Hydrolysis of Dipeptides and Polyamides Catalyzed by Acid-Base Bifunctional ZrO_2-Based Materials

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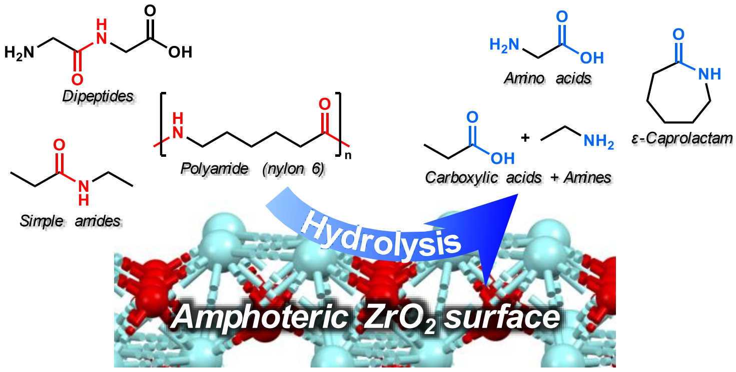
Amide bonds are ubiquitous in small organic compounds, proteins, and engineering plastics such as nylons and aramids). In the latter two categories, catalytic hydrolysis represents an attractive approach for yielding their building blocks from the perspectives of biorefinery and chemical recycling of plastics. However, because the hydrolysis products contain amino and carboxylic acid functional groups, conventional strong acids and bases—typical catalysts for hydrolyzing chemical bonds—are readily deactivated through neutralization by acidic or basic products; consequently, neither strong acids nor strong bases function effectively as catalysts for hydrolyzing amide bonds. Therefore, the development of well-designed catalysts is required for the efficient hydrolysis of amide bonds in proteins and polyamides.

In the hydrolysis of glycylglycine (Gly-Gly) as a model reaction, we found that monoclinic ZrO_2 (m-ZrO_2) functions as an efficient catalyst, producing glycine in up to 97% yield with only a small amount of glycine anhydride under optimized conditions.[1)] In stark contrast, conventional homogeneous acidic and basic catalysts, such as H_2SO_4 and NaOH, exhibited markedly inferior performance. NH_3- and CO_2-temperature-programmed desorption (TPD) measurements indicated that the acid-base bifunctionality of m-ZrO_2 plays a crucial role in the Gly-Gly hydrolysis. Furthermore, the m-ZrO_2 catalyst exhibited a broad substrate scope. Various dipeptides containing acidic or basic amino acid residue(s) were successfully hydrolyzed into their corresponding components at 373 K. In addition, nylon 6 was hydrolyzed into ε-caprolactam (81% yield) and ε-aminocaproic acid (13%) at 503 K, which is significantly lower than the temperatures previously reported for the hydrolysis of nylon 6 (≥573 K).



Reference 1) S. Tomita, M. Yabushita, Y. Nakagawa, K. Tomishige, *Catal. Sci. Technol.* 14, 3898–3908 (2024).

Biography (For Plenary, Keynote, and Invited Speakers)

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Personal History:
Mizuho Yabushita received his Ph.D. from Hokkaido University in 2015 under the supervision of Prof. Atsushi Fukuoka. He then pursued his postdoctoral research in the groups of Prof. Alexander Katz at University of California, Berkeley and Prof. Atsushi Fukuoka at Hokkaido University. He was appointed as an Assistant Professor at Tohoku University in the group of Prof. Atsushi Muramatsu (2018–2020) and subsequently in the group led by Prof. Keiichi Tomishige (since 2020). He has served as a member of Early Career Advisory Board of *ChemSusChem* (Wiley; since 2023) and Early Career Editorial Board of *Applied Catalysis A: General* (Elsevier; since 2024). In addition, he is also serving as Chair of Young Scientists Committee of the 19th International Congress on Catalysis (19th ICC), held in Kyoto in 2028. He has received many awards and honors, including the Emerging Investigator of *Green Chemistry* (Royal Society of Chemistry; 2025), the Japan Petroleum Institute Award for Encouragement of Research and Development (2025), and the Catalysis Society of Japan Award for Young Researchers (2026).

Research Keyword (3-5 keywords use commas to separate each word):
Heterogeneous catalysis, Biomass conversion, Carbon neutrality, Hydrolysis, Carbon dioxide