

# 中国科学院院长奖申报表

申报类别 优秀奖

姓 名 杨江伟

单位名称 中国科学院山西煤炭化学研究所

学科专业 化学工程与技术

学科专业代码 081700

攻读学位 博士研究生

导师姓名及职称 赵宁 研究员

中国科学院人才与人事局制

2026 年 04 月 08 日填

|                     |                 |  |             |       |        |                         |                 |
|---------------------|-----------------|--|-------------|-------|--------|-------------------------|-----------------|
| 一、基本信息              |                 |  |             |       |        |                         |                 |
| 姓名                  | 杨江伟             | 性别   | 男           | 民族    | 汉族     | 籍贯                      | 山东省   东营市   东营区 |
| 出生年月                | 1990.01.01      | 政治面貌   | 中国共产党正式党员   |       | 入学时间   | 2023.09.01              |                 |
| 办公电话                |                 | 手机号码   | 18654670800 |       | 电子邮件   | yangjiangwei727@163.com |                 |
| 何时何单位何专业获何种学位       |                 | 2023.9 至今，中国科学院山西煤炭化学研究所，攻读博士学位；<br>2013.09-2016.06，天津商业大学，获得硕士学位；<br>2009.09-2013.06，天津商业大学，获得学士学位。   |             |       |        |                         |                 |
| 个人简历                | 起止年月            | 学习和工作单位  |             |       | 获何种学位  |                         |                 |
|                     | 2023.09-至今      | 中国科学院山西煤炭化学研究所   |             |       | 攻读博士学位 |                         |                 |
|                     | 2013.09-2016.06 | 天津商业大学   |             |       | 硕士学位   |                         |                 |
|                     | 2009.09-2013.06 | 天津商业大学   |             |       | 学士学位   |                         |                 |
|                     |                 |  |             |       |        |                         |                 |
| 学位课成绩（请附成绩单）        |                 |  |             |       |        |                         |                 |
| 学年学期                |                 | 课程名称   |             | 学位课   | 学时     | 学分                      | 成绩              |
| 2024—2025 学年(秋)第一学期 |                 | 中国马克思主义与当代   |             | 是     | 36     | 2.0                     | 91              |
| 2025—2026 学年(秋)第一学期 |                 | 专题论证   |             | 是     | 40     | 2.0                     | 94              |
| 2025—2026 学年(秋)第一学期 |                 | 文献阅读   |             | 是     | 40     | 2.0                     | 94              |
| 2023—2024 学年秋季学期    |                 | 博士英语   |             | 是     | 64     | 2.0                     | 89              |
| 2023—2024 学年秋季学期    |                 | 学术道德与学术写作规范  |             | 是     | 20     | 1.0                     | 94              |
| 总学分                 |                 | 9.0  |             | 学位课学分 |        | 9.0                     |                 |
| 论文题目或成果名称           |                 | 1. Enhancement of Methanol Yield in CO <sub>2</sub> Hydrogenation by Promoting CO <sub>2</sub> Activation and Unlocking the RWGS + CO-Hydrogenation Pathway over Cu-La/ZrO <sub>x</sub> Catalysts<br><br>2. La-Promoted Conversion of Reaction Intermediates Over H <sub>3</sub> BTC-Modified ZrO <sub>x</sub> /Cu Catalysts for Methanol Synthesis From CO <sub>2</sub> Hydrogenation |             |       |        |                         |                 |
| 论文（或成果）性质           |                 | 基础研究   |             |       |        |                         |                 |

二、申报人在学期间发表论文、出版专著、专利、获奖情况（请在附件中附有关证明材料）

|  |        |  |        |              |           |                               |
|--|--------|--|--------|--------------|-----------|-------------------------------|
| 发表论文统计   | 国内刊物   | 国际刊物   | 国内学术会议 | 国际学术会议       | 其中发表在核心期刊 | 其中被 SCI (EI) 收录篇数             |
|  | 0 篇    | 2 篇  | 0 篇    | 0 篇          | 0 篇       | 2 篇                           |
| 第一作者   | 0 篇    | 2 篇  | 0 篇    | 0 篇          | 0 篇       | 2 篇                           |
| 论文名称   |        | 全部作者署名排序   |        | 发表时间         |           | 刊物名称                          |
| Enhancement of Methanol Yield in CO <sub>2</sub> Hydrogenation by Promoting CO <sub>2</sub> Activation and Unlocking the RWGS + CO-Hydrogenation Pathway over Cu-La/ZrO <sub>x</sub> Catalysts |        | Jiangwei Yang; Tengfei Gao; Jinhai Yang; Fukui Xiao; Shoujie Liu; Ning Zhao; Dong-bo Cao; Hao Li                           |        | 2026.2.13    |           | ACS Catalysis                 |
| La-Promoted Conversion of Reaction Intermediates Over H <sub>3</sub> BTC-Modified ZrO <sub>x</sub> /Cu Catalysts for Methanol Synthesis From CO <sub>2</sub> Hydrogenation                     |        | Jiangwei Yang; Jiayi Zhang; Jinhai Yang; Yan Song; Wenjun Yan; Shoujie Liu; Qiang Wang; Fukui Xiao; Tengfei Gao; Ning Zhao |        | 2026.1.27    |           | Advanced Functional Materials |
| 专著统计   | 出版专著数量 |  |        | 出版专著数量（第一作者） |           |                               |
|  | 0 部    |  |        | 0 部          |           |                               |
| 专著名称   |        | 全部作者署名排序   |        | 出版时间         |           | 出版社名称                         |

|      |               |       |                          |
|------|---------------|-------|--------------------------|
| 0    | 0             | 0     | 0                        |
| 专利统计 | 已授权发明或实用新型专利数 |       | 已授权发明或实用新型专利数<br>(第一发明人) |
|      | 0 件           |       | 0 件                      |
| 专利号  |               | 专利名称  | 全部发明人排序                  |
| 无    |               | 无     | 无                        |
| 获奖统计 | 国家级奖励         | 省部级奖励 |                          |
|      | 0 项           | 0 项   |                          |
| 奖励名称 |               | 奖励级别  | 全部获奖人排序                  |
| 无    |               | 无     | 无                        |

### 三、本人开展的科研工作及取得的成果情况介绍

本人开展的课题为  $\text{CO}_2$  加氢合成甲醇，这对于实现“双碳”目标过程具有十分重要的作用。本人在查阅大量文献的基础上，围绕如何有效提升 Cu 基催化剂  $\text{CO}_2$  转化率和甲醇选择性这两个关键性能指标，系统研究了稀土助剂 La，有机配体 1,3,5-苯三甲酸及其协同调控对 Cu-ZrO<sub>2</sub> 催化剂结构与  $\text{CO}_2$  加氢制甲醇性能的影响，并结合一系列表征与理论计算，深入揭示了催化剂的构效关系及反应机理，取得了一系列创新性的成果，研究结论对于高效催化剂的开发提供了很好的理论指导。并以第一作者在高水平的 SCI 一区期刊 Advanced Functional Materials (IF=19.4) 和 ACS Catalysis (IF=13.3) 各发表论文一篇，以第三作者在高影响因子 SCI 二区期刊 International Journal of Hydrogen Energy (IF=8.3) 发表论文一篇。

#### 四、在政治思想、道德品质、学风等方面自我评价

本人作为一名共产党员，为人正直，诚实守信，学习能力强，有很强的上进心和责任心；学习认真踏实，吃苦耐劳，善于沟通，积极进取；基础理论知识和专业知识扎实，注重团队合作，具有较强的科研能力和勇于创新的精神，在两年多的时间里，出色的完成了科研任务，取得了高水平的研究成果。

#### 五、导师对申请人的评价及推荐意见

同意推荐

签名：



2026年4月15日

五、研究所/院系推荐意见

负责人签名： (公 章)


年 月 日

六、学校推荐意见

负责人签名： (公 章)

年 月 日

# 院长优秀奖学金申请者申请信息情况统计表

|              |   |      |  |  |                       |      |        |      |
|--------------|---|------|--|--|-----------------------|------|--------|------|
| 姓名           | 杨江伟   |      | 以第一作者发表论文情况（含学术会议）   |  | SCI/EI 收录文章<br>累计影响因子 | 参与专利 | 重要获奖荣誉 |      |
| 类别           | 博士  | 论文篇数 | 主要论文刊物名称（当年 IF）  |  |                       |      |        |      |
| 专业           | 化学工程与技术   | 2    | A、ACS Catalysis (13.3)<br>B、Advanced Functional Materials (19.4) |  | 32.7                  | 0    | 科研学习   | 学生工作 |
| 联系电话         | 18654670800   |      |  |  |                       |      | 无      | 无    |
| 指导教师<br>审核签名 |  |      |  |  |                       |      |        |      |

发表论文题目列表：

1、Enhancement of Methanol Yield in CO<sub>2</sub> Hydrogenation by Promoting CO<sub>2</sub> Activation and Unlocking the RWGS + CO-Hydrogenation Pathway over Cu-La/ZrO<sub>x</sub> Catalysts (A)

2、La-Promoted Conversion of Reaction Intermediates Over H<sub>3</sub>BTC-Modified ZrO<sub>x</sub>/Cu Catalysts for Methanol Synthesis From CO<sub>2</sub> Hydrogenation (B)

注意：1、申请者的论文刊物分区及影响因子数据登记，统一使用网站 <http://apps.webofknowledge.com> 查询

2、国家奖学金申请使用特别说明：已得国家奖学金的同学，再次参评不得使用上次获评国家奖学金时的学术工作成果作参评材料。

3、所有获得奖项和荣誉称号请按提示标注具体年份、级别。

4、指导教师对材料的真实性、有效性负责，审核后签名。

5、评选前统计表将在网站公示 3 天，公示期如有材料错误或虚假问题举报，一律取消相关申报人的评奖资格。

附件 3

## 奖学金申请诚信承诺书

申请人: 杨江华, 博士/硕士研究生, 学号: 202318004333023,  
身份证号: 370502199001016077。本人已认真阅读《中国科学院山西煤炭化学研究所申报材料科研诚信提醒清单》(附件 4),  
对照提醒内容逐项自查确认。现郑重承诺:

在 2026 年度 院长 奖学金申请中所使用材料、相关证明真实有效, 无弄虚作假; 所填报内容不存在科研失信行为。  
如有不实之处, 自愿接受中国科学院大学和我所根据有关规定做出的处罚。

承诺人: 杨江华

日期: 2026 年 4 月 27 日

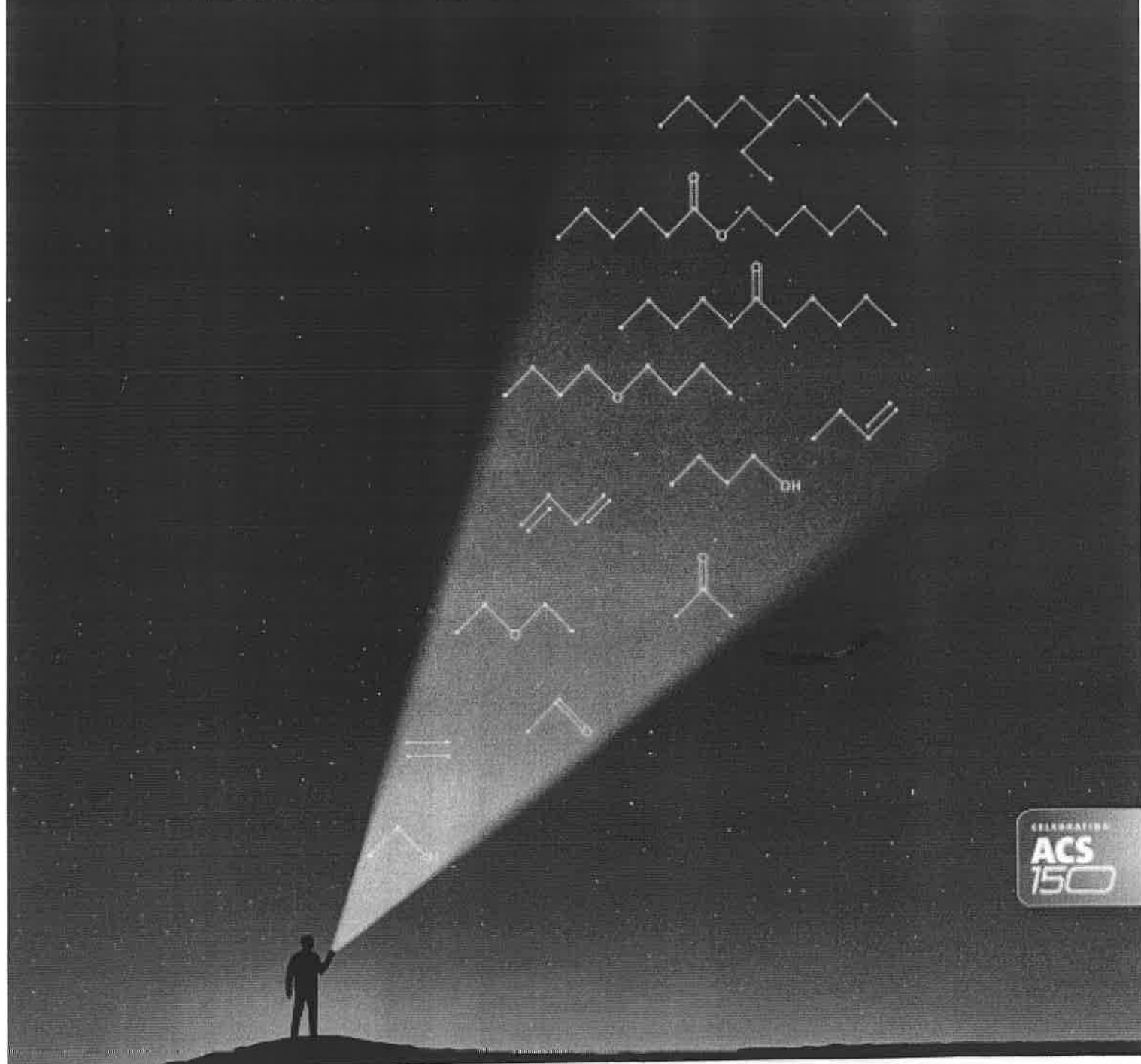


# ACS Catalysis

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# Enhancement of Methanol Yield in CO<sub>2</sub> Hydrogenation by Promoting CO<sub>2</sub> Activation and Unlocking the RWGS + CO-Hydrogenation Pathway over Cu–La/ZrO<sub>x</sub> Catalysts

Jiangwei Yang, Tengfei Gao, Jinhai Yang, Fukui Xiao, Shoujie Liu, Ning Zhao,\* Dong-bo Cao,\* and Hao Li\*



Cite This: <https://doi.org/10.1021/acscatal.5c08427>



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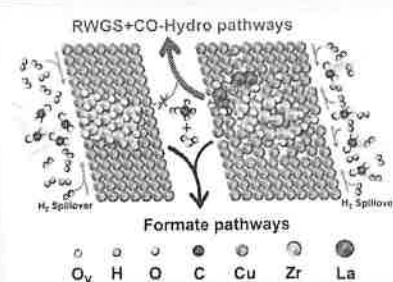
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Supporting Information

**ABSTRACT:** Cu-based catalysts have been widely recognized as the most representative systems for the hydrogenation of CO<sub>2</sub> to methanol, and they also serve as the primary catalysts for the reverse water–gas shift (RWGS) reaction. However, effectively tuning the active sites and reaction pathways of Cu-based catalysts through promoters to overcome the trade-off between CO<sub>2</sub> conversion and methanol selectivity remains a significant challenge. In this work, a RWGS + CO-hydrogenation pathway was established on Cu–La/ZrO<sub>x</sub> (CLZ-X) catalysts by selectively enhancing the interaction between La<sub>2</sub>O<sub>3</sub> and Cu. In situ X-ray absorption spectroscopy (XAS) demonstrated that the coordination environment of Cu was altered upon La<sub>2</sub>O<sub>3</sub> addition, rendering it highly sensitive to the reaction atmosphere and the reaction conditions. Meanwhile, La<sub>2</sub>O<sub>3</sub> enhanced CO<sub>2</sub> adsorption and activation on the catalyst surface and optimized its distribution, leading to a 1.5- to 2.4-fold increase in CO<sub>2</sub> conversion, accompanied by a simultaneous enhancement in methanol selectivity, with the CLZ-3 catalyst achieving the highest value of methanol selectivity (76.33%). In situ DRIFTS and DFT calculation results indicated that the hydrogenation of CO<sub>2</sub> to methanol was more favorable on La<sub>2</sub>O<sub>3</sub>/Cu(111), where the resulting \*CO species could be efficiently converted into subsequent intermediates with the rate-determining step further optimized, whereas the conventional formate pathway primarily occurred at the Cu–Zr interface. These two pathways cooperatively promoted the hydrogenation of surface oxygenate intermediates. The findings offer clear and practical guidelines for controlling active sites and reaction pathways in CO<sub>2</sub> hydrogenation.

**KEYWORDS:** CO<sub>2</sub> hydrogenation, methanol, pathway, coordination, in situ XAS, DFT



## 1. INTRODUCTION

The synthesis of methanol from the hydrogenation of CO<sub>2</sub> represents a promising pathway for achieving a carbon-neutral economy. However, the activation and controlled conversion of CO<sub>2</sub> remain challenging due to its thermodynamically stable and chemically inert nature.<sup>1</sup> Among the active components, copper (Cu) is widely used owing to the high activity under low pressure and cost-effectiveness.<sup>2</sup> As a support, zirconia (ZrO<sub>2</sub>) can interact with both active metals, Cu, and other oxides,<sup>3</sup> thereby modulating the activity and selectivity of the catalysts.<sup>4</sup>

The synergistic effects induced by ZrO<sub>2</sub> are achieved by enhancing metal dispersion, modifying surface basicity and interacting with components such as metals, cosupports, or promoters.<sup>5</sup> Studies have shown that ZrO<sub>2</sub> could influence the CO<sub>2</sub> adsorption and activation, enhance the H<sub>2</sub> dissociation and the spillover of atomic hydrogen to alter the reaction pathways, and/or affect the binding of key intermediates for further conversion.<sup>6</sup> Additionally, the catalytic performance was strongly influenced by the metal-support interface, which was crucial for the conversion of the intermediates to

methanol.<sup>7</sup> However, excessively strong bonding affinity of Zr sites toward the O-containing species was undesirable as it introduced competition between these species and CO<sub>2</sub> for the limited interface sites. Since such active interface sites were already scarce in catalysts, the further occupation resulted in a low CO<sub>2</sub> conversion, even though the barriers for CO<sub>2</sub> direct hydrogenation/decomposition were relatively low. This observation was consistent with experimental results, showing that the CO<sub>2</sub> conversion over Cu–ZrO<sub>2</sub> catalysts was typically below 10%, despite the measured barrier for methanol formation not being high. When a notable enhancement in CO<sub>2</sub> conversion was observed, it was usually caused by the reverse water–gas shift (RWGS) reaction, thereby leading to a pronounced decrease in methanol selectivity.

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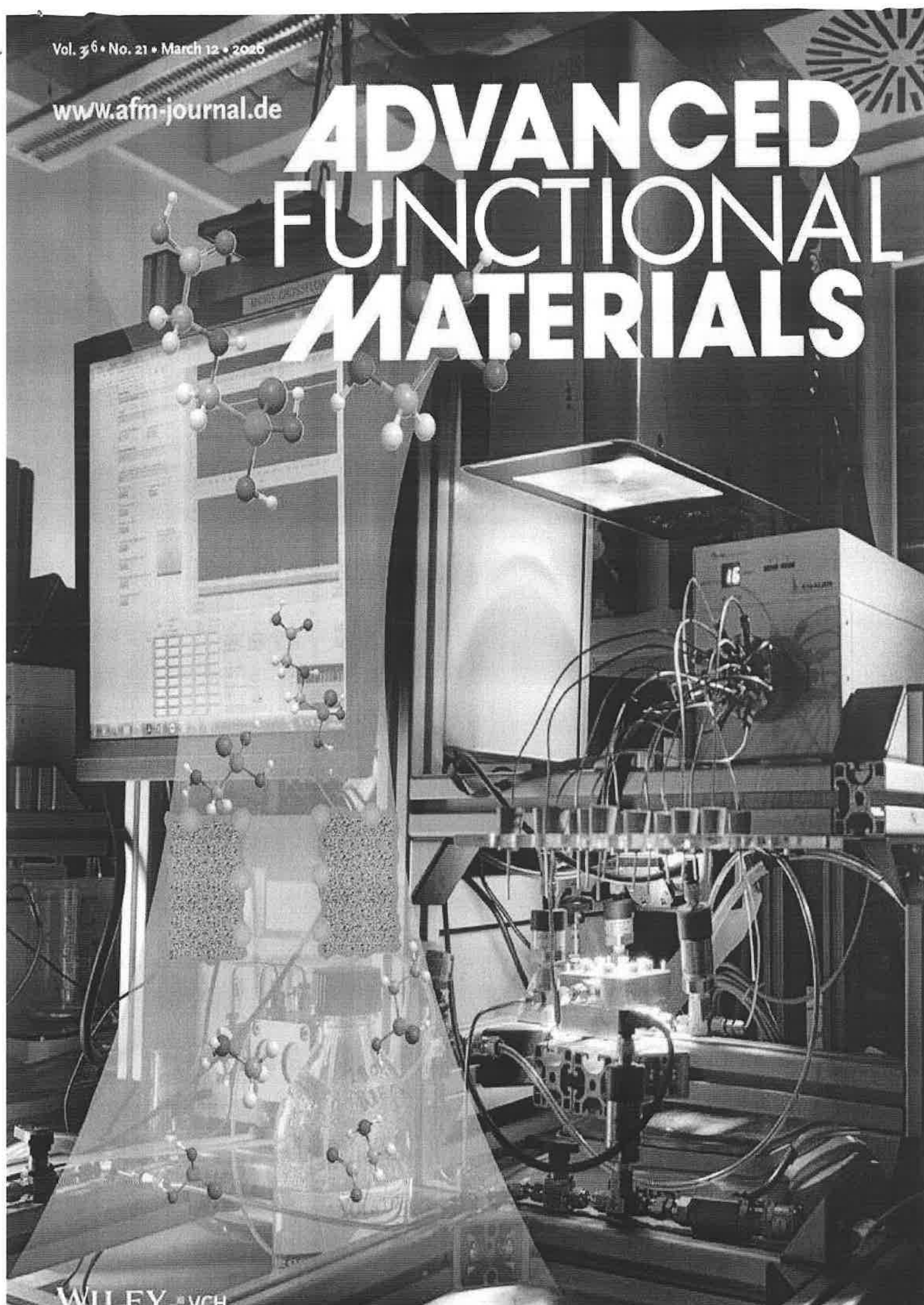
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<https://doi.org/10.1021/acscatal.5c08427>  
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# ADVANCED FUNCTIONAL MATERIALS



WILEY-VCH

## RESEARCH ARTICLE

# La-Promoted Conversion of Reaction Intermediates Over $H_3BTC$ -Modified $ZrO_x/Cu$ Catalysts for Methanol Synthesis From $CO_2$ Hydrogenation

Jiangwei Yang<sup>1,2</sup> | Jiayi Zhang<sup>1,2</sup> | Jinhai Yang<sup>1,2</sup> | Yan Song<sup>3,4</sup> | Wenjun Yan<sup>1,2</sup> | Shoujie Liu<sup>5</sup> | Qiang Wang<sup>1,2</sup> | Fukui Xiao<sup>1,2</sup> | Tengfei Gao<sup>6</sup> | Ning Zhao<sup>1,2</sup>

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**Received:** 15 November 2025 | **Revised:** 24 December 2025 | **Accepted:** 31 December 2025

**Keywords:**  $CO_2$  hydrogenation |  $H_3BTC$  | in situ XAS | La modification | methanol |  $ZrO_x/Cu$  catalyst

## ABSTRACT

Given the growing importance of  $CO_2$  hydrogenation to methanol for future energy systems, extensive research focuses on identifying the active sites, interactions, and reaction pathways. However, the formation and conversion of intermediates are unavoidable in this process. In this study, a series of La- $ZrO_x/Cu$  catalysts are synthesized by co-precipitation followed by treatment with  $H_3BTC$ . In situ XAS and in situ XPS results demonstrate that the coordination environment of Cu and the  $Cu^0$  fraction are significantly modified upon  $H_3BTC$  treatment, rendering the catalysts highly sensitive to the reaction atmosphere and conditions. This improvement is lead not only to the significant enhancement of  $CO_2$  adsorption and activation on the La-modified Cu surface, together with the increased proportion of  $Cu^+$  and low-coordinated Cu, but also to the synergistic effect between an appropriate proportion of  $Zr^{4+}$  and the enriched Cu- $ZrO_2$  interface with oxygen vacancies. As a result, a high methanol selectivity of 92.98% is obtained, while the  $CO_2$  conversion is increased by 2.38 times compared with that of the  $ZrO_x/Cu$ . This work therefore provides a viable strategy for generating uniformly dispersed active sites and, with the assistance of La, improving the conversion of intermediates in  $CO_2$  hydrogenation, rather than creating new reaction pathways.

## 1 | Introduction

The activation and transformation of  $CO_2$  had long been regarded as a subject of extensive research interest because of its essential role in the carbon-neutral cycle and the sustainable production of valuable chemicals [1]. Chemicals and fuels such as methanol, light olefins, and gasoline were produced through  $CO_2$  hydrogenation [2]. Among them, methanol was recognized as an important liquid fuel for transportation and a hydrogen carrier in

renewable energy-to-chemicals schemes. In addition, methanol was widely utilized as a feedstock for the synthesis of other chemicals such as olefins [3].

Cu-based catalysts were extensively studied due to their low cost and high catalytic performance under intermediate reaction temperatures [4]. The catalysts were reduced before the reaction, resulting in metallic Cu as the primary active phase [5, 6]. To enhance the activity, various strategies had been developed to