

Direct dehydrogenation of ethane over Pt/Sn–Ca/Al₂O₃ catalyst

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To obtain the catalyst, Al₂O₃ support (Procatalyse, France) was impregnated with a solution of SnCl₄•5H₂O (Vekton, Russia, 98.0%) and Ca(NO₃)₂•4H₂O (Labtech, Russia, 99.9%) salts. NaOH solution was then slowly added dropwise with constant stirring. The resulting sample, after 5-fold washing with a dilute ammonia solution, was dried at room temperature for 24 h. Drying was then continued at 120 °C for 8 h, after which it was calcined at 500 °C in nitrogen stream. After calcination, the sample was impregnated with a solution of H₂PtCl₆, after which it was treated in air at 500 °C for 4 h. Immediately before the experiment, the resulting catalyst was activated in hydrogen for 2 h at 650°C.

Physico-chemical research of the catalysts

X-ray photoelectron spectra (XPS) were recorded on a Kratos Axis Ultra DLD spectrometer. Monochromatic Al-K α radiation with an energy of $E=1486.6$ eV was used. Transmission energy was 160 eV for overview and 40 eV for individual lines.

The crystal structure of the catalysts was studied using X-ray diffraction (XRD). XRD was performed at room temperature using a Rigaku D/Max-2500 diffractometer with Cu-K α radiation.

Target-oriented approach was utilized for the optimization of the analytic measurements.^{S1} Before measurements the sample was mounted on a 25 mm aluminum specimen stub, fixed by conductive carbon tape and coated with a 30 nm carbon film. The observations were carried out using Hitachi Regulus8230 field-emission scanning electron microscope (FE-SEM). Images were acquired in backscattered electron mode (compositional contrast) at a 20 kV accelerating voltage and in secondary electron mode at a 3 kV accelerating voltage. EDS-SEM studies were carried out using Bruker Quantax 400 EDS system equipped with XFlash 6|60 detector at a 20 kV accelerating voltage.

ICP-AES analysis was performed using an Agilent 720 instrument. A 25 mg portion of the solid sample was placed into 50 ml polypropylene Falcon tubes, and 15 ml of concentrated nitric acid and 5 ml of concentrated hydrochloric acid were added. All reagents were chemically pure grades. The mixture was kept at 60 °C for 1 h and then left at room temperature for 12 h. The resulting solution was transferred to a 25.0 ml class B volumetric flask and diluted to the mark with deionized water. Before analysis, the solutions were diluted 10- and 100-fold. Optimization of the ICP-AES conditions was carried out according to the procedure described earlier.^{S2} Elemental determination by ICP-AES was performed using the following analytical lines: Ca 315.887, 317.933, 373.690, 393.366 and 396.847 nm; Na 568.821 and 589.592 nm; Pt 191.107, 203.646, 214.424, 217.468, 224.552 and 265.945 nm; and Sn 189.925 and 235.485 nm. Element concentrations were calculated as the average of at least two analytical lines; the variation between the results did not exceed 5.0%. To enhance the reproducibility of the results, the Sc line at 335.372 nm was utilized as an internal standard at a concentration of 20 mg dm⁻³ and was mixed online with the sample.

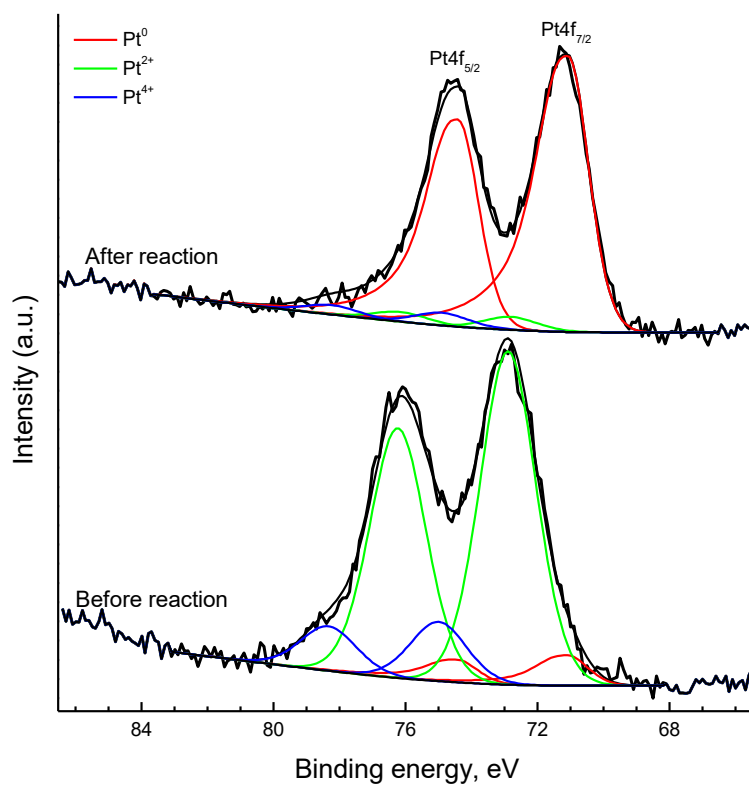


Figure S1 Pt4f XPS spectra of the samples.

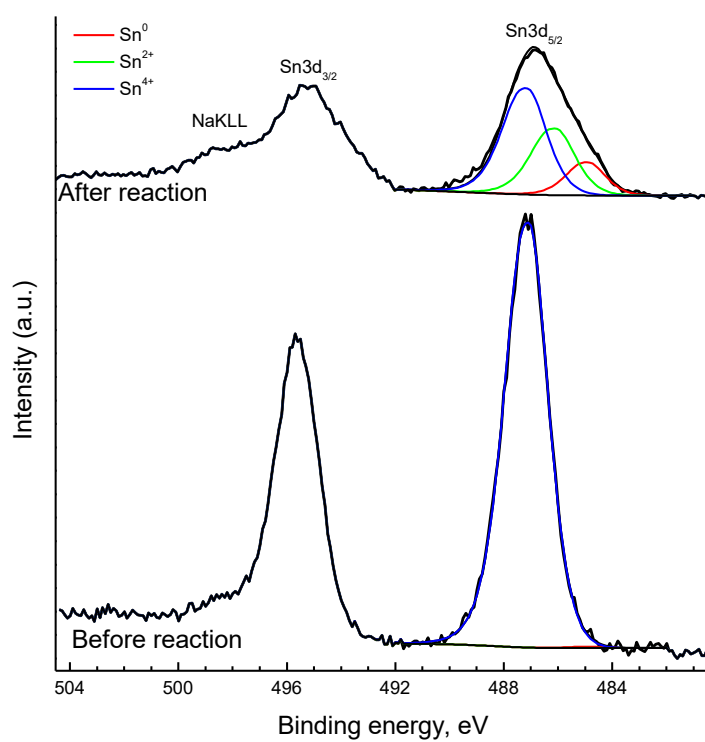


Figure S2 Sn3d XPS spectra of samples.

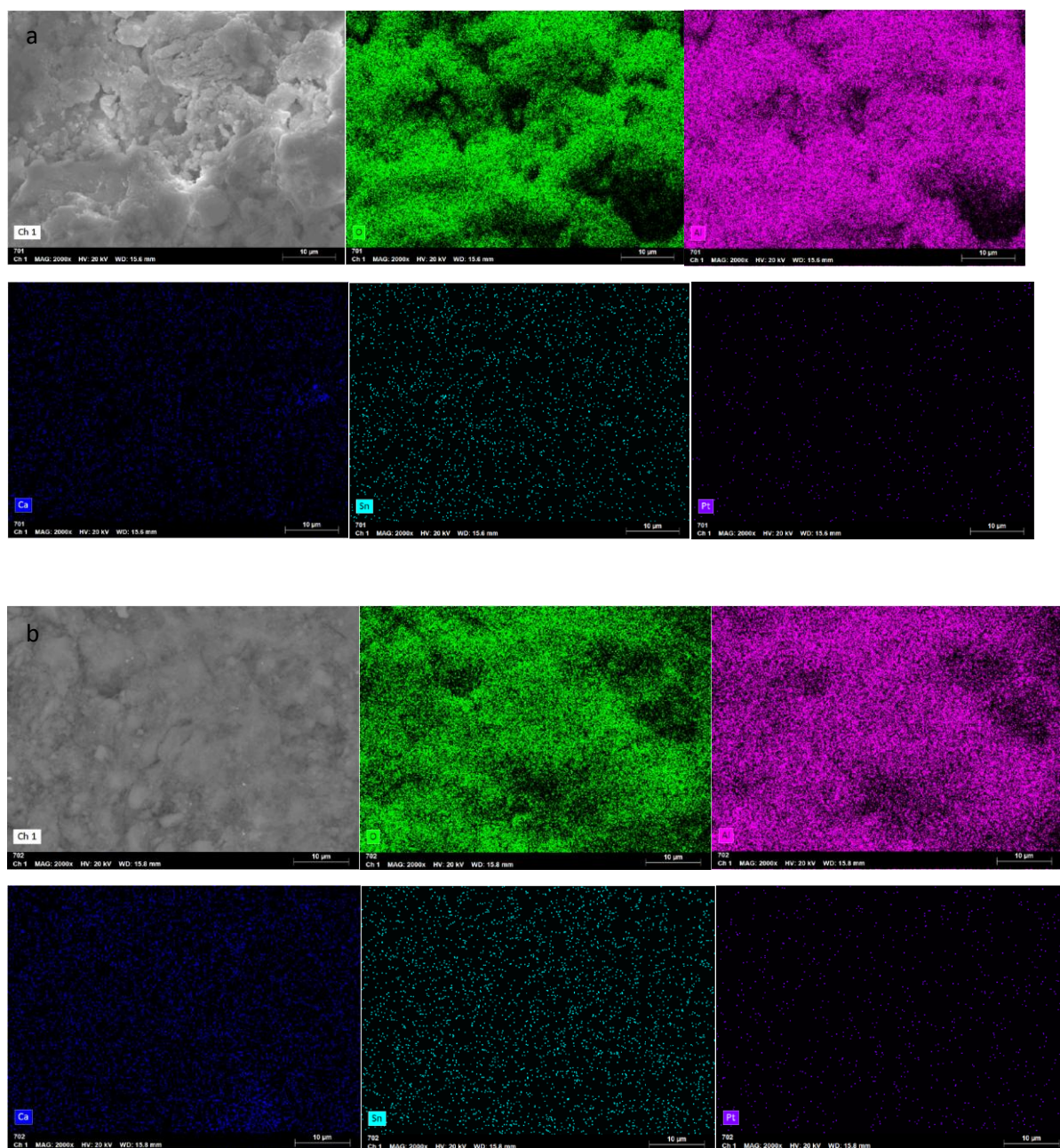


Figure S3 SEM micrographs and EDX elemental mapping of the Pt–Ca–Sn/Al₂O₃ catalyst: (a) before catalysis and (b) after catalysis.

References

- S1 V. V. Kachala, L. L. Khemchyan, A. S. Kashin, N. V. Orlov, A. A. Grachev, S. S. Zalesskiy and V. P. Ananikov, *Russ. Chem. Rev.*, 2013, **82**, 648; <https://doi.org/10.1070/rc2013v082n07abeh004413>.
- S2 I. A. Poimenova, E. Yu. Zhukova, S. T. Ovseenko, N. S. Saratovsky, I. K. Kiryukhin, D.-M. V. Ratova, D. M. Filatov, A. M. Alekseeva, S. V. Smirnova, M. A. Proskurnin and I. V. Mikheev, *Anal. Chim. Acta*, 2026, **1392**, 345140; <https://doi.org/10.1016/j.aca.2026.345140>.