

Leaching of Waste Pharmaceutical Blister Package Aluminium in Sulphuric Acid Media

Sugam Shukla *, Alexander Chernyaev, Petteri Halli, Jari Aromaa and Mari Lundström

Department of Chemical and Metallurgical Engineering (CMET), School of Chemical Engineering, Aalto University, Vuorimiehentie 2 K, 02150 Espoo, Finland;
alexander.chernyaev@aalto.fi (A.C.); petteri.halli@aalto.fi (P.H.); jari.aromaa@aalto.fi (J.A.);
mari.lundstrom@aalto.fi (M.L.)

*Correspondence: sugam.shukla@aalto.fi; Tel.: +358-404873434

Table S1. Leaching experiments and their respective the aluminium extraction (%).

Experimental Set	Experiment Code	Temperature (°C)	H ₂ SO ₄ (M)	S:L ratio (g/L)	Time (hours)	Aluminium Extraction (%)
PE	PE-1	80	0.25	4.0	24	91.69
	PE-2	80	0.50	4.0	24	92.40
	PE-3	80	0.75	4.0	24	91.33
	PE-4	80	1.00	4.0	24	91.40
Experimental Set	Experiment Code	Temperature (°C)	H ₂ O ₂ (vol-%)	S:L ratio (g/L)	Time (hours)	Aluminium Extraction (%)
T1	A1*	40	0	4.5	24	40.96
	A2*	60	0	4.5	24	91.91
	A3*#	80	0	4.5	24	100.00
	A4*	40	1.25	4.5	24	80.80
	A5*	60	1.25	4.5	24	100.00
	A6*#	80	1.25	4.5	24	100.00
	A7*	40	2.5	4.5	24	71.30
	A8*	60	2.5	4.5	24	100.00
	A9*#	80	2.5	4.5	24	100.00
T2	A10	60	1.25	4.5	24	100.00
	A11	60	1.25	4.5	24	100.00
	A12	60	1.25	4.5	24	100.00
T3	A13	50	0	4.5	5	8.04
	A14	70	0	4.5	5	37.20
	A15	50	1.25	4.5	5	25.81
	A16	70	1.25	4.5	5	87.30
	A17	40	0.625	4.5	5	10.80
	A18	60	0.625	4.5	5	56.50
	A19	40	1.875	4.5	5	11.77
	A20	60	1.875	4.5	5	58.64

T4	A21	60	1.25	2.25	5	52.49
	A22	60	1.25	3.375	5	45.64
	A23	60	1.25	5.625	5	41.45
	A24	60	1.25	6.75	5	36.85
	A25	80	1.25	2.25	5	95.48
	A26	80	1.25	3.375	5	91.36
	A27	80	1.25	5.625	5	89.02
	A28	80	1.25	6.75	5	80.83

Table S2. Central composite design and the response for the dissolution experiments

Experimental Code	Coded Values		Uncoded Values		Response
	[T]	[H ₂ O ₂]	Temperature (°C)	H ₂ O ₂ (vol-%)	Rate Constant
A1	-1	-1	40	0	0.00518
A2	0	-1	60	0	0.01674
A3	+1	-1	80	0	0.06324
A4	-1	0	40	1.25	0.00953
A5	0	0	60	1.25	0.04799
A6	+1	0	80	1.25	0.18135
A7	-1	+1	40	2.5	0.00876
A8	0	+1	60	2.5	0.04311
A9	+1	+1	80	2.5	0.17393
A10	0	0	60	1.25	0.04171
A11	0	0	60	1.25	0.04185
A12	0	0	60	1.25	0.04162

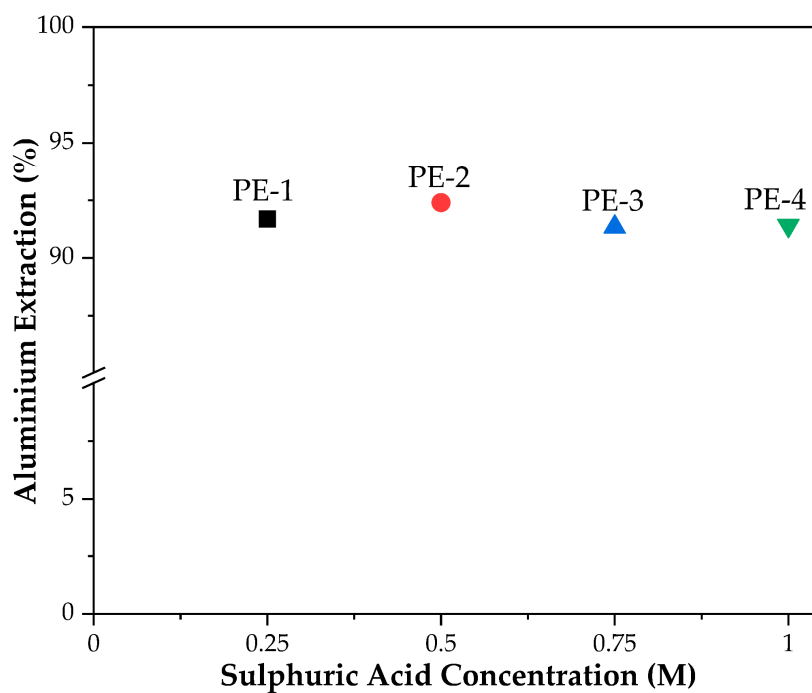


Figure S1. Aluminium extraction for preliminary experiments (experiments PE-1–PE-4) as a function of sulphuric acid concentration (0.25 – 1.0 M)

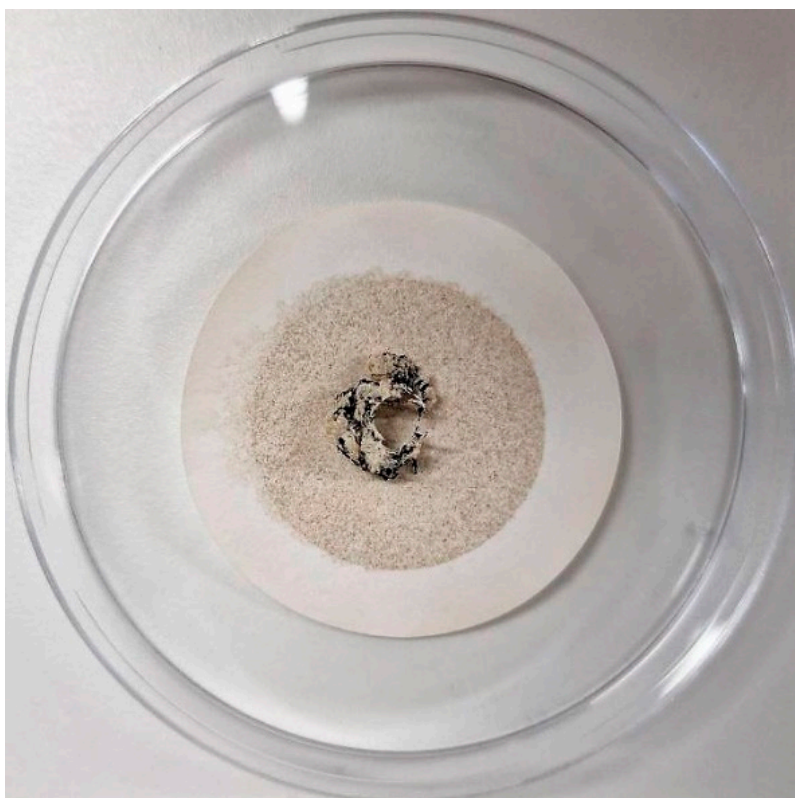


Figure S2. Filtration residue after leaching experiment when total aluminium extraction was achieved

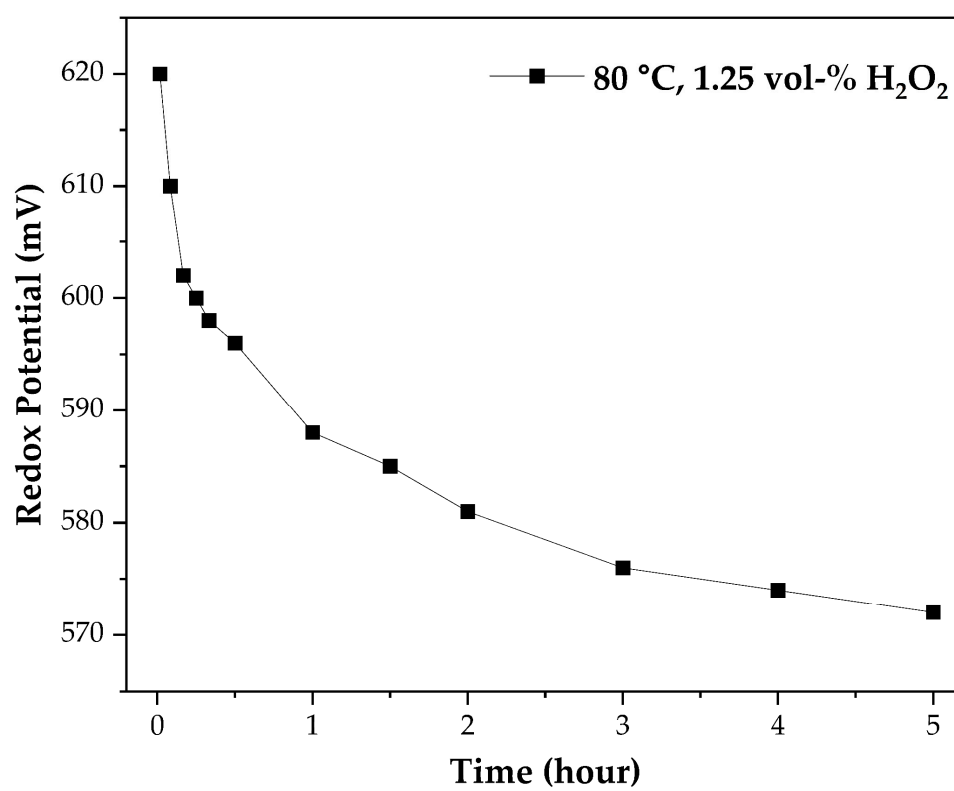


Figure S3. Redox Potential (mV) versus time for leaching system of 1.25 vol-% H_2O_2 in 0.25 M H_2SO_4

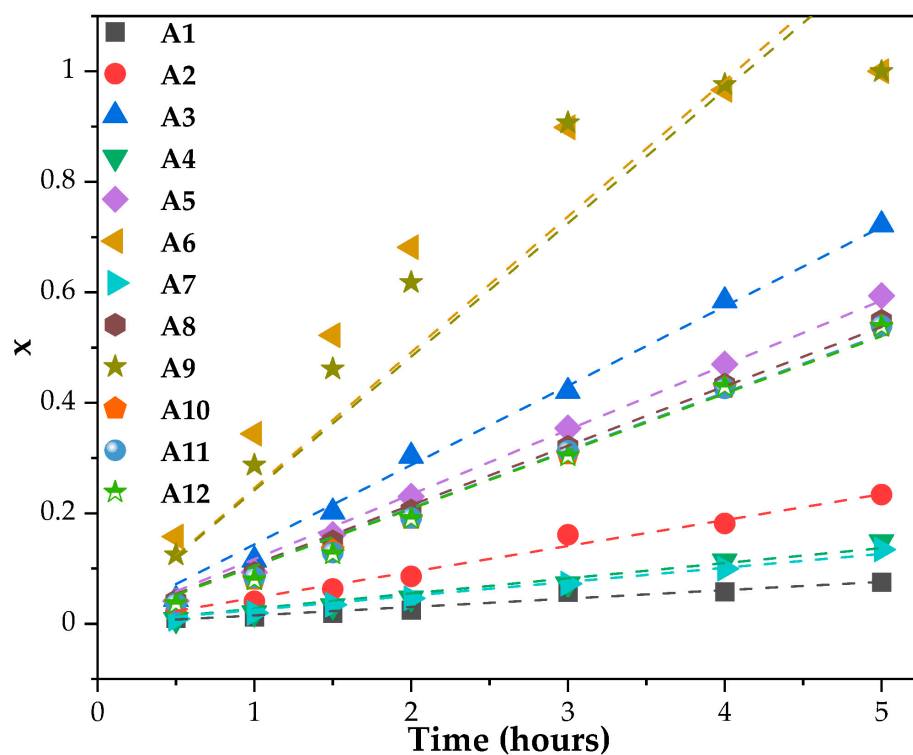


Figure S4. Film diffusion control model fitted for all the leaching experiments (A1-A12) according to first $t = 5$ h ($R^2 = 0.98$ – 0.99 , excluding A6 and A9)

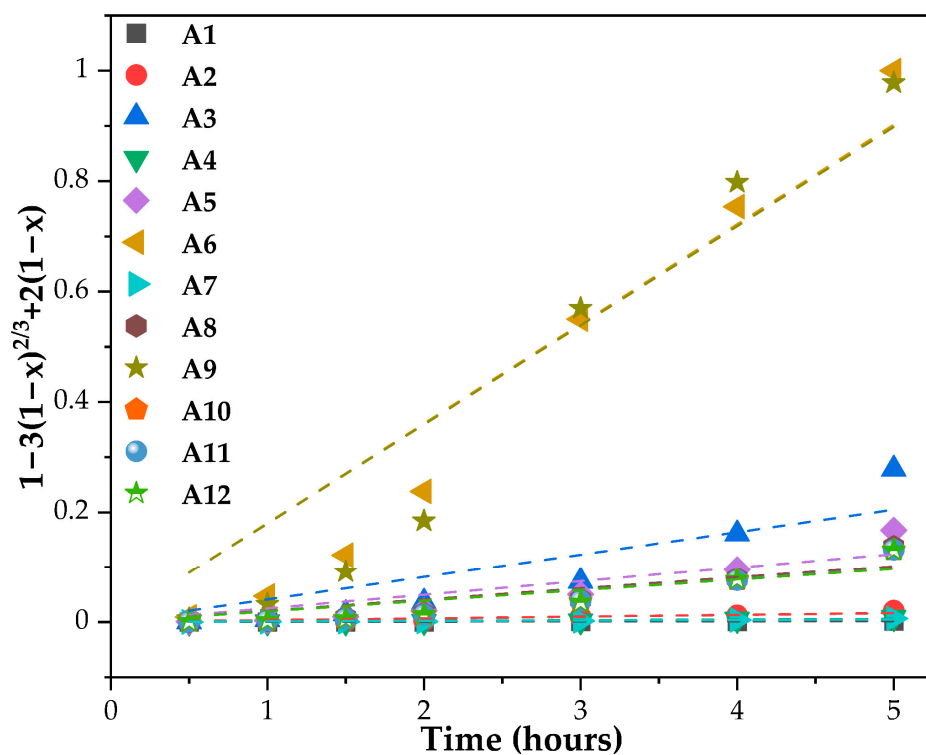


Figure S5. Product layer diffusion control model fitted for all the leaching experiments (A1-A12) according to first $t = 5$ h ($R^2 = 0.85$ – 0.97)

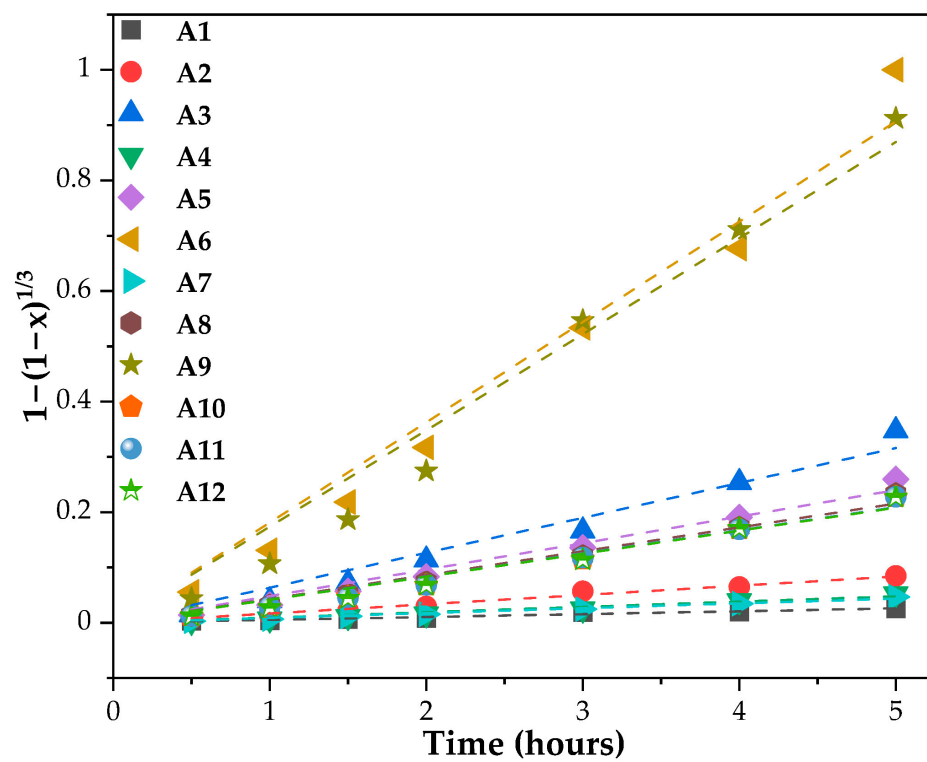


Figure S6. Chemical reaction control model fitted for all the leaching experiments (A1-A12) according to first $t = 5$ h ($R^2 = 0.98-0.99$)