

Study on Direct CO₂ Capture from Motorcycle Exhaust Gases (Part II) -Influence of Coexisting Species on CO₂ Adsorption Performance-

Takumi Miwa¹⁾ Momona Hirao¹⁾ Hashimoto Shogo¹⁾ Toru Uenishi¹⁾

1) Kitami Institute of Technology, School of Earth, Energy and Environmental Engineering
165 Koen-cho, Kitami-city, Hokkaido, Postal Code 090-8507, Japan. (E-mail: toru_uenishi@mail.kitami-it.ac.jp)

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This study investigates the direct capture of carbon dioxide (CO₂) from motorcycle exhaust gases, with a particular focus on how coexisting gas species influence CO₂ adsorption performance. Reducing CO₂ emissions from the transportation sector, which accounts for approximately 20% of total emissions in Japan, is a critical challenge. While improvements in engine efficiency and alternative fuels have been explored, their large-scale impact remains limited. Therefore, direct onboard CO₂ capture from exhaust gases has emerged as a promising approach. Previous studies demonstrated that zeolites suffer performance degradation under real exhaust conditions, whereas amine-impregnated silica shows improved performance, particularly in the presence of water vapor. In this study, the authors aim to clarify the mechanisms behind these observations by systematically examining the effects of individual coexisting gases—specifically water vapor (H₂O), nitrogen monoxide (NO), and sulfur dioxide (SO₂)—on CO₂ adsorption. Experiments were conducted using polyethyleneimine (PEI)-impregnated silica with different pore sizes, under controlled model-gas conditions simulating motorcycle exhaust. The results show that pore structure plays a significant role in adsorption performance. Smaller pore diameters lead to higher CO₂ adsorption capacity, although this advantage diminishes with repeated adsorption-desorption cycles. Larger pores, on the other hand, exhibit better durability against performance degradation. Among the coexisting gases, water vapor enhances CO₂ adsorption capacity, likely due to favorable interactions with amine functional groups(Fig.1). However, this enhancement decreases with repeated cycling. In contrast, NO has negligible impact on both adsorption and desorption behavior. SO₂, however, significantly degrades adsorption performance, and repeated exposure leads to substantial deterioration, indicating strong chemical interactions that negatively affect the adsorbent(Fig.2). Structural analyses using nitrogen adsorption and microscopy revealed no significant physical changes in pore structure before and after testing. This suggests that performance changes are primarily due to chemical alterations in the amine phase rather than physical degradation of the support. Overall, the study concludes that optimizing pore structure and amine impregnation methods is essential for improving CO₂ capture performance under realistic exhaust conditions. In particular, strategies to mitigate SO₂-induced degradation and to maximize the beneficial effects of water vapor are crucial for practical application.

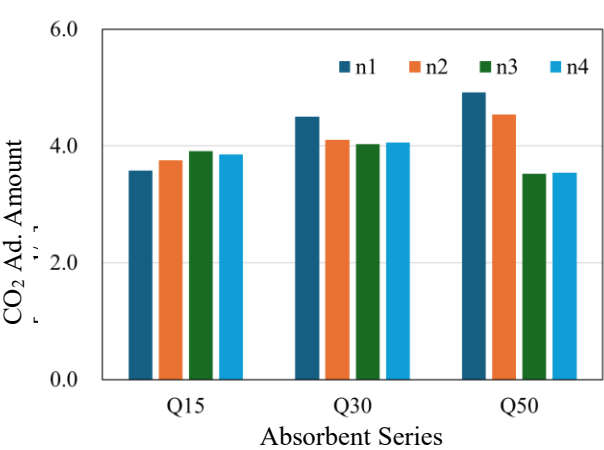


Fig.1 Effect of water vapor on the amount of carbon dioxide adsorption

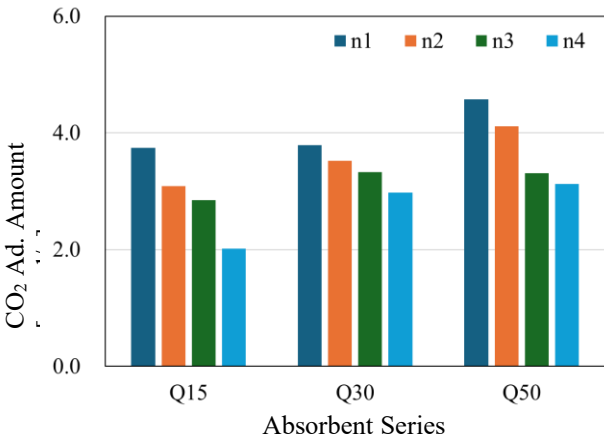


Fig. 2 Effect of sulfur dioxide on the amount of carbon dioxide adsorption