Supporting Information

Foiled for Choice: Sustainability and Life Cycle Assessment of Bench Top Heating

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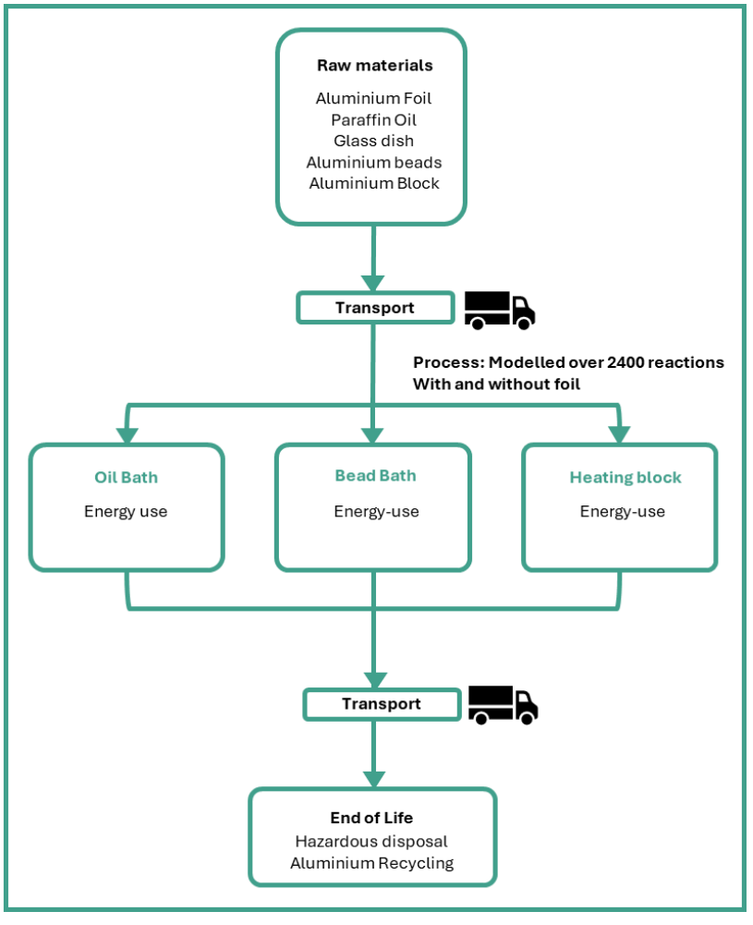

Figure S1 System boundaries of the life cycle stages of the use of different heating media for reaction set up over 2400 uses

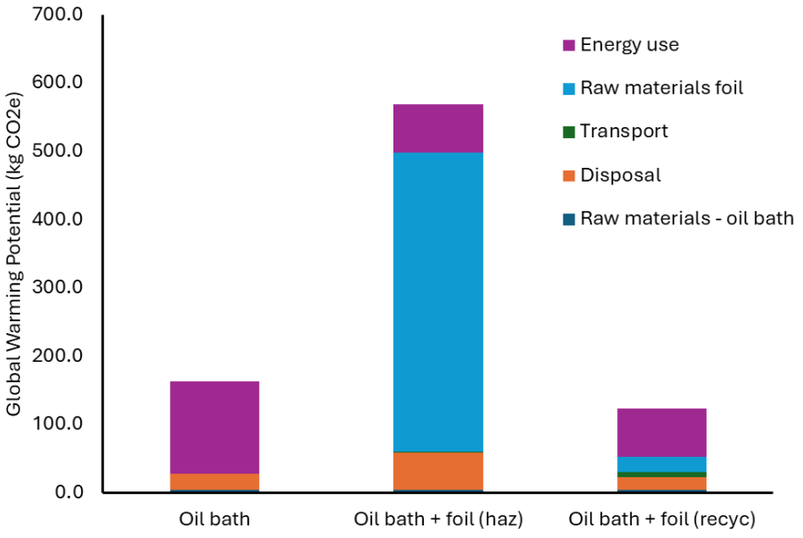

Figure S2 Life cycle analysis showing the break-down of contributions on the effect of foil use of using oil bath over 2400 uses

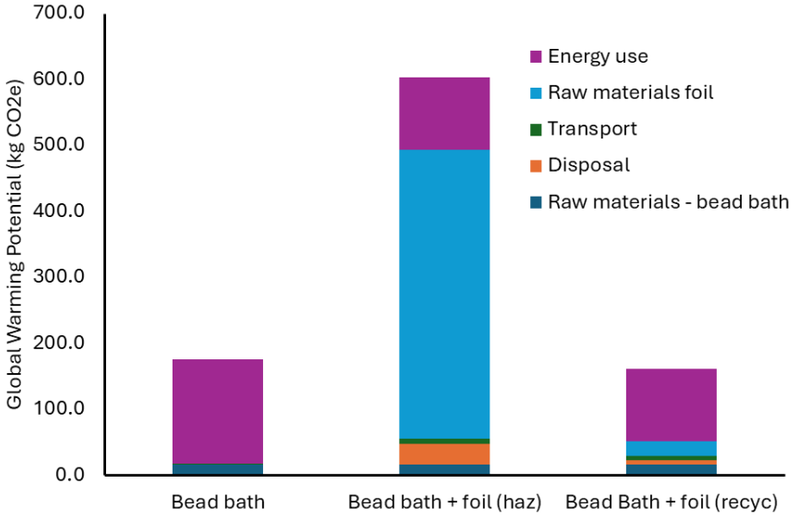

Figure S3 Life cycle analysis showing the break-down of contributions on the effect of foil use of using bead bath over 2400 uses

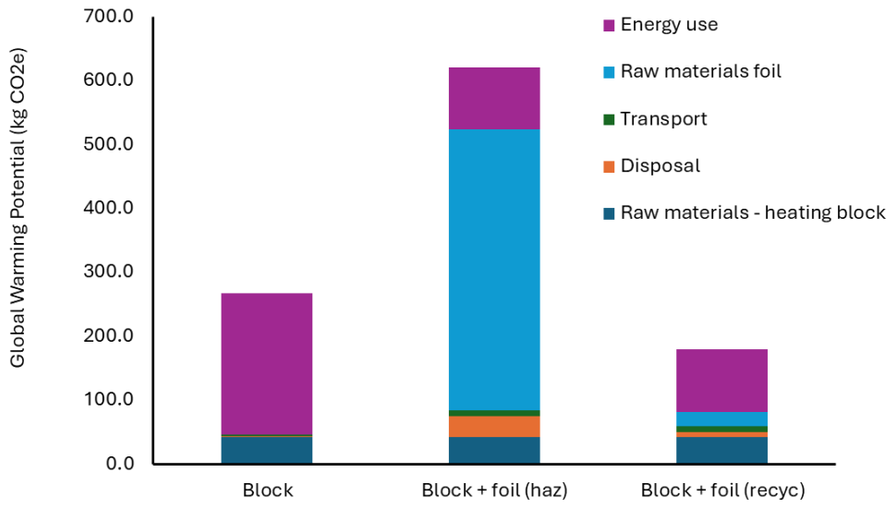

Figure S4 Life cycle analysis showing the break-down of contributions on the effect of foil use of using heating block over 2400 uses

Table S1 Global warming potential in kg CO_2 equivalents of using oil bath for 2400 reactions with foil covering and without. The value shown for raw materials foil in the recycling scenario includes the displacement of the primary production of aluminium

	Global warming potential (kg CO_2 eq)					
	Raw materials - oil bath	**Disposal**	**Transport**	**Raw materials foil**	**Energy use**	**Total**
Oil bath	4.6	23.2	0.7	-	134.8	163.2
Oil bath + foil (haz)	4.6	54.5	1.0	438.3	70.4	568.7
Oil bath + foil (recyc)	4.6	19.0	7.1	22.1	70.4	123.2

Table S2 Global warming potential in kg CO_2 equivalents of using bead bath for 2400 reactions with foil covering and without. The value shown for raw materials foil in the recycling scenario includes the displacement of the primary production of aluminium

	Global warming potential (kg CO_2 eq)					
	Raw materials - bead bath	**Disposal**	**Transport**	**Raw materials foil**	**Energy use**	**Total**

Bead bath	15.6	1.1	0.5	-	157.9	175.1
Bead bath + foil (haz)	15.6	32.3	7.3	438.3	109.3	602.8
Bead Bath + foil (recyc)	15.6	7.0	7.0	22.1	109.3	161.0

Table S3 Global warming potential in kg CO_2 equivalents of using heating block for 2400 reactions with foil covering and without. The value shown for raw materials foil in the recycling scenario includes the displacement of the primary production of aluminium

	Global warming potential (kg CO_2 eq)					
	Raw materials - heating block	**Disposal**	**Transport**	**Raw materials foil**	**Energy use**	**Total**
Block	42.7	1.4	2.8	-	220.7	267.6
Block + foil (haz)	42.7	32.6	9.6	438.3	97.3	620.5
Block + foil (recyc)	42.7	8.0	9.3	22.1	97.3	179.4

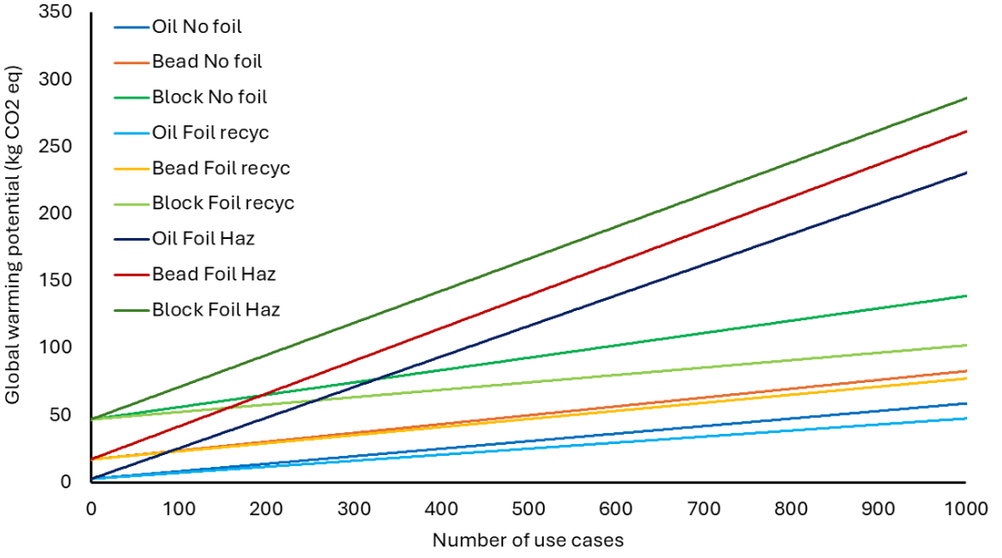

Figure S5 Global warming potential as a function of use cases for each heating scenario up to 1000 use cases with no oil changes.

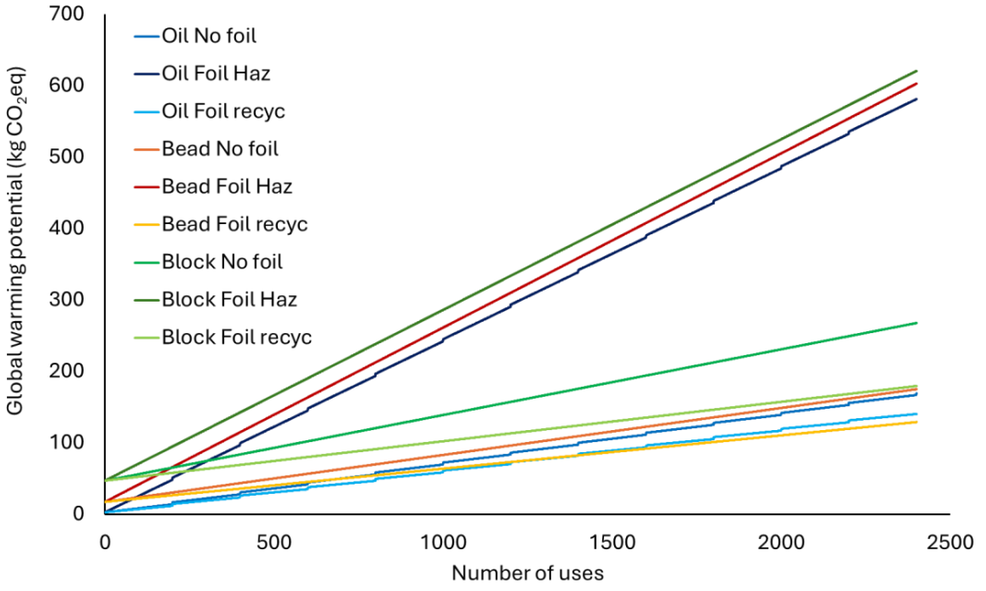

Figure S6 Global warming potential as a function of use cases considering the lifetime of oil as 200 uses

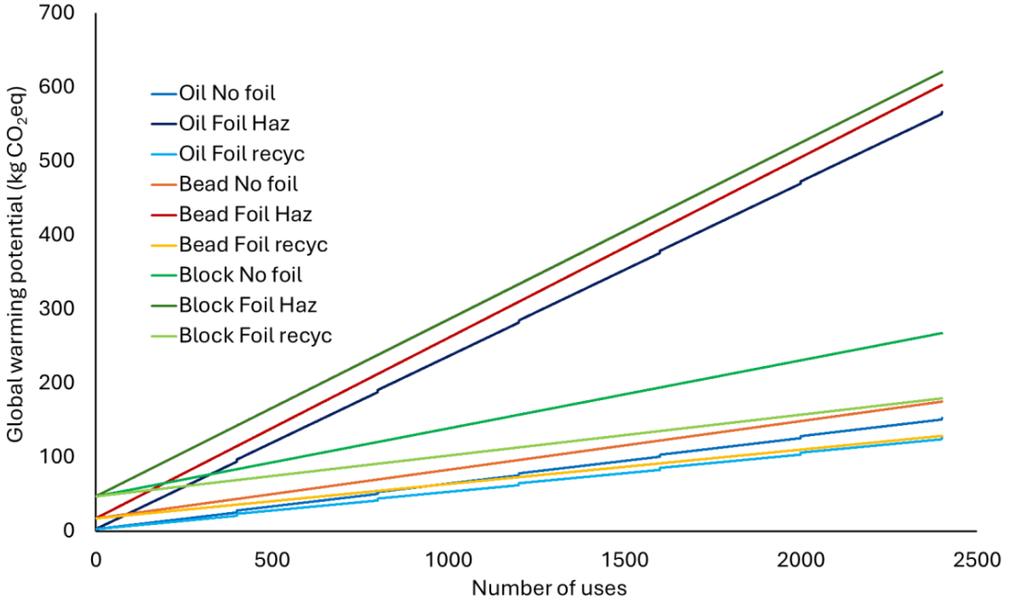

Figure S7 Global warming potential as a function of use cases considering the lifetime of oil as 400 uses

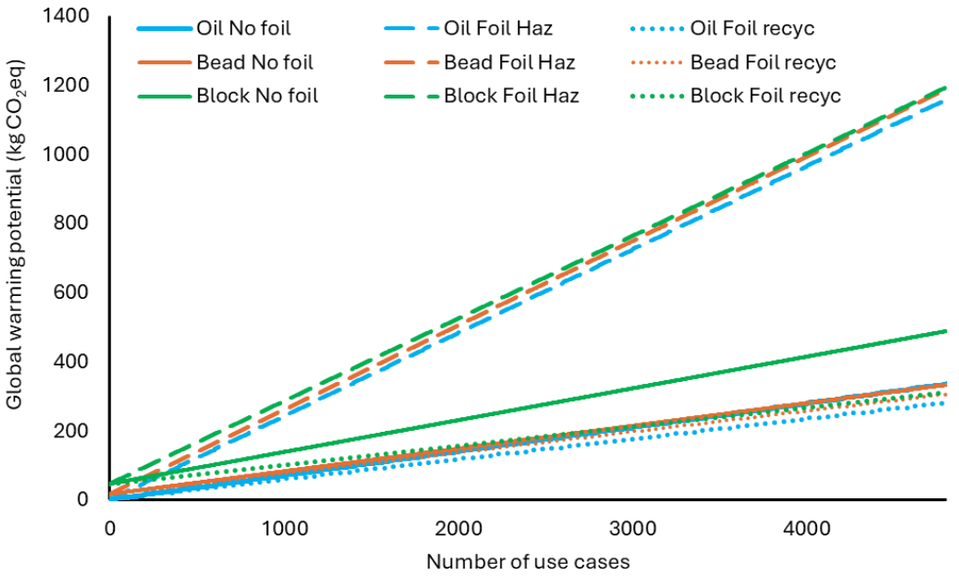

Figure S8 Global warming potential as a function of use cases considering the lifetime of oil as 200 uses over 4800 use cases, estimated to be a 20 year period.

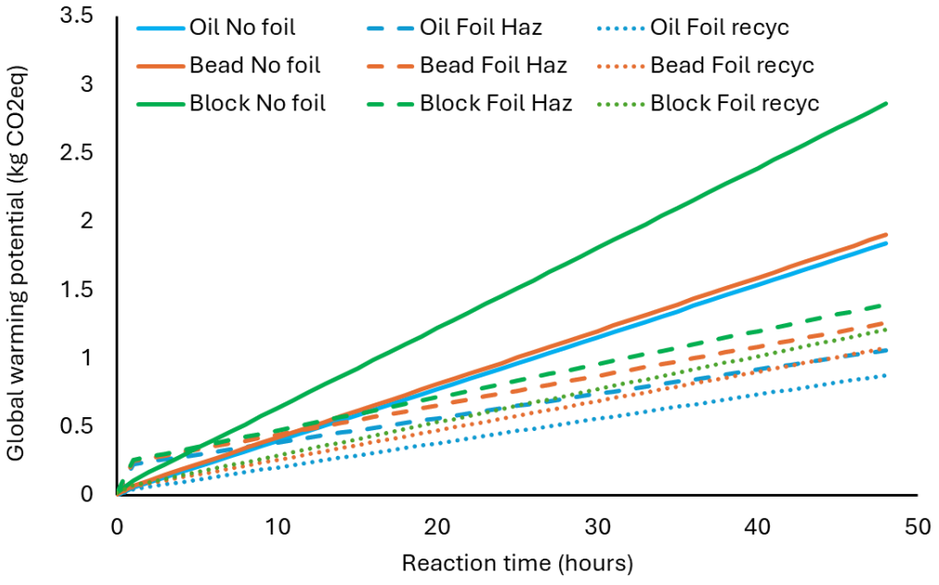

Figure S9 Global warming potential of reaction heating water to 80 °C as a function of hours of reaction with embedded carbon of the heating set up normalised to 2400 uses.

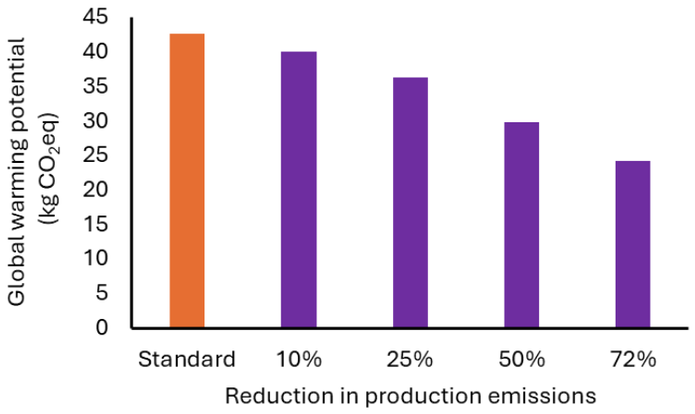

Figure S10. Total embodied carbon (EC) associated with the production and treatment of the aluminium block, modelled with % reductions associated with the aluminium production.

Table S4 Life cycle inventory data of whole heating systems (oil bath, bead bath, heating block) using foil and without over 2400 reactions

	Oil	Oil with foil (haz)	Oil with foil (recyc)	Beads	Beads with foil (haz)	Beads with foil (recyc)	Blocks	Blocks with foil (haz)	Blocks with foil (recyc)
Raw materials									
Production: glass dish (kg)	0.19	0.19	0.19	0.19	0.19	0.19			
Production: paraffin oil (kg)	5.55	5.55	5.55						
Production: Aluminium (kg)		12.96	0.65	1.22	14.18	1.87	3.52	16.48	4.18
Aluminium anodising (m^2)		108.00	5.44		108.00	5.44		108.00	5.44
Aluminium sheet rolling (kg)		12.96	0.65		12.96	0.65		12.96	0.65
Aluminium working (kg)				1.16	1.16	1.16	2.71	2.71	2.71
Transport									
Light commercial vehicle (tkm)	0.18	0.18	0.18	0.01	0.01	0.01	0.89	0.89	0.89
Freight 16-32 lorry (tkm)	0.56	24.01	24.01	0.12	23.56	23.56	5.21	28.66	28.66
Freight 3.5-7.5 lorry (tkm)	0.31	6.47	6.07	0.54	6.71	6.31		6.16	130.68
Freight shipping (tkm)	0.05	3.77	3.77	19.09	22.81	19.09	0.78	4.50	4.50
Disposal									
Hazardous glass waste (kg)	0.19	0.19	0.19	0.19	0.19	0.19			
Hazardous oil waste (kg)	5.55	5.55	5.55						
Hazardous foil waste (kg)		12.96			12.96			12.96	
Aluminium recycling (kg)			12.96	1.16	1.16	14.12	2.71	2.71	15.67
Use phase - Energy									
Electricity (MJ)	1793.65	912.34	912.34	2162.88	1497.57	1497.57	3024.00	1333.41	1333.41

Table S5. List of ecoinvent directories employed within the life cycle assessment of different heating media and foil use.

Materials flow	Ecoinvent database
UK electricity	Electricity, medium voltage {GB}| market for electricity, medium voltage | APOS, S Ecoinvent 3 - allocation at point of substitution - system
Glass dish	Glass tube, borosilicate {GLO}| market for glass tube, borosilicate | APOS, S
Paraffin production	Paraffin {GLO}| market for paraffin | APOS, S
Aluminium production	Aluminium, primary, ingot {IAI Area, EU27 & EFTA}| market for aluminium, primary, ingot | APOS, S
Aluminium anodising	Anodising, aluminium sheet {RER}| anodising, aluminium sheet | APOS, S
Aluminium rolling (foil)	Sheet rolling, aluminium {RER}| sheet rolling, aluminium | APOS, S
Aluminium treatment (beads)	Metal working, average for aluminium product manufacturing {RER}| metal working, average for aluminium product manufacturing | APOS, S
Aluminium treatment (block)	Metal working, average for aluminium product manufacturing {GLO}| market for metal working, average for aluminium product manufacturing
Transport	Transport, freight, light commercial vehicle {Europe without Switzerland}| transport, freight, light commercial vehicle | APOS, S
	Transport, freight, lorry 16-32 metric ton, EURO3 {RER}| transport, freight, lorry 16-32 metric ton, EURO3 | APOS, S
	Transport, freight, lorry 16-32 metric ton, EURO3 {RER}| transport, freight, lorry 16-32 metric ton, EURO3 | APOS, S
	Transport, freight, lorry 3.5-7.5 metric ton, EURO3 {RER}| transport, freight, lorry 3.5-7.5 metric ton, EURO3 | APOS, S
	Transport, freight, lorry 3.5-7.5 metric ton, EURO3 {RoW}| transport, freight, lorry 3.5-7.5 metric ton, EURO3 | APOS, S
	Transport, freight, sea, bulk carrier for dry goods {GLO}| transport, freight, sea, bulk carrier for dry goods | APOS, S
	Transport, freight, sea, bulk carrier for dry goods {GLO}| transport, freight, sea, bulk carrier for dry goods | APOS, S
	Transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | APOS, S
Oil disposal	Waste mineral oil {CH}| treatment of waste mineral oil, hazardous waste incineration | APOS, S
Foil disposal	Hazardous waste, for incineration {Europe without Switzerland}| treatment of hazardous waste, hazardous waste incineration | APOS, S
Foil recycling	Aluminium scrap, post-consumer, prepared for melting {RER}| treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter | APOS, S

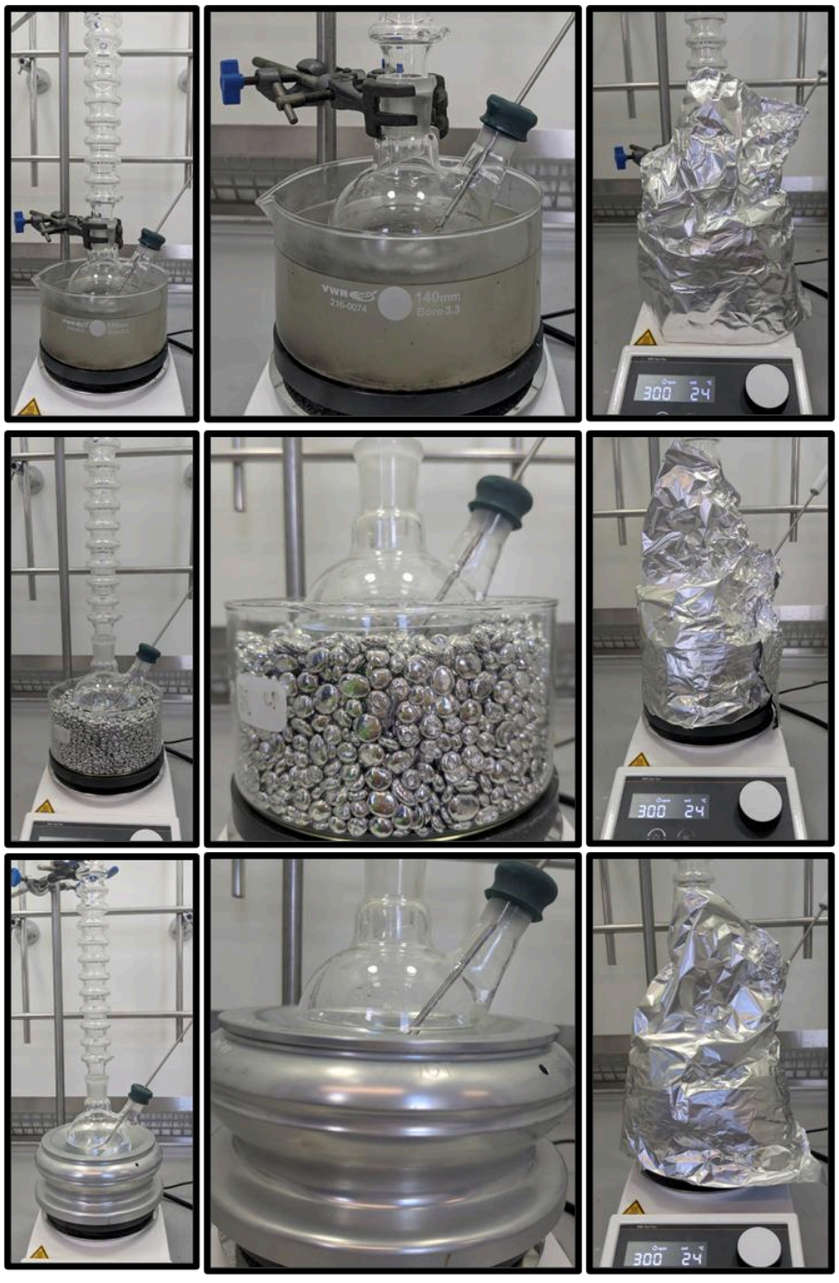

Figure S11. Reaction set up of different heating media with and without foil. Top row = oil bath; middle row = Bead bath; bottom row = heating block. Left column = without foil; middle column = close up of heating level; right column = foil covering.