catalysts

Supplementary Information

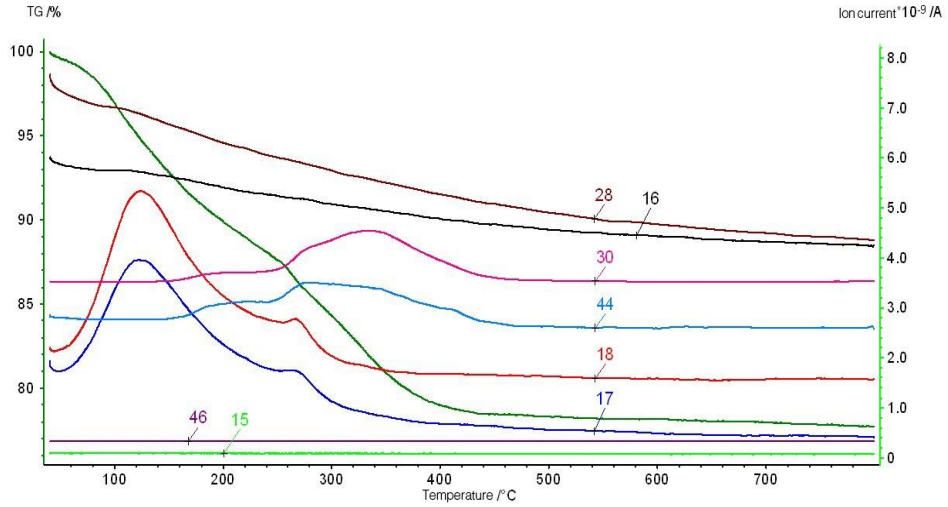

Figure S1. TGA curves for the sample 20CZ/Si-5.

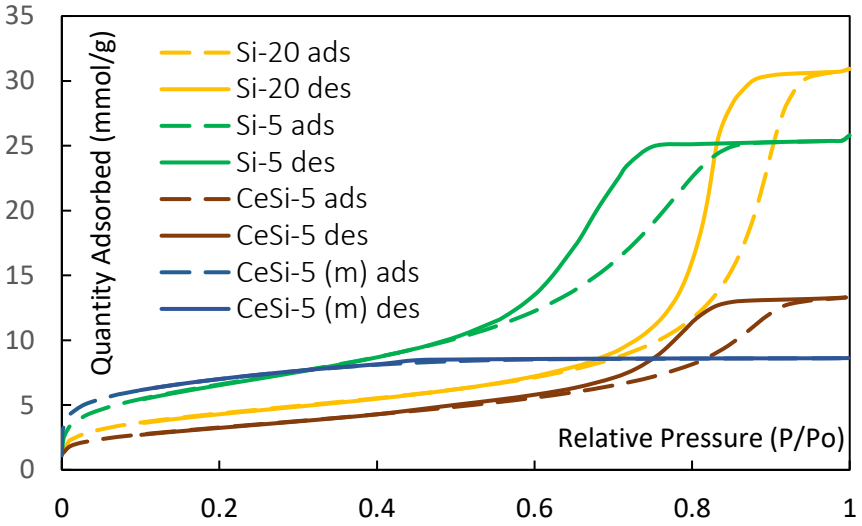

Figure S2. N_2 adsorption-desorption curves for the supports.

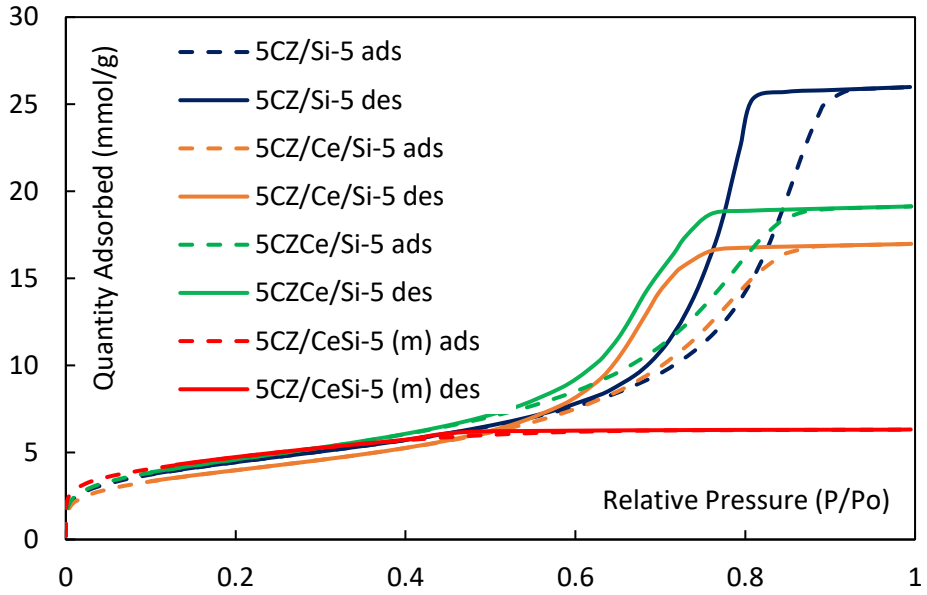

Figure S3. N_2 adsorption-desorption curves for the catalysts.

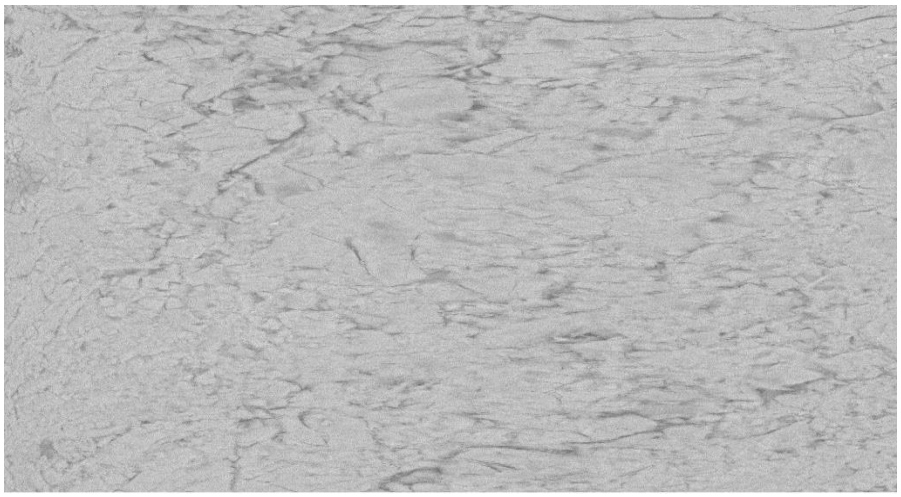

Figure S4. SEM image of the sample 5CZ/CeSi-5.

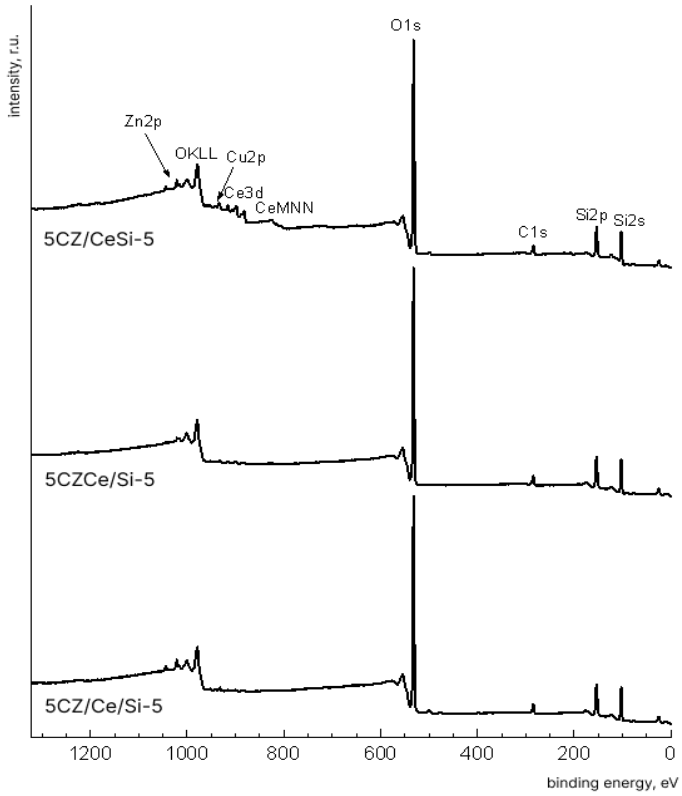

Figure S5. General XPS-spectra of the ceria-based samples.

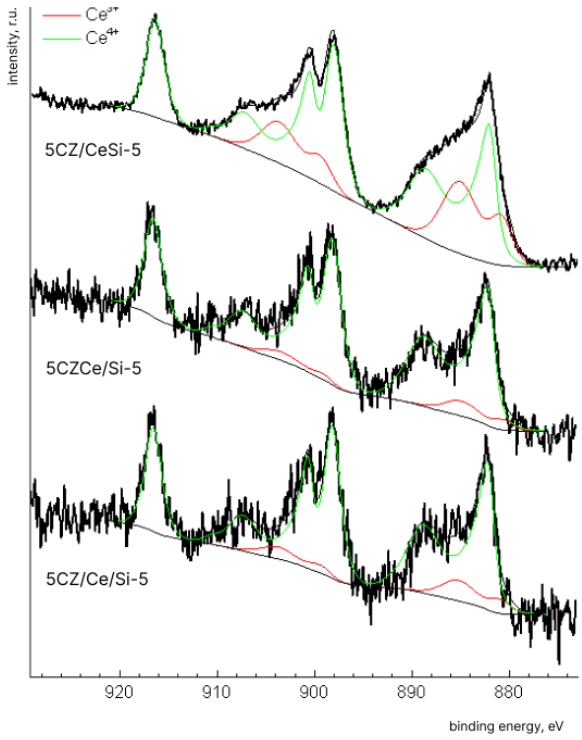

Figure S6. Ce3d-XPS-spectra of the samples.

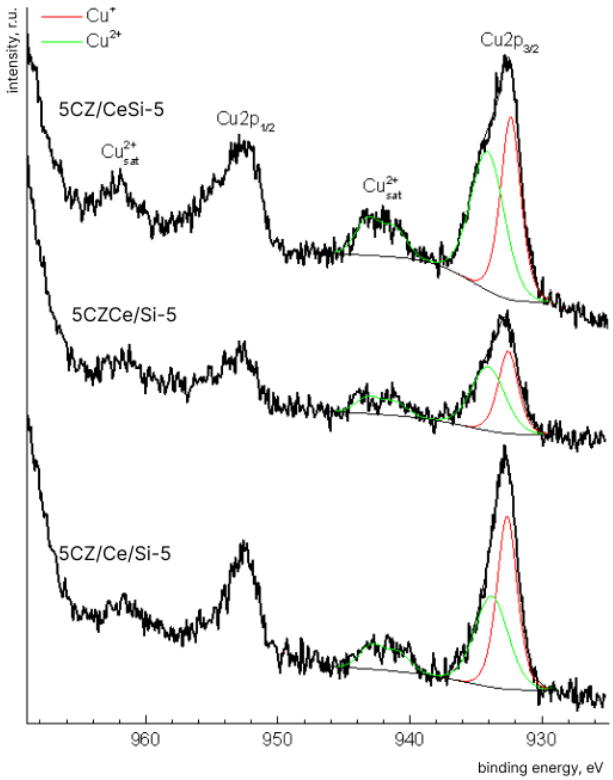

Figure S7. Cu2p-XPS-spectra of the samples.

Thermal behaviour of the precursors was investigated by thermogravimetric and differential thermal analyses with mass-spectrometric analysis of gaseous decomposition products. This study was carried out by using a NETZSCH STA 409 PC LuxxÒ (Germany)combined with a NETZSCH QMS 403 C AëolosÒ quadrupole mass spectrometer (Germany). The samples were heated from room temperature up to 800-900 °C under an air flow 50 ml min^{-1} at a heating rate of 10 °C per minute.

The phase composition of the samples was studied by XRD. X-ray diffractograms were recorded in the 2Theta range of 10–80° using a RigakuDMAX2500 diffractometer (Japan) with the rotating anode operating in the reflection mode using the Cu Kα radiation and a graphite monochromator. ICDDPDF2 database (PCPDFWIN, Version 2.2, June 2001, JCPDS-ICCD) was used for phase identification. The X-ray diffractograms were treated with the WinXPow software package.

The textural properties of the samples were measured by low-temperature N_2 physisorption using an ASAP 2020 Plus unit (Micromeritics, Norcross, GA 30093, USA). The micropore contribution was evaluated using the t-plot method.

EDX characterization was carried out using a Leo Supra 50VP device with microanalysis system INCA Materials Energy+Oxford (Leo Carl Zeiss SMT LTD, Germany). The detector resolution was 129 eV at the line K_α(Mn). The pressure of nitrogen was 40 Pa. Before the measurement, the samples were pressed into tablets by using an Emmevi OG5-F01 press.

XPS spectra were measured using an Axis Ultra DLD (Kratos Analytical, UK) with the energy 160.40 eV at the line AlK_α and the calibration of Si2p – 103.2 eV.

EPR spectra were recorded in the X-band ($\nu \approx 9.1$ GHz) with a Varian E-4 radio spectrometer (USA) at room temperature. The spectra were simulated using the EasySpin package [1].

The magnetic properties were recorded with a Quantum Design PPMS (QD, USA) system in the fields up to 5 T at room temperature.

References

1. Rahman, I.A.; Padavettan, V. Synthesis of silica nanoparticles by sol-gel: size-dependent properties, surface modification, and applications in silica-polymer nanocomposites—a review J Nanomater, 2012, 15. DOI: 10.1155/2012/132424