

Materials Science

Rare-earth-metal-alloyed mesoporous PtPb nanosheets for selective electrosynthesis of glyceric acid from glycerol upcycling

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Received 4 September 2025; Accepted 4 September 2025; Published online 5 September 2025

Mesoporous metals have shown considerable promise in the field of electrocatalysis due to their intrinsic properties [1,2]. On one hand, high porosity offers a larger surface area than solid nanoparticles, significantly enhancing the utilization efficiency of precious metals [3–5]. On the other hand, the continuous crystalline framework facilitates rapid electron and mass transfer while inhibiting Ostwald ripening, thereby significantly enhancing electrocatalytic activity and stability [2]. More importantly, nanopores create a confined, enzyme-like microenvironment that modulates local electronic states and reaction conditions, steering catalytic selectivity [6]. Despite their great potential, the application of mesoporous metals, especially through precise modulation of electronic structure to achieve single-product selectivity in complex electrocatalytic reactions, remains limited.

The rapid growth of the biodiesel industry has resulted in a significant surplus of its byproduct, glycerol, which has drastically reduced its market value. Glycerol upcycling via electrochemical oxidation reaction (GOR) offers an appealing “waste-to-wealth” strategy to convert this abundant resource into high-value chemicals [7]. Among the various products, glyceric acid (GLA) is especially crucial due to its wide applications in the food, pharmaceutical, and chemical industries [8]. However, the GOR process involves a complex network of parallel reaction pathways, leading to the generation of numerous byproducts, including lactic acid (LA), tartronic acid (TA), formic acid (FA), glycolic acid (GA), acetic acid (AA), and others [9]. The inherent complexity of the GOR process makes achieving high selectivity for GLA extremely challenging. Consequently, the development of advanced electrocatalysts with superior activity and selectivity for GLA production remains a primary challenge in realizing the practical potential of this sustainable process.

In a recent report, Fan *et al.* [10] successfully synthesized a new class of two-dimensional rare-earth-metal-alloyed PtPb mesoporous nanosheets (REM-PtPb MNSs) electrocatalyst via a well-designed two-step, template-free selective etching route (Figure 1a). By screening more than 10 rare-earth metal elements, the authors found that yttrium-alloyed PtPb MNSs (PtPbY MNSs) exhibited the highest performance for selective GOR electrocatalysis, demonstrating notable activity and selectivity for GLA electrosynthesis. In contrast to traditional mesoporous metals, PtPbY MNSs exhibited a nearly hexagonal, quasi-single-crys-

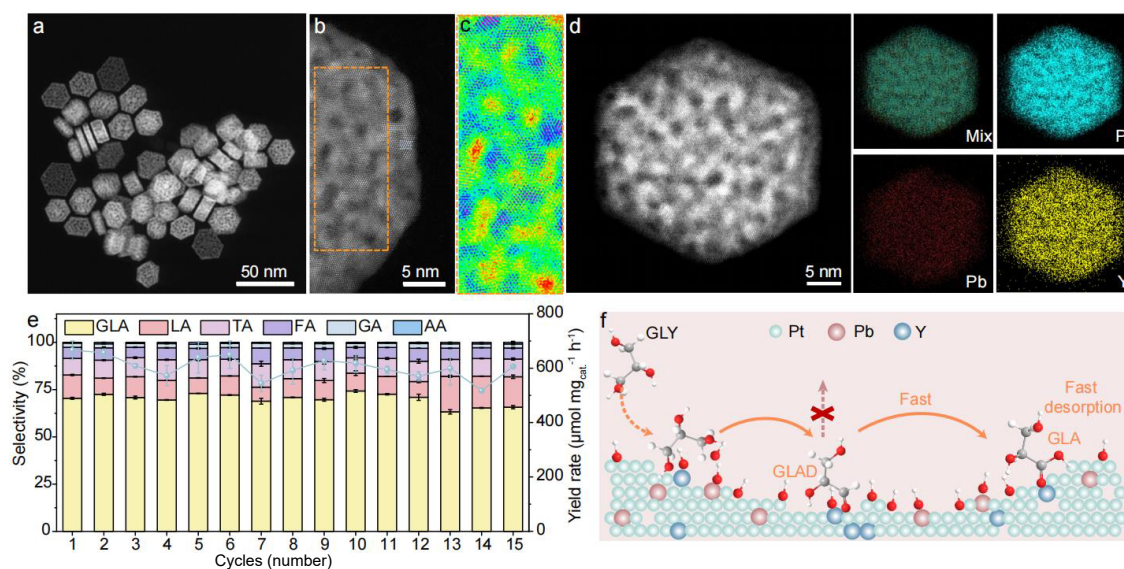


Figure 1 (a) Low-magnification high-angle annular dark field scanning transmission electron microscopy (HAADF-STEM) image. (b) High-resolution HAADF-STEM images. (c) Equalized rainbow color mode image. (d) HAADF-STEM energy dispersive X-ray spectroscopy (EDX) mapping images of PtPbY MNSs. (e) Electrocatalytic performance. (f) Proposed mechanism of PtPbY MNSs for selective GLA electrosynthesis from GOR. Reprinted with permission from Ref. [10]. Copyright 2025, The Author(s).

talline structure, with a high density of uniform mesopores (2–4 nm) (Figure 1b, c). These mesopores, which penetrated the entire nanosheets, not only increased the specific surface area and provided abundant unsaturated sites but also helped modulate the chemisorption behavior of OH^- , which is crucial for the upcycling of glycerol into GLA. Furthermore, the rare-earth metal yttrium was found to effectively modify the surface electronic structure of Pt atoms, optimizing both the chemisorption strength and the configuration of reactive species (Figure 1d). As a result, PtPbY MNSs achieved a selectivity of 72.5% and a yield of $656 \mu\text{mol mg}_{\text{cat}}^{-1} \text{h}^{-1}$ for GLA electrosynthesis (Figure 1e). Additionally, PtPbY MNSs demonstrated good stability, with minimal performance decay after 15 consecutive cycles, suggesting their potential for practical applications. The experimental and theoretical studies reveal that the high performance of PtPbY MNSs can be attributed to the synergistic effects of the structure and composition, which enhanced glycerol reactivity, facilitated GLA desorption and minimized undesired C–C bond cleavage (Figure 1f).

In summary, the authors developed a class of functional REM-PtPb MNS electrocatalysts that facilitate the selective electrosynthesis of high-value GLA from waste glycerol through the optimization of chemisorption properties. These electrocatalysts are capable of effectively extending to various electrocatalytic oxidation reactions, promoting the selective production of additional valuable chemicals. Furthermore, the electrochemical oxidation reaction at the anode is expected to be coupled with cathodic reduction reactions in a two-electrode system, enhancing the production of more valuable chemicals. Overall, this study makes a significant contribution to the sustainable valorization of biomass feedstocks and highlights the importance of optimizing chemisorption properties to modulate the electrocatalytic process.

Conflict of interest

The authors declare no conflict of interest.

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