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SUPPLEMENTARY INFORMATION

Characterization of Particle Emissions and Fate of Nanomaterials During Incineration

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Table S1 Active surface area concentration in the diluted exhaust from waste containing different nanomaterials

nanomaterial	active surface area ($mm^2\ m^{-3}$)		
	0.1 wt%	1 wt%	10 wt%
silver	24 ± 4	23 ± 5	18 ± 5
NiO	54 ± 8	26 ± 7	4 ± 3
TiO_2	33 ± 6	17 ± 5	6 ± 2
ceria	39 ± 4	12 ± 4	4 ± 4
C_{60}	46 ± 7	5 ± 2	9 ± 4
Fe_2O_3	21 ± 5	9 ± 4	5 ± 3
CdSe QD	26 ± 6	37 ± 7	---
nanomaterial-free	0 wt%		
control[a]	15 ± 5		
paper	14 ± 4		
polyethylene	54 ± 7		
PVC	20 ± 4		

[a]combination of paper, polyethylene, and PVC.

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Table S2 Metal content in the control waste[a]

metal/metal oxide	concentration ($\mu g\ g^{-1}$ of surrogate waste) PM	concentration ($\mu g\ g^{-1}$ of surrogate waste) bottom ash
silver	nd	26±3
nickel	16±1	350±40
titanium	nd	38±8
cerium	nd	40±17
iron	120±16	440±90
cadmium	nd	nd

[a]combination of paper, polyethylene, and PVC.
C_{60} was not detected in the unspiked control waste.
nd not detected

Table S3 Concentration of nanomaterials in the PM and bottom ash fractions

nanomaterial	concentration ($\mu g\ g^{-1}$ of surrogate waste) 0.1 wt% PM	0.1 wt% botttom ash	1 wt% PM	1 wt% bottom ash	10 wt% PM	10 wt% bottom ash
silver	21	260	13	2400	44	29000
NiO	24	620	10[a]	7700	8[a]	110000
TiO_2	1.9	58	0.44	1100	3.5	75000
ceria	nd	57	nd	3800	2.3	82000
C_{60}[c]	nd	nd	1800	nd	6800	nd
Fe_2O_3	75[a]	320	67[a]	6700	82[a]	100000
CdSe QD[b]	6.6	15	56	570	4	40000

All values are corrected for the metal/metal oxide/C_{60} concentration in the unspiked control waste except for values indicated with (a), in which the concentration for unspiked waste is higher than with nanomaterial, [b]measured as Cd, [c]measured by HPLC, nd not detected. The relative standard deviation for six of the samples (two samples at each mass loading) that were run in duplicate was less than 12%.

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Table S4 Particle size and particle number emission factor from the incineration of waste

nanomaterial	median diameter (nm)		emission factor (# g^{-1} of waste) ($\times10^{13}$)	
	0.1 wt%	10 wt%	0.1 wt%	10 wt%
silver	385±17	312±2	1.9±1.8	3.0±0.23
NiO	397±12	319±8	2.2±1.6	3.2±0.19
TiO_2	399±1	310±6	3.3±0.26	3.6±0.14
ceria	392±1	324±12	3.6±0.35	4.4±0.92
C_{60}	397±1	311±2	4.5±0.57	2.4±0.56
Fe_2O_3	398±1	339±14	3.3±0.17	2.9±0.51
CdSe QD	401±3		4.0±0.55	
nanomaterial-free	0 wt%		0 wt%	
control	400±3		1.2±0.25	

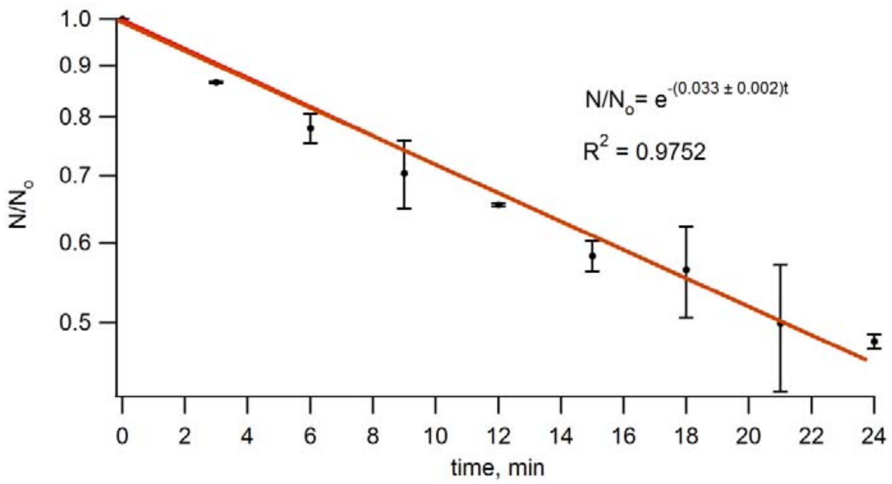

Fig. S1 Loss in total number concentration for NaCl particles in the aerosol holding chamber.

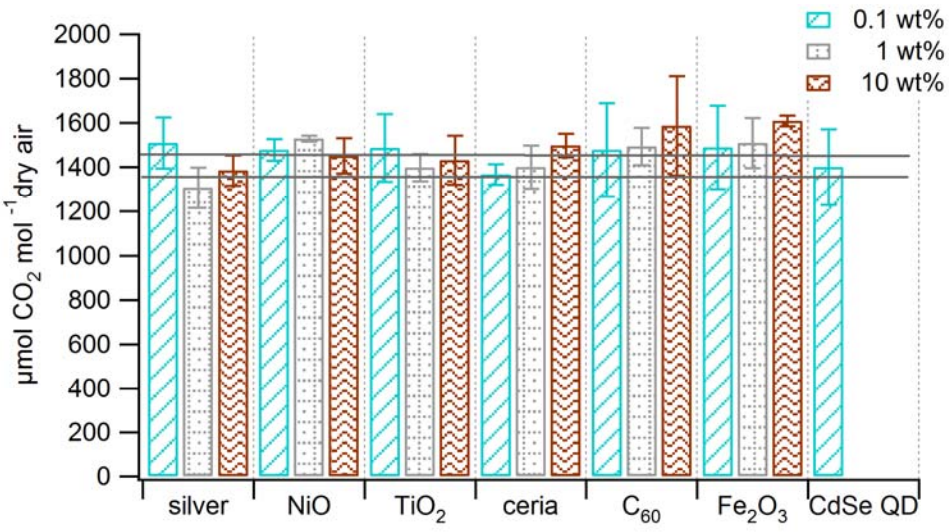

Fig. S2 CO_2 mixing ratio in the undiluted exhaust from samples containing various nanomaterials at different mass loadings. The solid gray lines bound the 95 % confidence interval of the mixing ratio for the unspiked control waste.

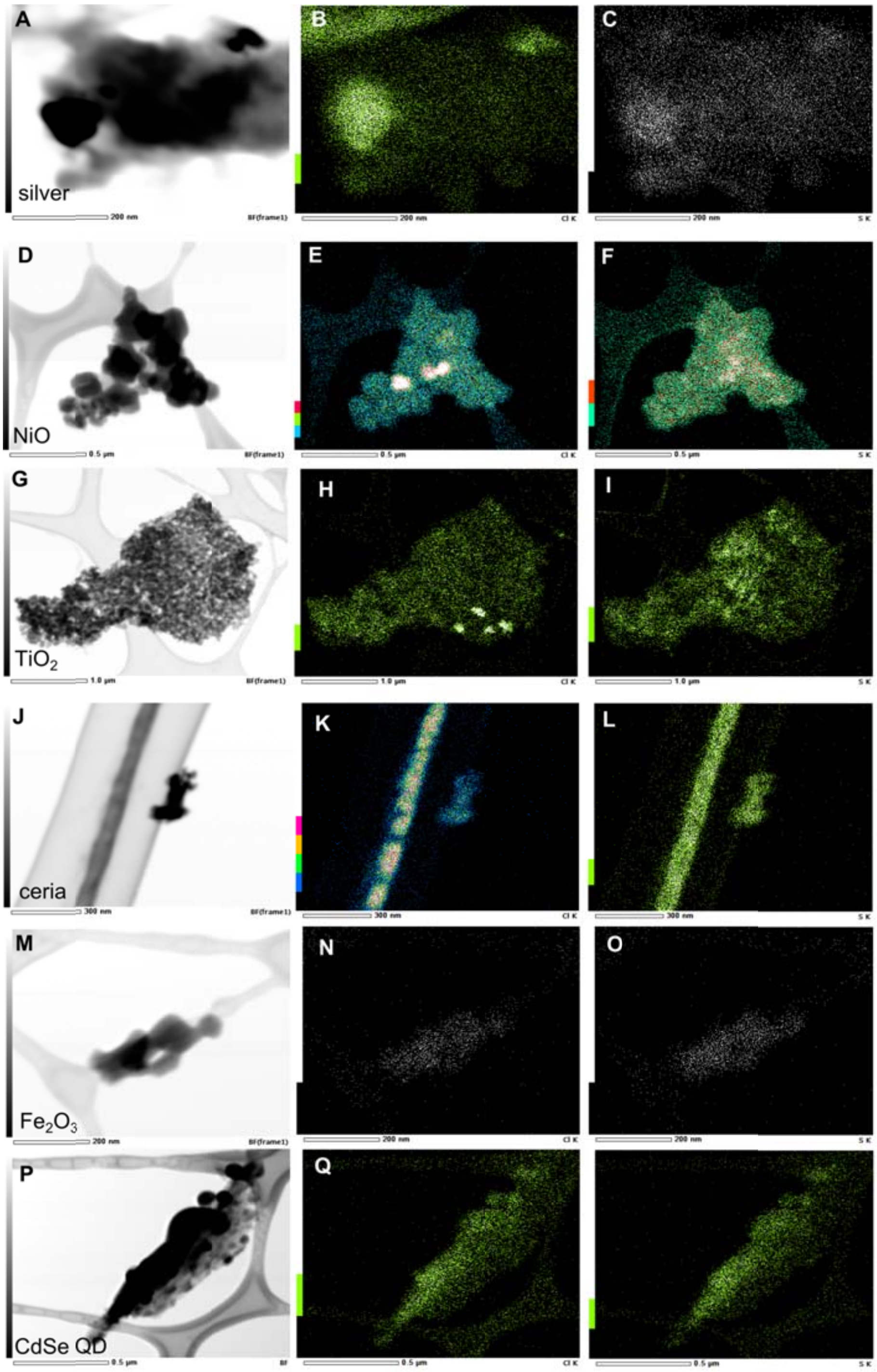

Fig. S3 Brightfield images of particle from waste containing (A) silver, (D) NiO, (G) TiO_2, (J) ceria, (M) Fe_2O_3, and (P) CdSe QD. (B), (E), (H), (K), (N), and (Q) are the chlorine EDX maps and (C), (F), (I), (L), (O), and (R) are the sulfur EDX maps of the brightfield images on the left. Brighter colors indicate higher X-ray counts.

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Equation 1 Propagated uncertainty for ratio

$$\sigma_{A/B} = \sqrt{\left(\frac{1}{B}\sigma_A\right)^2 + \left(\frac{A}{2B^2}\sigma_B\right)^2}$$

where A and B are the means, and σ_A and σ_B are the corresponding standard deviations.

Equation 2 Coagulation coefficient

$$\bar{K} = \frac{2kT}{3\eta}\left[1 + e^{ln^2\sigma_g} + (\frac{2.49\lambda}{\mathrm{CMD}}) \times \left(e^{0.50ln^2\sigma_g} + e^{2.5ln^2\sigma_g}\right)\right]$$

Where:

$\bar{K}$ = Coagulation coefficient
k = Boltzmann constant
T = Temperature
σ_g =Geometric standard deviation
CMD = Class median diameter
λ = Mean free path of air (0.066 μm at 293 K)
η = viscosity of air (1.83 × 10^{-5} Pa·s at 293 K)