Supplementary Information

Lithium-ion batteries: direct solid sampling for characterisation of black mass recyclates using graphite furnace atomic absorption spectrometry

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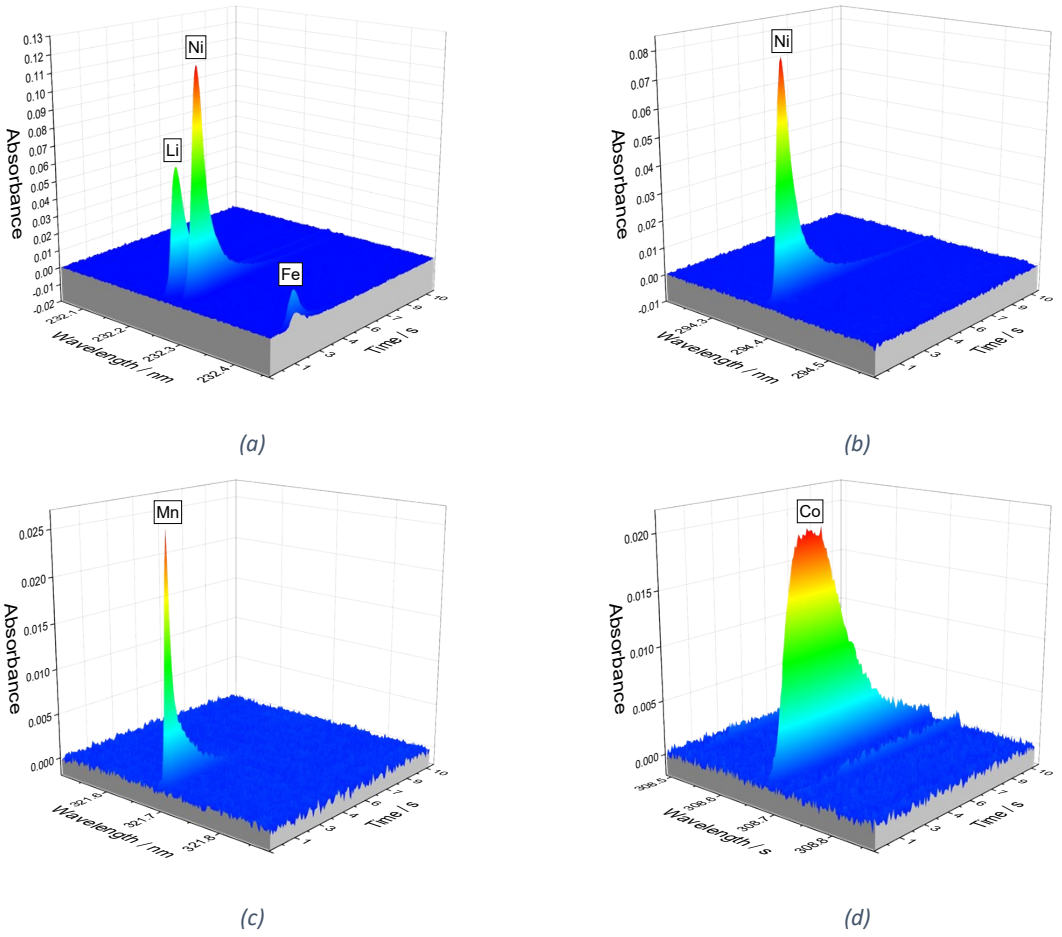
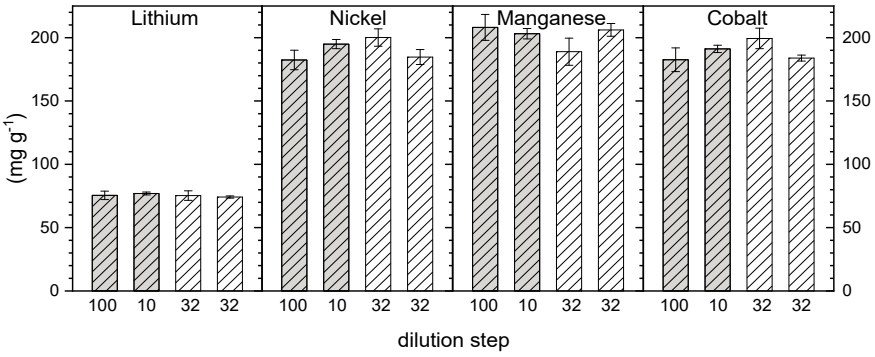
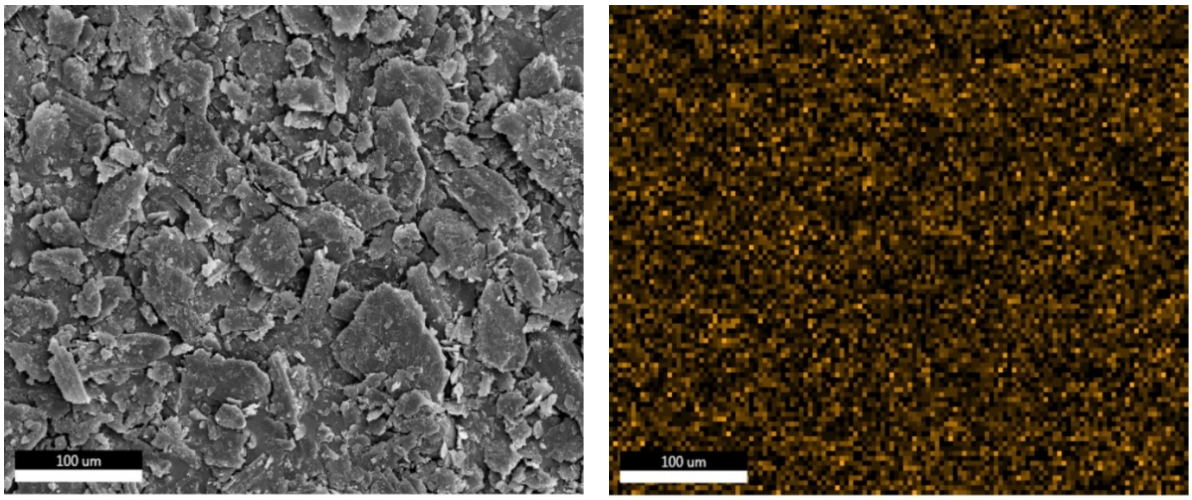


Supplementary Figure S 1. *Time- and wavelength-resolved absorption spectra for about 0.4 mg of solid NMC standard in the vicinity of the* ***(a)*** *Li line at 323.2657 nm* ***(b)*** *Ni line at 294.3912 nm* ***(c)*** *Mn line at 321.6945 nm and* ***(d)*** *Co line at 308.6792 nm usimg the optimised temperature programme for solid analysis with HR-CS GF AAS.*



Supplementary Figure S 2. *Analytical contents (n = 5) for lithium, nickel, manganese and cobalt in NMC/graphite solid dilutions with the successive dilution factors 100/10 and 32/32 (dilution factor 1/dilution factor 2) in mg g^{-1}. The solid samples were dissolved wet-chemically and analysed with ICP-OES. The measurement uncertainty corresponds to 1σ.*



(a) *(b)*

Supplementary Figure S 3. *111NMC/Graphite material (dilution factor 1000): SEM micrograph (a) Magnification 264X, (b) EDX element mapping for nickel indicated by yellow color.*

Supplementary Table S 1 *Calculated stoichiometric ratios of NMC (mean ± standard deviation, n = 3) for the determination of Li, Ni, Mn and Co (mg g^{-1})) in the certified reference material "BAM-S014 Li-NMC 111 Cathode Material" and in various recyclates of cathode coatings.*

		Stoichiometric factors			
Sample		Li	Ni	Mn	Co
CRM BAM-S014 Li-NMC 111	Found ICP-OES Certified	1.25 ± 0.49 1.11 ± 0.01 1.09 ± 0.21	0.32 ± 0.10 0.33 ± 0.01 0.34 ± 0.06	0.34 ± 0.10 0.33 ± 0.10 0.33 ± 0.06	0.34 ± 0.10 0.34 ± 0.01 0.33 ± 0.07
Recyclate 1	Found ICP-OES	0.91 ± 0.37 0.95 ± 0.01	0.41 ± 0.13 0.41 ± 0.01	0.31 ± 0.09 0.29 ± 0.00	0.28 ± 0.10 0.30 ± 0.00
Recyclate 2	Found ICP-OES	0.55 ± 0.21 0.63 ± 0.01	0.39 ± 0.12 0.41 ± 0.01	0.31 ± 0.10 0.29 ± 0.01	0.30 ± 0.10 0.30 ± 0.01
Recyclate 3	Found ICP-OES	0.78 ± 0.08 0.84 ± 0.01	0.39 ± 0.12 0.41 ± 0.01	0.28 ± 0.02 0.29 ± 0.00	0.33 ± 0.03 0.30 ± 0.00
Recyclate 4	Found ICP-OES	0.85 ± 0.38 1.09 ± 0.05	0.57 ± 0.21 0.61 ± 0.02	0.23 ± 0.08 0.21 ± 0.01	0.20 ± 0.09 0.19 ± 0.01