2018 MO99 TOPICAL MEETING

Argonne NATIONAL LABORATORY

FY18 UPDATE ON LARGE-SCALE DISSOLUTION AND RECYCLE PROCESSES FOR NEUTRON CAPTURE, AND ACCELERATOR DRIVEN PRODUCTION OF MO-99

PETER TKAC

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U.S. DEPARTMENT OF ENERGY

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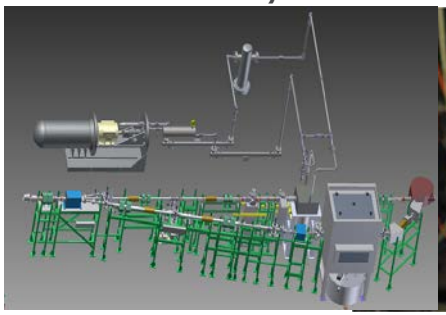
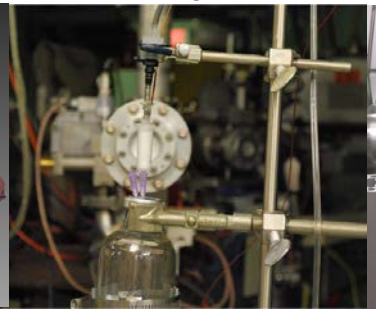
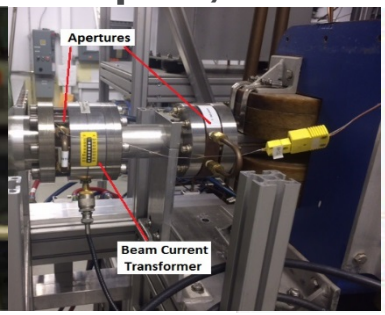
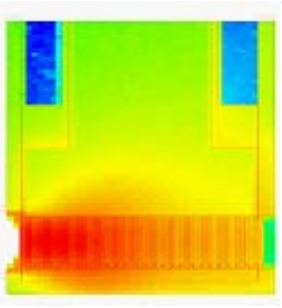
ARGONNE'S SUPPORT TO NORTHSTAR

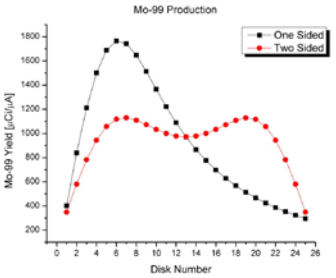
Irradiations, radiation dose, beam transport, shielding and target design, MCNPX



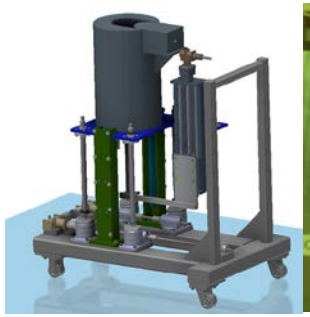


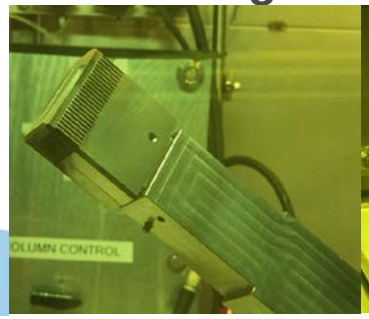


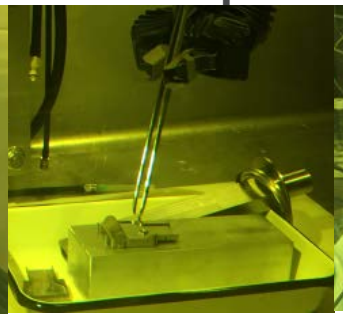


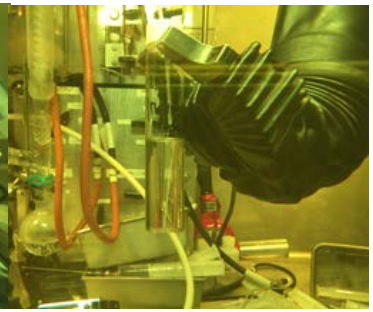


Post-irradiation handling and hot-cell processing









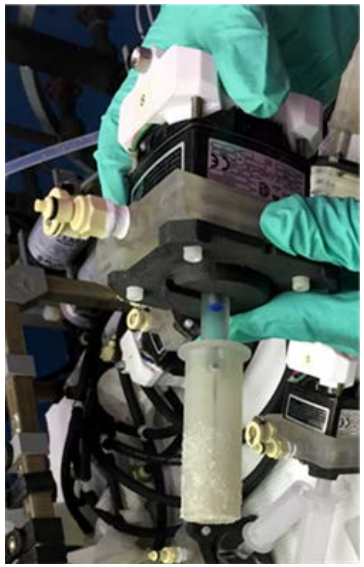
Chemical processes R&D

CENTRIFUGAL CONTACTOR UPDATE

Acrylic

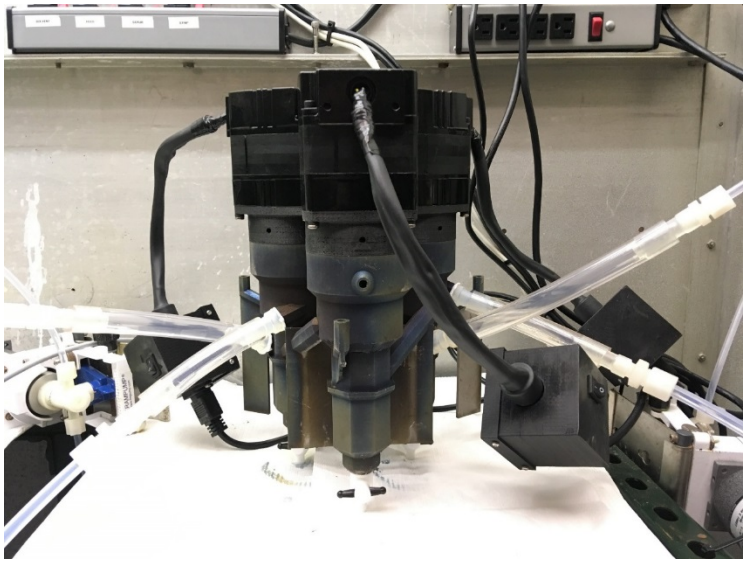
Polypropylene

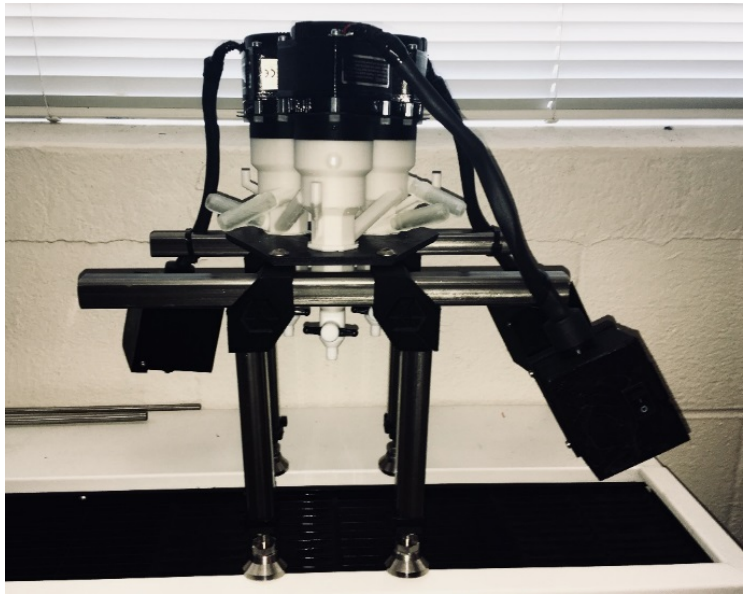
Inconel 625



Rotor coupling

3D-PRINTED INCONEL & POLYPROPYLENE



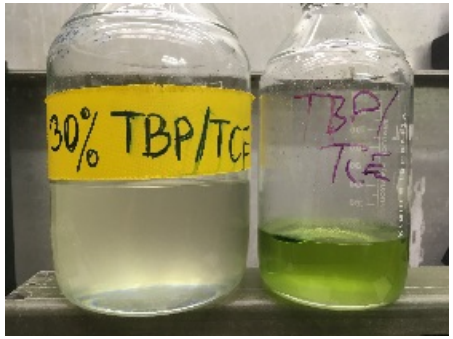


Inconel 625

	Cr	Mo	Co	Nb+Ta	Al	Ti	C	Fe	Mn	Si	P	S	Ni
Min	20	8	--	3.15	--	--	--	--	--	--	--	--	Balance
Max	23	10	1	4.15	.4	.4	.1	5	.5	.5	.015	.015	Balance

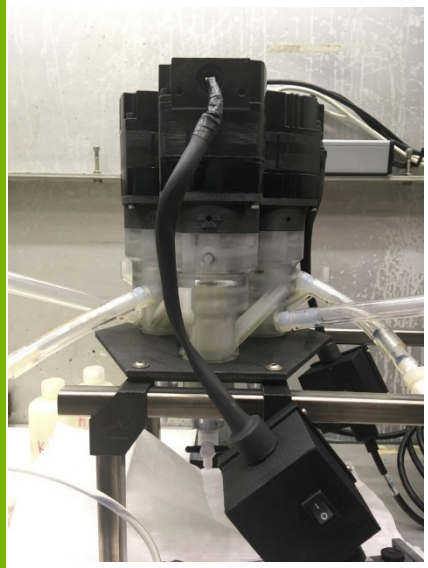
Elevated concentrations of: Ni, Cr, Nb, Si, Co in raffinate

Inconel – not suitable due to substantial corrosion



PP – not suitable due to rotor failure, too soft

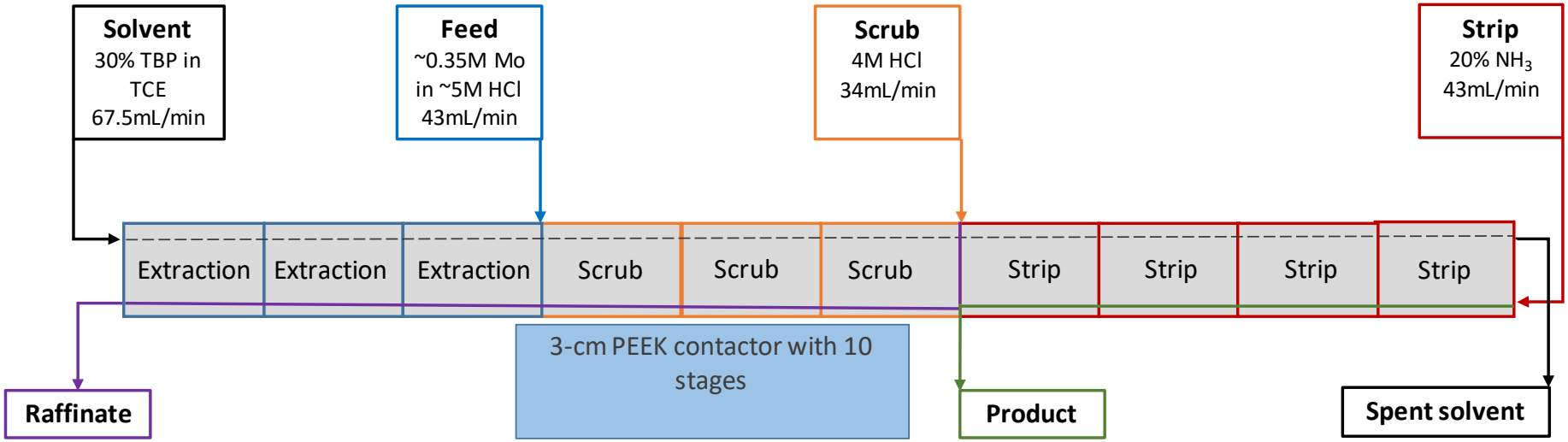
3D-PRINTED HIGH DENSITY ACRYLIC

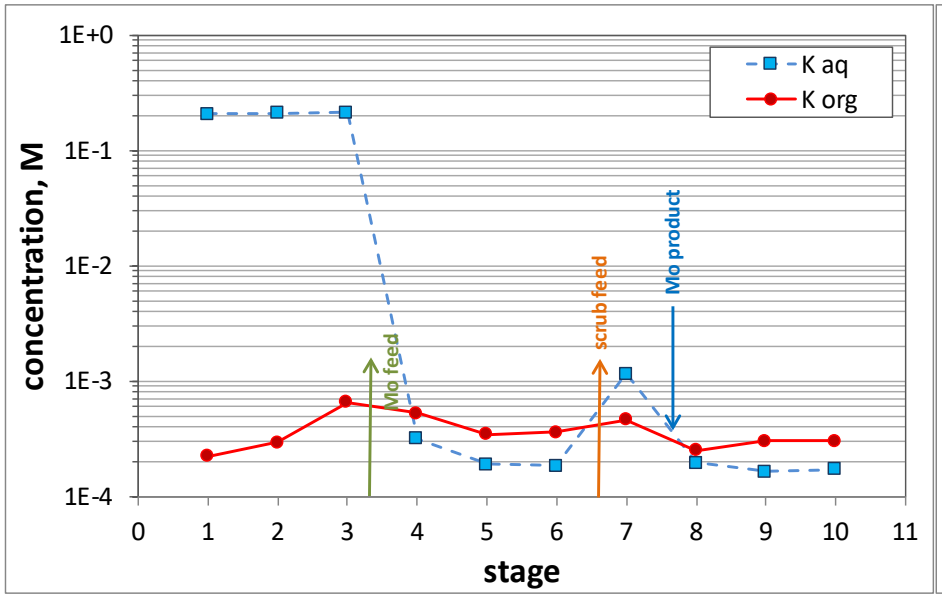


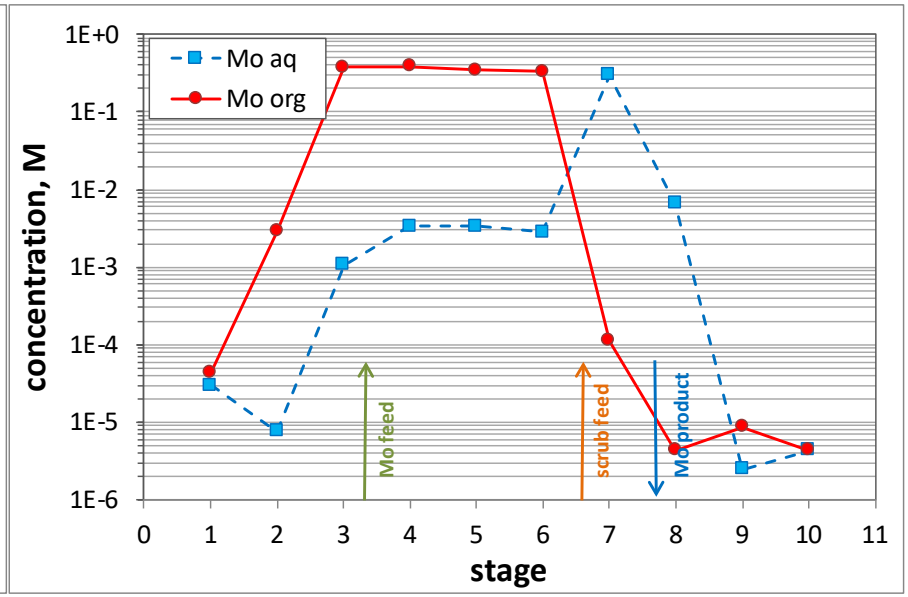
High density acrylic – good with some effects, cheap

PEEK – **robust and chemically compatible**

MOEX RECYCLE PROCESS – 3CM PEEK CONTACTOR







MOEX RECYCLE PROCESS – 3CM PEEK CONTACTOR

3-cm vs. 2-cm: ~3.5x faster throughput

12L of Mo feed at ~0.33M Mo is ~400g of Mo (~1kg of KCl removed): 4.5hrs of run time

More dilute Mo solution: 4-5cm contactor needed

Extraction:

Mo raffinate: 0.015% of Mo possibly due to minor phase carryover, ~100% of K

2nd stage: Mo: <DL, ~100% of K

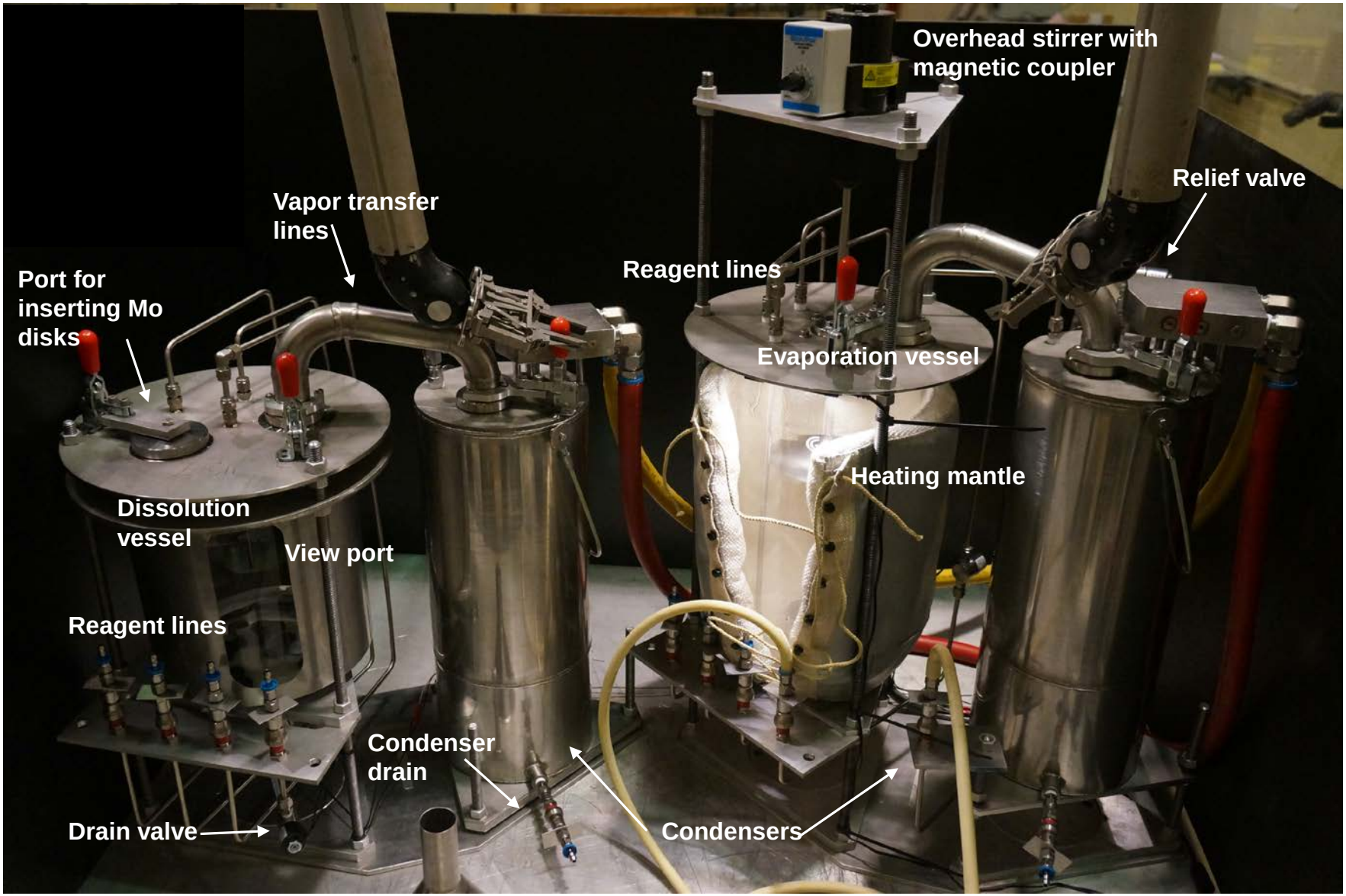
Strip:

9th and 10th stage aqueous phase: Mo: <DL

TBP recycled: Mo: <DL

PEEK has excellent durability, easy to machine, potential for 3D printing

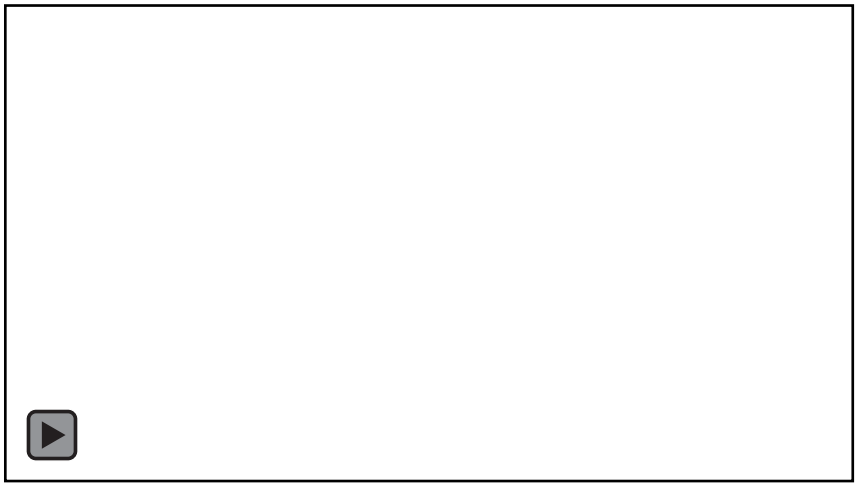
FULL-SCALE DISSOLVER FOR HOT CELL OPERATIONS

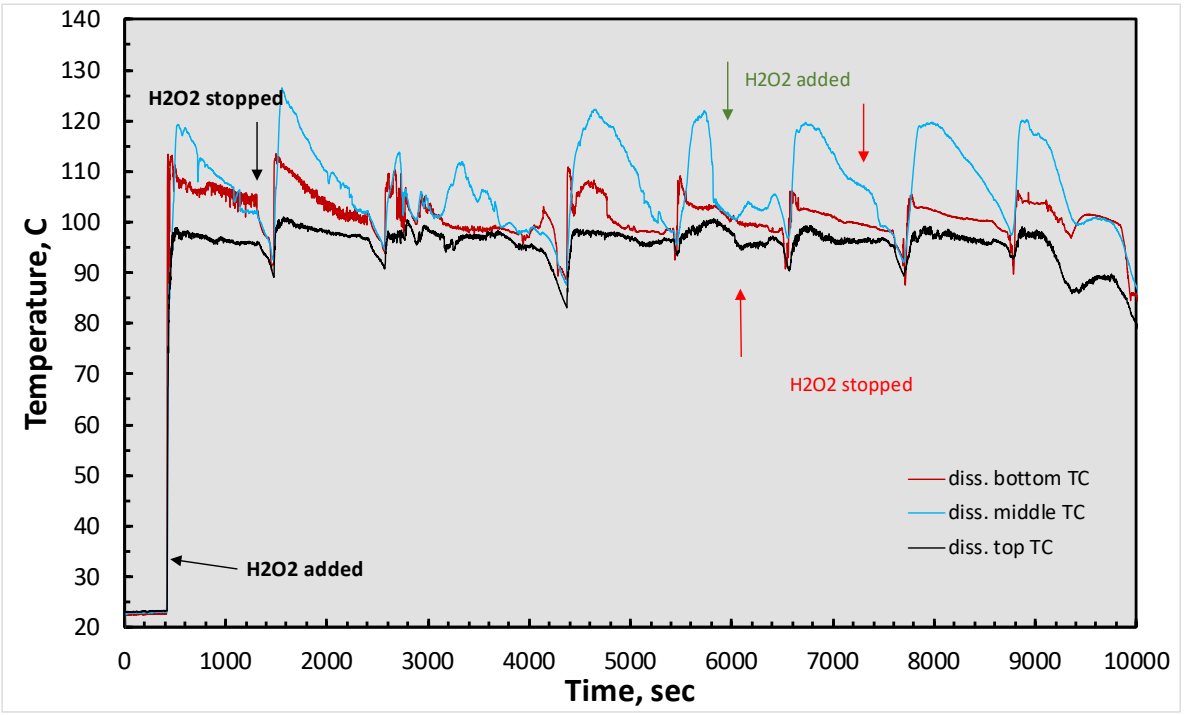


FULL-SCALE DISSOLVER FOR HOT CELL OPERATIONS

- Dissolution of up to 600g of Mo
- Vigorous and exothermic reaction
- ~1L of water condensed in 15min ~2.6kW
- Optimized processing time from 9hrs (300g FY15) to ~2.5-4hrs (600g)

FULL-SCALE DISSOLVER FOR HOT CELL OPERATIONS





FULL-SCALE DISSOLVER FOR HOT CELL OPERATIONS

LARGE-SCALE DISSOLUTION RESULTS

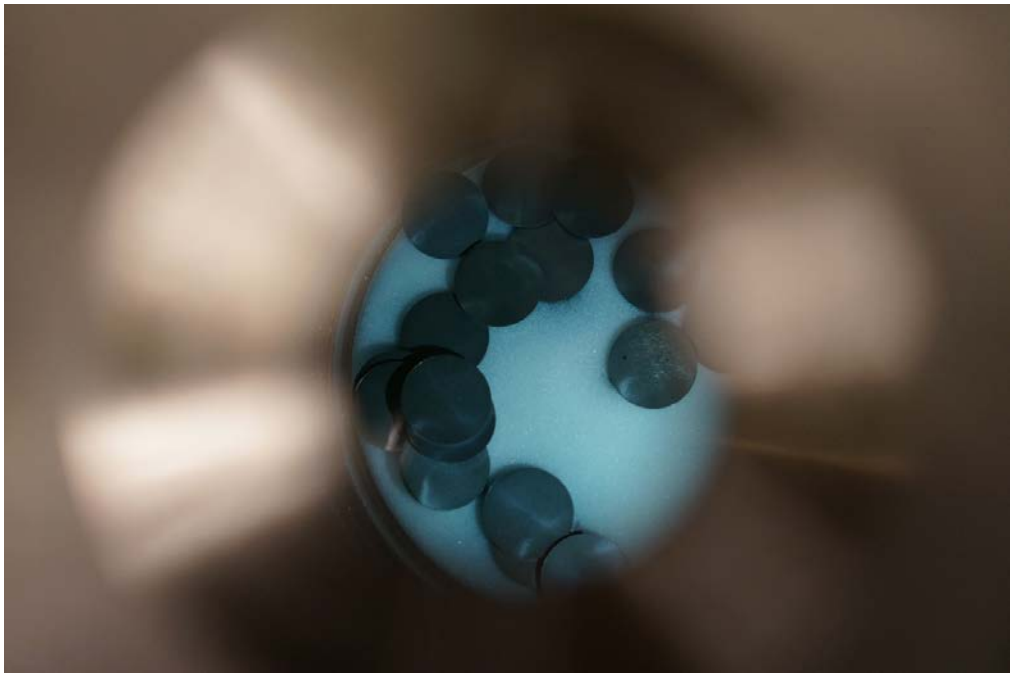
disks mass, g	Mo disks	peroxide manufacturer	50% peroxide consumed, L	water cond. from diss., L	dissolution time, min	evaporation, min	water cond. from evap., L	filtration, min	total, min	diss. rate, g/min	Total processing g/min
302.00	NS 26x1	Acros Organics	3.75	2.14	72	60	0.5	10	150	4.19	2.01
586.2	NS 26x1	Acros Organics	7.2	4.81	84	30	2.4	20	150	6.98	3.91
599.5	NS 26x0.5	Fisher Chemical	7.6	5.26	89	10	0.36	30	150	6.74	4.00
592.6	NS 26x1	Fisher Chemical	7.4	4.88	103	100*	0.20	4	267	5.75	2.22
600.6	NS 26x1	Fisher Chemical	9.05	5.93	120	24	1.06	10	165	5.01	3.64
600.8	NS 26x1	Fisher Chemical	8.9	6.11	106	9	0.80	10	128	5.67	4.69
599	ORNL 29x1	Sigma Aldrich	9.55	5.8	150	76	1.25	20	246	3.99	1.23
601.8	NS 26x1	Sigma Aldrich	11.5	5.62	176	120	1.78	17	313	3.42	1.87
598.8	ORNL 29x0.5	Sigma Aldrich	8.96	5.18	207	97	1.32	26	330	2.89	1.82
604.6	NS 26x1	Sigma Aldrich	7.4	4.86	156	70	1.05	45	266	3.88	2.27
600.9	NS 26x1	Sigma Aldrich	7.73	4.63	190	12	1.38	24	232	3.16	2.59
600.7	NS 26x1	Sigma Aldrich	8.41	5.08	189	10	1.37	3	210	3.18	2.86

- Peroxide used: 14.1 ± 2 mL/g of Mo for 600g batches
- Dissolution water condensed: 62 ± 6% of peroxide consumed
- **Dissolution rates for 600g batches (dissolution only):**
- Across Organics: 7g/min
- Fisher Chemical: 5.8 ± 0.7 g/min
- Sigma Aldrich: 3.4 ± 0.4 g/min

HYDROGEN PEROXIDE SUPPLIERS - DIFFERENCES

part #	Fisher Chemical H341-500 ppm	Sigma Aldrich 516813-4L ppm	Across Organics AC302860025 ppm
K	4.84	6.10	<57.2
Na	16.4	85.0	87.2
P	< 11.2	81.0	83.4
Ca	16.4	44.0	<146
Ti	0.071	0.071	0.100
Cr	< 0.11	< 0.14	0.12
Mn	0.037	0.044	0.006
Ni	< 0.036	0.125	0.037
Cu	0.023	0.023	0.016
Zn	0.214	0.483	0.061
Sn	6.65	18.8	0.31

ACKNOWLEDGEMENT



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QUESTIONS?