Innovative Production of 3D-Printed Ceramic Monolithic Catalysts for Oxidation of VOCs by Using Fused Filament Fabrication

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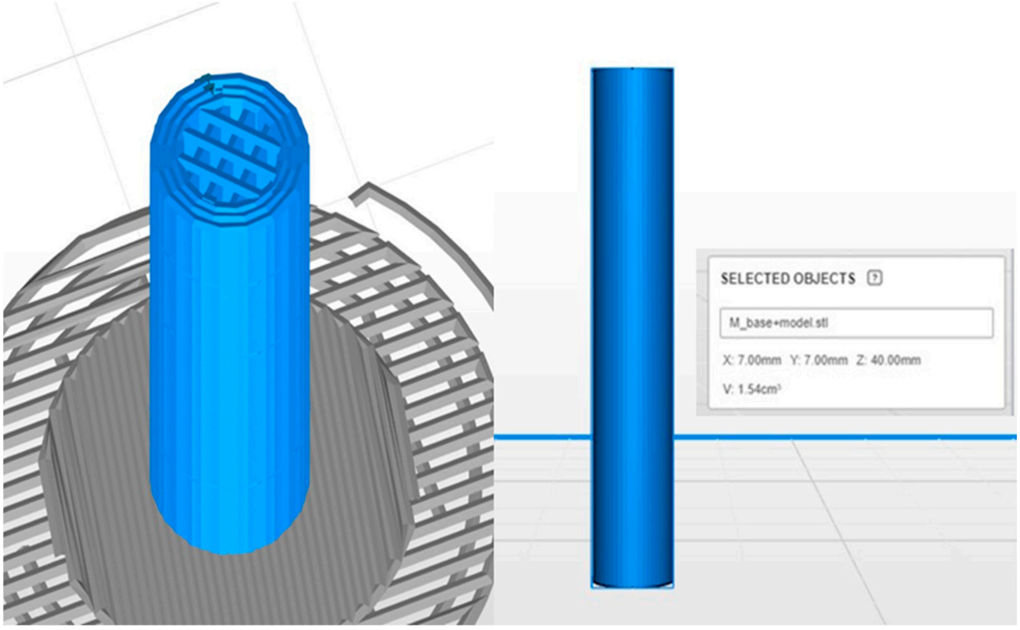

Figure S1. CAD model of 3D-printed catalyst carrier M.

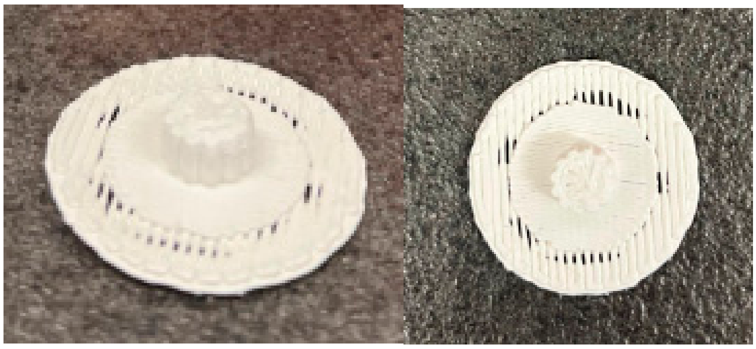

Figure S2. 3D-printed model with default 3D-printing settings.

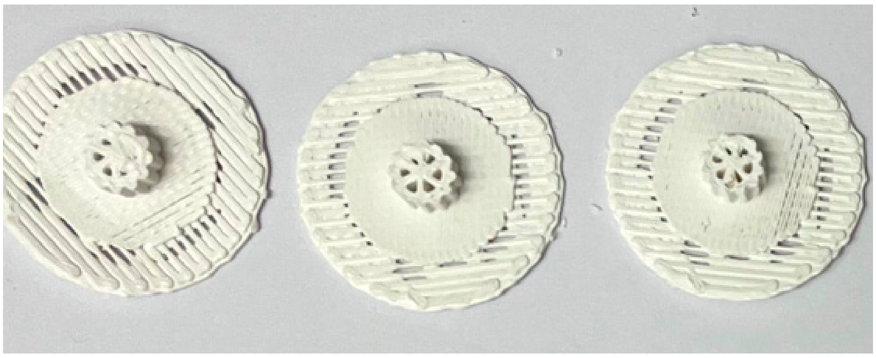

Figure S3. 3D-printed model with EFR print settings (from left to right): -20%, -40%, -50%.

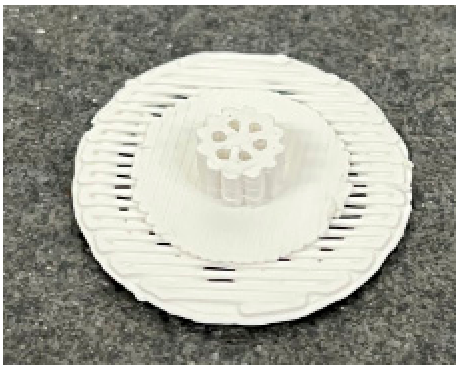

Figure S4. Monolithic catalyst carrier with ZDP geometry, obtained by optimizing the settings and increasing the cooling rate of the material.

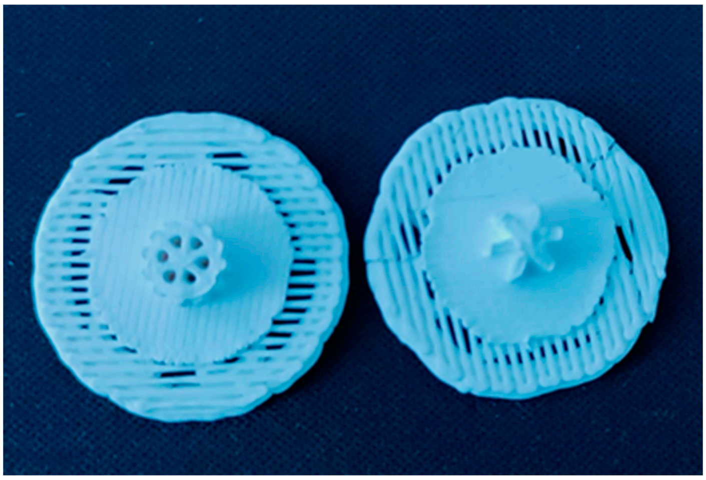

Figure S5. Catalyst carriers ZDP (left) and Z (right) 3D-printed using optimal 3D-printing settings.

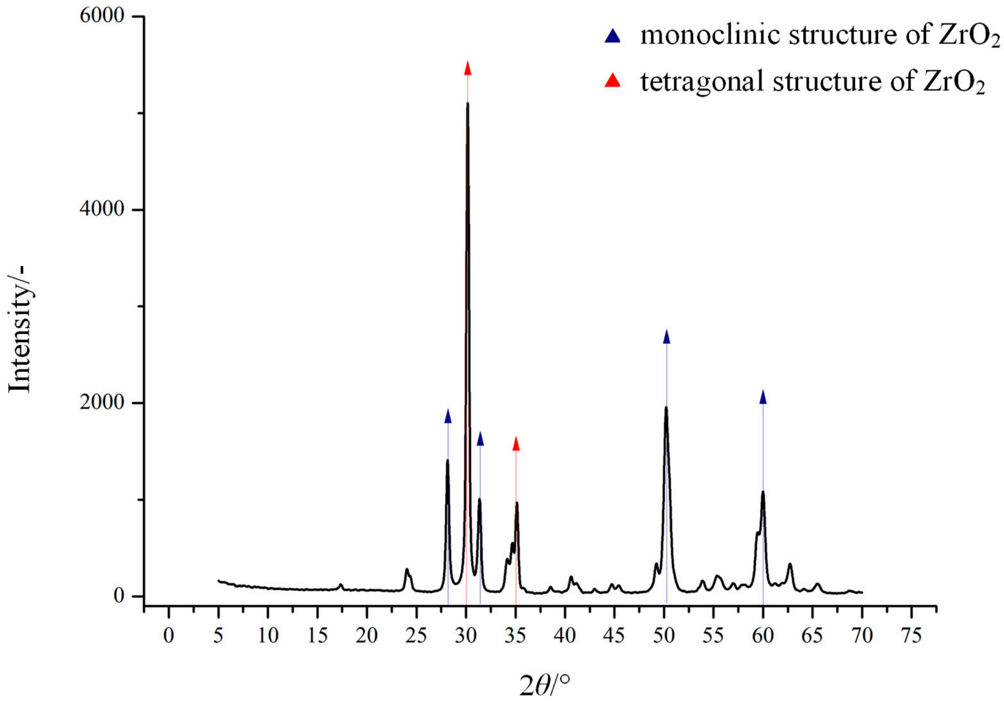

Figure S6. X-ray diffractogram of the ZrO_2-based composite filament.

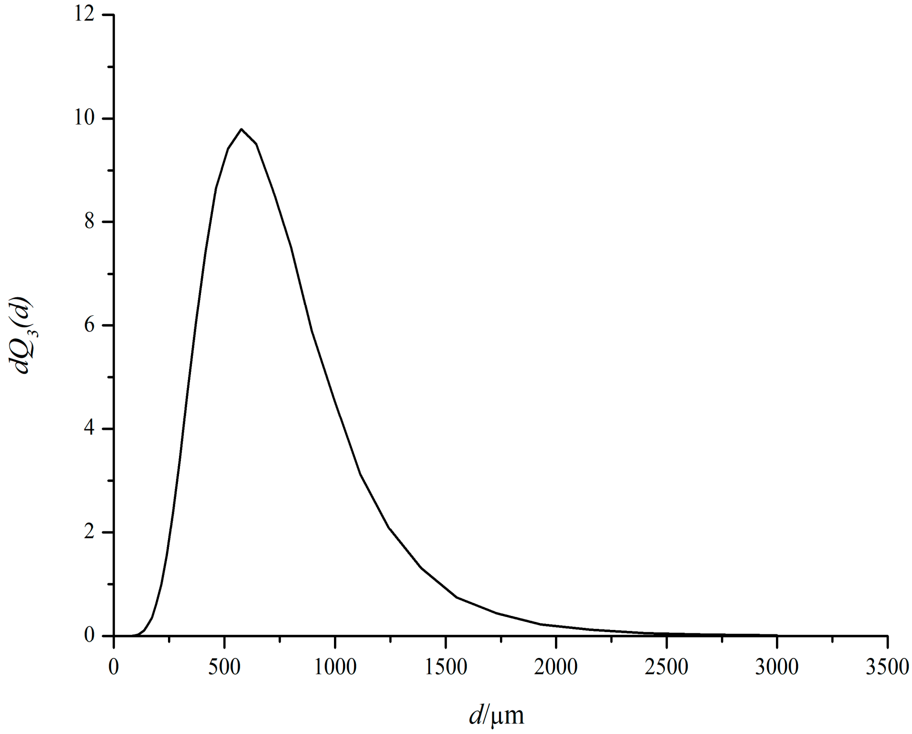

Figure S7. Size distribution of ceramic particles in ZrO_2-based filament.

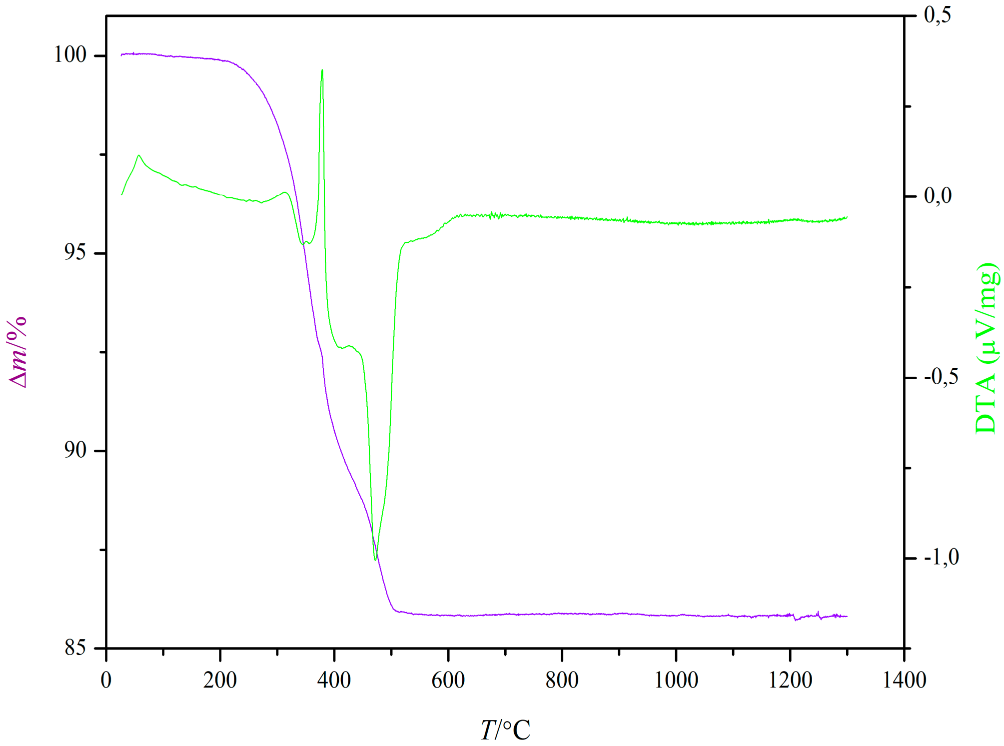

Figure S8. Results of simultaneous TGA/DTA analysis of the ZrO_2-based filament.

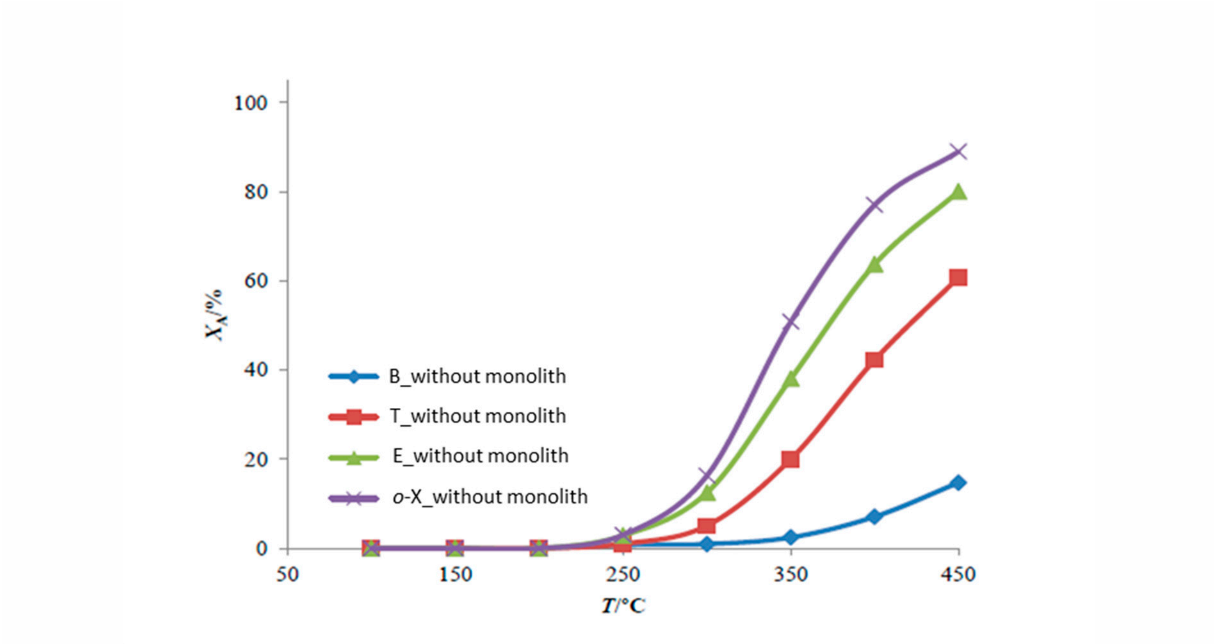

Figure S9. Homogeneous oxidation of BTEX on a monolithic support M without a catalytic layer at a total reaction mixture flow rate of 92 mL/min (B-benzene; T-toluene, E-ethylbenzene, *o*-X-*o*-xylene).

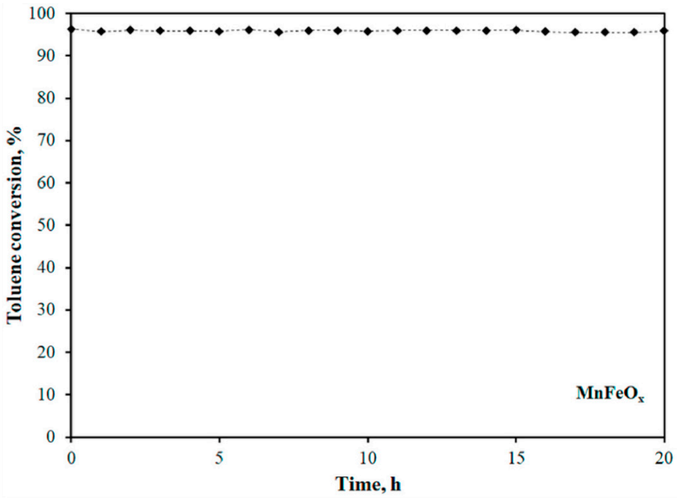

Figure S10. Catalyst stability test using M catalyst carrier with $MnFeO_x$ at 170 °C. The catalytic evaluation was performed 3 times under the same reaction conditions, constant inlet flow rate of the toluene (92 cm^3/min) and constant inlet toluene concentration (51.3 ppm).

Table S1. Weight hourly space velocity (WHSV) values using Z, ZDP, and M catalyst carriers during homogenous oxidation of BTEX compounds.

Geometry	Inlet gas flow (mL/h)	Mass of the catalyst (g)	WHSV (mL/h g)
Z	5520	0,0144	383 333
ZDP	5520	0,0337	163 798
M	5520	0,0503	109 741

Table S2. Insight into the crystalline phases of powder $MnMO_x$ (M: Fe, Cu, Ni) catalyst determined by XRD [34, 35], XPS [34], and Raman spectroscopy [35].

	$MnFeO_x$	**$MnCuO_x$**	**$MnNiO_x$**	**Reference**
XRD	MnO_2 Mn_2O_3 Fe_2O_3 $FeMnO_3$	MnO_2 Mn_2O_3 CuO $CuMn_2O_4$	MnO_2 NiO $NiMnO_3$	Duplančić et al. [34] Car et al. [35]
XPS	MnO_2 Mn_2O_3 Fe_2O_3	MnO MnO_2 CuO	MnO_2 NiO	Duplančić et al. [34]
Raman spectroscopy	MnO_2 Mn_2O_3 Fe_2O_3 $FeMnO_3$	MnO_2 Mn_2O_3 CuO $CuMn_2O_4$	/	Car et al. [35]

Table S3. T_{10}, T_{50}, and T_{90} values for individual BTEX compounds using M monolith without catalytic layer at a reaction mixture flow rate of 92 mL/min during homogenous oxidation of BTEX compounds

	Benzene (B)	Toluene (T)	Ethylbenzene (E)	*o*-xylene (*o*-X)
T_{10}/ °C	421	317	219	277
T_{50}/ °C	> 450	422	374	350
T_{90}/ °C	> 450	> 450	> 450	> 450