ICANADCOH

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Iron catalyzed N-methylation of amines via direct CO2 hydrogenation

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Carbon dioxide (CO?) utilization in chemical reactions plays a significant role in advancing carbon capture technologies and represents a promising approach to the sustainable consumption of this greenhouse gas. Despite being a thermodynamically stable molecule, its excessive emission necessitates its conversion into value-added products to mitigate environmental impact. N-methylated compounds are important structural motifs contained in natural products and industrial chemicals, such as agrochemicals, lubricants, surfactants, and pharmaceuticals. Traditional methods for methylation of amines involve the use of toxic reagents and precious transition metals (ruthenium, palladium, platinum), thereby making these methods unsustainable. The development of a robust and sustainable N-methylating strategy that will rely on the use of CO2 as the C1 building block and catalyzed by earth-abundant and environmentally benign iron metal complexes is the main goal of the current proposal. Hydrogen gas will be employed as the reductant; such approach will ensure the formation of the products with high atom economies and with water as the only by-product. The aims of the project involve the synthesis of the complexes with suitable ligands and their application in the N-methylation reaction. In collaboration with our pharmaceutical industry partner (SERVIER), we aim to develop green and scalable methods for the N-methylation of amines, an important structural motif in many active pharmaceutical ingredients. This sustainable approach for the production of pharmaceuticals addresses several United Nations Sustainable Development Goals (SDGs), namely SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate action).

Sustainable Development Goals

Meet the Project

If you had to explain your project to someone outside your field, how would you describe it in three sentences?

My project proposal focuses on using carbon dioxide (CO?) as a building block rather than treating it only as a waste. CO2 is a greenhouse gas, causing environmental issues, but it contains carbon, which also is a basic building block of organic compounds, such as many pharmaceuticals. We would like to study the possibility of incorporating the carbon-dioxide derived carbon into high value chemicals, such as pharmaceuticals. In this way, we would not only avoid its cumulation in the atmosphere, but we would turn it into something useful and valuable.
If the proposed plan works, then it sets a new benchmark for green chemistry, a sustainable route to fine chemicals, eliminates waste generation, and contributes to carbon management efforts.

What fascinates you most about the topic of your research project?

My research proposal focuses on rethinking CO? not just as a problem, but as an opportunity. Instead of just seeing it as a greenhouse gas, this project looks at how we can use it as a building block to make valuable chemicals, which feels both exciting and meaningful. I also find it really interesting that iron, a benign and biocompatible metal, can be used as a catalyst for this transformation. What fascinates me is that the N-methylated amines are important synthons for pharmaceuticals, so how we make them in a more sustainable way could have real-world impact. It makes the project feel relevant, not just academically interesting.

How does your research contribute specifically to achieving the UN Sustainable Development Goals?

The present research proposal is focused on the reduction of CO? and the synthesis of industrially important methylated amines.
The proposed research contributes to different United Nations Sustainable Development Goals, such as SDG 3 (Good Health and Well-Being), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) by developing a catalytic methodology to utilize CO? for the synthesis of methylated amines, which are key intermediates in pharmaceuticals and agrochemicals.
By converting CO? (greenhouse gas) into value-added chemicals, this research supports carbon capture and utilization (CCU) strategies and contributes to the reduction of net emissions of CO2, and creates a circular carbon economy.
The process emphasizes atom economy and the use of renewable starting materials. Compared to conventional synthesis routes for methylated amines, this approach minimizes waste and reduces dependency on non-renewable resources. This aligns with the transition toward greener route.
Methylated amines are essential building blocks in the synthesis of many active pharmaceutical ingredients (APIs). By enabling a more sustainable and potentially less toxic production route, this research indirectly contributes to safer pharmaceutical manufacturing. This can reduce environmental contamination and exposure to hazardous chemicals therfore improving public health outcomes.

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