doubled in the past three decades and are projected to triple by 2040, driving an urgent need for innovative solutions to mitigate climate change and its environmental impacts. One significant consequence of escalating CO2 levels is the consistent rise in average global temperatures, with profound effects on ecosystems worldwide. These concerns, coupled with the looming energy crisis, have spurred researchers to explore novel methods of converting CO2 into valuable fuels and chemical feedstocks.

Recent advances have highlighted the potential of electrochemical conversion to transform CO2 into reduced carbon compounds. This approach uses CO2 as a low-cost and abundant carbon source. However, progress has been hindered by the substantial overpotential required for its reduction. Researchers are addressing this challenge by focusing on metal complexes capable of stabilizing intermediates and facilitating the conversion process at more favorable redox potentials.

A promising development in this field involves copper-based molecular catalysts. These catalysts have shown great potential in reducing CO2 electrochemically to syngas, a flexible feedstock that can be further processed into various fuels and chemicals. The ligand structure surrounding the copper core plays a pivotal role in determining both catalytic activity and product selectivity.

A breakthrough study carried out by Dr. Sumanta Kumar Padhi, Associate Professor in the Department of Chemistry and Chemical Biology at IIT (ISM), in association with SK Samim Akhter, Diship Shrivastava, Aman Mishra, Niladri Patra, and Pankaj Kumar, has introduced novel copper complexes designed with an electron-rich dipicolinate framework.

The study, prominently featured on the cover of Chemistry: A European Journal, published by Chemistry Europe, highlights the innovative design and catalytic properties of these copper complexes. Chemistry Europe, an association of 16 chemical societies from European countries, supports researchers worldwide by publishing high-impact chemistry journals.

Dr. Padhi and his co-workers observed the generation of hydrogen (H2) as a by-product due to the competitive proton reduction reaction ($2H^+ + 2e^-$). Their kinetic studies reveal that the hydrogen evolution reaction (HER) occurs prior to the CO2 reduction reaction (CO2RR), influencing the overall efficiency of the process.

Copper, being cost-effective and exhibiting intrinsic CO2 reduction activity, is an ideal candidate for such catalytic applications. The team synthesized two innovative copper complexes using derivatives of pyridyl-quinoline and deprotonated dipicolinic acid (DPA). These complexes incorporate redox-active ligands to facilitate efficient electron transfer during reduction processes, enhancing overall performance.

“Our goal is to provide insights into the characteristics and behaviour of these copper complexes, paving the way for their application in catalysis and energy conversion,” said Dr. Padhi. “These findings could mark a

significant step toward achieving sustainable energy solutions and mitigating climate change" added Prof. Padhi.

This research underscores the potential of copper-based molecular catalysts to address critical challenges in CO2 reduction, offering a pathway to sustainable energy systems and advancing global efforts to combat the effects of rising emissions.

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