Electronic Supplementary Material (ESI) for Green Chemistry.

Supporting Information

Toolbox study for application of hydrogen peroxide as a versatile, safe and industrially-relevant green oxidant in continuous flow mode

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1) General methods

All commercially available materials and solvents were used as received without any further purification.

Where GC was employed (all transformations except *N*-oxidation) it was fitted with an FID detector, RestekRtx®-5 Amine column (30m x 0.32 mm x 1.5 µm), and injection was at 50 °C ramping to 300 °C.

NMR spectra were measured on a Bruker 400 MHz spectrometer. In order to measure the kinetics of formation of peracetic acid from acetic acid the characteristic acetyl signals by ^{1}H NMR (δ 2.11 & 2.09 ppm respectively) were integrated at 5.0 minute intervals after addition of the hydrogen peroxide. The experiments were run within the NMR tube (no stirring).

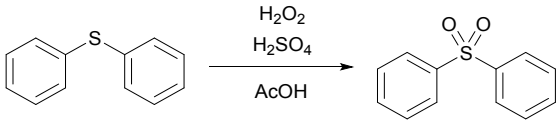
When ^{1}H NMR was used for kinetic studies which included diphenylsulfide substrate the characteristic low-field signals of diphenyl sulfide (δ 7.33–7.19 ppm), sulfoxide (δ 7.72–7.67 ppm) and sulfone (δ 7.98–7.94 ppm) were integrated at 2.5 minute intervals following addition of hydrogen peroxide (solvent was 9:1 acetic acid-d4:acetic acid).

Where quantitative *in-situ* yields are quoted, napthalene or *N,N*-dimethyloctanamide had been added to the starting material stock solutions as internal standards (the latter only used for the preparation of (3-methoxyphenyl)(morpholino)methanone). In order to determine the *in-situ* yield, the appropriate internal standard had been co-injected with the commercially available product (synthesised in the case of (3-methoxyphenyl)(morpholino)methanone) and the relative area ratios compared to determine the theoretical yield.

When ^{1}H NMR was used as in-process control (*N*-oxidation of isoquinoline) an NMR method with extended delay (30 seconds) between pulses was employed to ensure complete relaxation of spin states. Co-measurement of equimolar amounts of isoquinoline and isoquinoline *N*-oxide with this method provided a 1:1 ratio between the most low-field signals (at δ 9.29–9.26 ppm and δ 8.81–8.79 ppm respectively). Conversion was therefore determined based on their ratio in the in-process control aliquots which were diluted with acetonitrile-d3. A series of representative NMR spectra are shown in the section 2) below.

2) Batch experimental (best method, followed by the optimisation that lead to that method)

Diphenylsulfone 1:



1

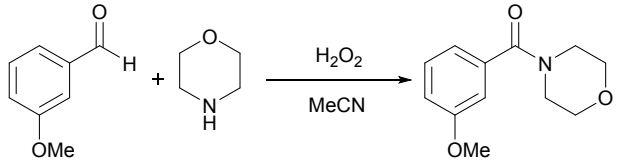
To a solution of diphenyl sulfide (100 mg, 0.54 mmol, 1.0 eq.), sulfuric acid (95-98%, 9 µL, 0.16 mmol, 0.3 eq.) and naphthalene (69 mg, 0.54 mmol, 1.0 eq.) in acetic acid (>99.7 %, 0.91 mL, 16.14 mmol, 30.0 eq.) pre-heated at 50 °C was added an aq. solution of hydrogen peroxide (30 wt.%, 0.17 mL, 1.6mmol, 3.0 eq.). At 5 and 15 min, a reaction sample (10 µL) was taken, diluted with acetonitrile (2 mL) and analysed by GC. Diphenylsulfone **1** was afforded in quantitative yield at 15 min. The reaction mixture was quenched with saturated sodium sulfite solution and disposed of.

The same procedure was used in the following screening, which enabled identification of the key reaction parameters.

Entry	H_2SO_4 (eq.)	AcOH (eq.)	H_2O_2 (eq.)	Temp. (° C)	2-MeTHF (mL)	GC Conv. (%)
1	0.3	24.0	3.0	20	0.26	35[c]
2	0.3	3.0	3.0	20	0.28	5[c]
3	0.3	0.0	3.0	20	0.38	7[c]
4	0.0	3.0	3.0	20	0.28	0[c]
5	0.3	30.0	3.0	50	0	81[a], 100[b]

Table1. Sulfide oxidation - reaction condition screening in batch. [a] 5 min; [b] 15 min; [c] 30 min.

(3-methoxyphenyl)(morpholino)methanone 2:



2

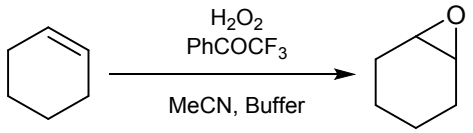
To a 0.7 M solution of 3-methoxy benzaldehyde (0.12 mL, 1.00 mmol, 1.0 eq.), morpholine (0.35 mL, 4.0 mmol, 4.0 eq.) and *N,N*-dimethyloctanamide (internal standard, 54.2 mg) in acetonitrile (1 mL) pre-heated at 65 °C was added a solution of hydrogen peroxide 30 wt.% in water (0.20 mL, 2.0 mmol, 2.0 eq.). At 15, 30 and 60 min, a reaction sample (10 µL) was taken, diluted with acetonitrile (2 mL) and analysed by GC. (3-methoxyphenyl)(morpholino)methanone **2** was afforded in 73 % at 15 min (according to elution time compared to an isolated reference). The reaction mixture was quenched with saturated sodium sulfite solution and disposed of.

The same procedure was used in the following screening, which enabled identification of the key reaction parameters. The *in-situ* product yield was determined only in entries 4 & 5 after isolation of the product as analytical reference.

Entry	H_2O_2 (eq.)	Temp. (° C)	Reagent added last	GC SM unreacted (%)			GC Conversion (%)		
				15 min	30 min	60 min	15 min	30 min	60 min
1[a]	2.0	65	Morpholine	17	11	8	-	-	-
2[a]	1.2	65	Morpholine	41	39	31	-	-	-
3[a]	2.0	65	Peroxide	33	25	14	-	-	-
4[b]	2.0	65	Peroxide	34	17	17	-	69	-
5[b,c]	2.0	65	Peroxide	9	4	1	73	78	79

Table 2. Oxidative amidation - reaction condition screening in batch. [a] napthalene used as internal standard; [b] *N,N*-dimethyloctanamide used as internal standard; [c] concentration doubled.

Cyclohexene oxide 6:



6

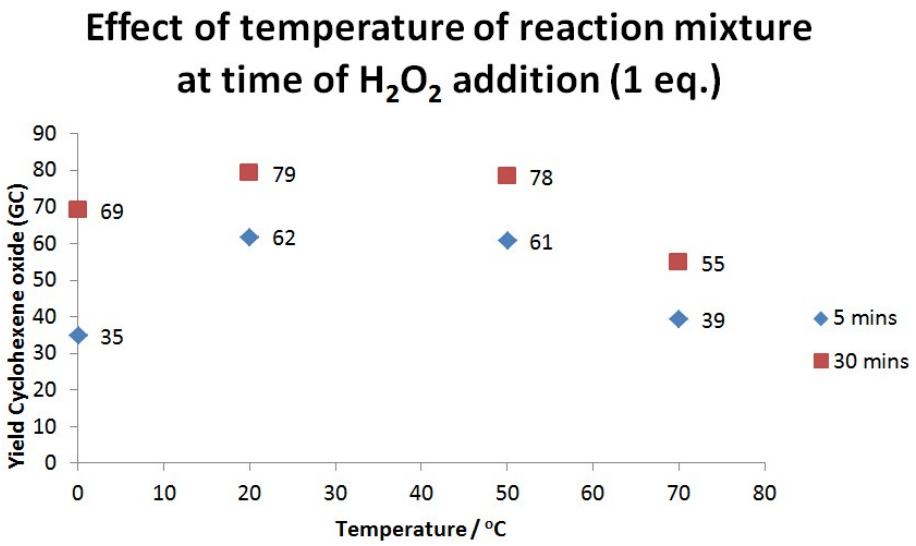
The following components were pre-heated to 50 °C: cyclohexene (81.7 mg, 0.99 mmol, 1.0 eq.), trifluoroacetophenone (9 mg, 0.05 mmol, 0.05 eq.); aq. buffer solution (0.6 M K_2CO_3; 0.04 mM EDTA tetrasodium salt, pH 11, 0.1 mL) and acetonitrile (0.9 mL). To this stirred mixture was added an aq. solution of hydrogen peroxide (30 wt.%, 0.20 mL, 2.00 mmol, 2.0 eq.). At 5, 15, 30 and 60 min, a reaction sample (10 µL) was taken, diluted with acetonitrile (20 mL) and analysed by GC. At 5 min, complete conversion and selectivity to cyclohexene oxide by GC was afforded (according to elution time compared to a commercial reference). The reaction mixture was quenched with saturated sodium sulfite solution and disposed of.

The same procedure was used in the following screening, which enabled identification of the key reaction parameters.

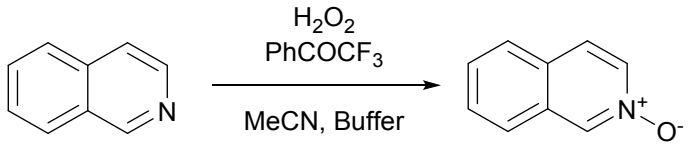
Entry	Cat (eq.)	Temp. (°C)	H_2O_2 (eq.)	GC SM unreacted (A%)				GC Conversion (A%)			
				5 min	15 min	30 min	60 min	5 min	15 min	30 min	60 min
1	0.00	50	2.0	76	58	51	36	24	42	49	64
2	0.05	50	2.0	0	0	0	0	100	100	100	100
3	0.10	50	2.0	1	0	0	0	99	100	100	100
4	0.05	10	2.0	86	78	56	44	14	22	44	56
5	0.05	30	2.0	37	5	0	0	63	95	100	100
6	0.05	50	1.0	28	16	12	9	72	84	88	91
7	0.05	50	3.0	0	0	0	0	100	100	100	100

Table 3. Olefin epoxidation - reaction condition screening in batch.

Since significant oxygen gas evolution was observed on addition of hydrogen peroxide, we investigated the temperature at which this reagent was added. In the experiments where addition of hydrogen peroxide is at 0 °C and 20 °C, the reaction mixture was allowed to stir for a further 5 mins. at this temperature before heating to 50 °C. Napthalene was used as internal standard in order to generate results as *in-situ* yield of product.
It was concluded that addition of hydrogen peroxide at 20 °C had no adverse effect on yield and led to less disproportionation of hydrogen peroxide based on visual gas release.



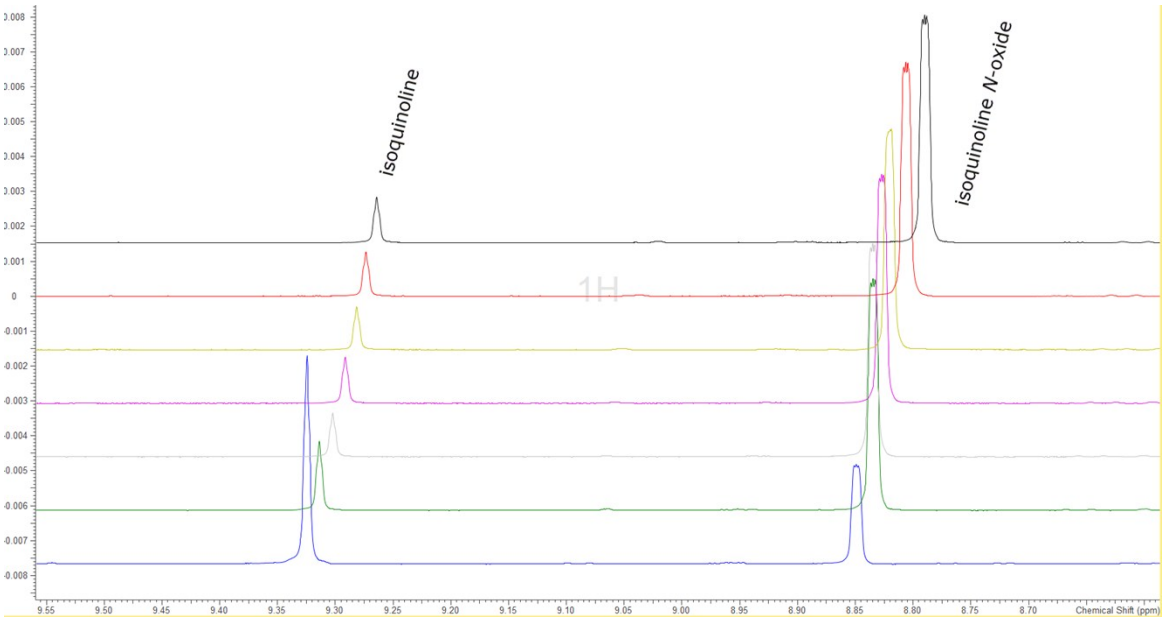
Isoquinoline *N*-oxide 7:



7

The following components were pre-heated to 50 °C: isoquinoline (129 mg, 0.98 mmol, 1.0 eq.); trifluoroacetophenone (17 mg, 0.098 mmol, 0.1 eq.); aq. buffer solution (0.6 M K_2CO_3; 0.04 mM EDTA tetrasodium salt, pH 11, 0.1 mL) and acetonitrile (0.6 mL). To this stirred mixture was added an aq. solution of hydrogen peroxide (30 wt.%, 0.150 mL, 1.469 mmol, 1.5 eq.). At 3, 5, 10 and 15 min, a reaction sample (10 µL) was taken, diluted with deuterated acetonitrile (0.75 mL) and submitted for ^{1}H NMR analysis. Isoquinoline *N*-oxide was afforded in 91 % conversion 10 min. The reaction mixture was quenched with saturated sodium sulfite solution and disposed of.

^{1}H NMR (acetonitrile-d3) of a series of time-points (NMR experiment outlined in the General methods section 1) above). The reaction time increases from the blue coloured spectrum towards the black.



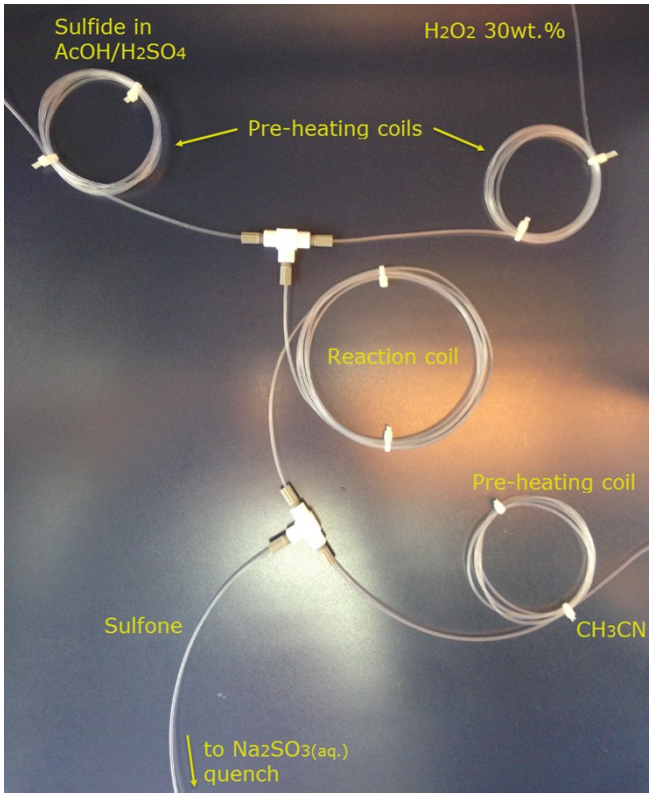
The same procedure was used in the following screening, which enabled identification of the key reaction parameters.

Entry	Cat (eq.)	Temp. (°C)	H_2O_2 (eq.)	GC SM unreacted (%)				^{1}H-NMR Conversion (%)			
				3 min	5 min	10 min	15 min	3 min	5 min	10 min	15 min
1	0.10	50	1.0	67.1	49.3	26.5	19.3	32.9	50.7	73.5	80.7
2	0.10	50	1.5	13.3	11.4	9.4	7.6	86.7	88.6	90.6	92.4
3	0.10	50	2.0	12.5	10.2	8.9	8.2	87.5	89.8	91.1	91.8
4	0.20	10	1.0	31.3	15.2	9.7	8.8	68.8	84.8	90.3	91.2

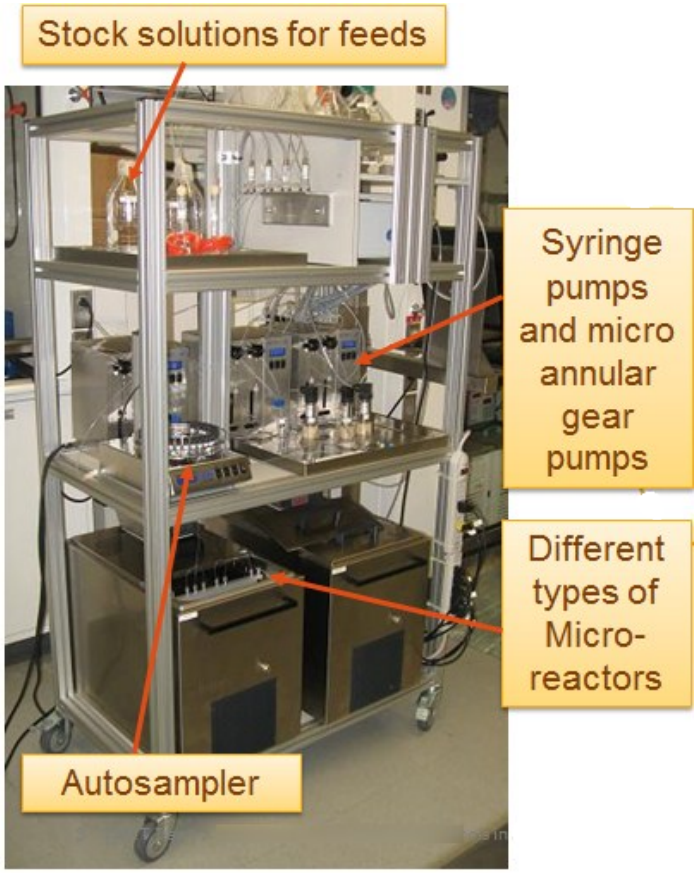
Table 4. *N*-oxidation - reaction condition screening in batch.

3) General continuous flow set up for the hydrogen peroxide mediated oxidations:

All stock solutions were prepared by dissolving the reagent(s) in the appropriate solvent at room temperature under nitrogen and then connection to the dedicated pump. Pumping was *via* continuous syringe-pumps (SyrDos2, HITEC ZANG) with solutions passing through PFA (perfluoroalkoxy) tubing (sizing specified in each experimental. Supplier: Bola, Germany) for both pre-heating of the reactants as well as reaction post PTFE T-pieces (polytetrafluoroethylene, Bola: I.D. 1.6 mm) or 4-way PTFE mixer (Bola: I.D. 1.6 mm). An image of the general setup applicable to preparation of **1**, **2** & **6** with tubular reactors is shown below (annotated for the oxidation to diphenylsulfone **1**).



A steady-state period of at least two reactor volumes was employed, with confirmation coming from in-process control (GC or ^{1}H NMR).
Pressure sensor data as well as bath temperatures (Huber thermostat) were compiled into the HITEC ZANG interface where the reaction profile was monitored online. The integrated software control features enabled automatic safety shut-down or emergency actions based upon user predefined parameters (maximum pressure and bath temperature) thereby increasing the overall safety of the continuous flow process. An image of the mobile continuous flow unit used for small scale processes is shown below.



Flow set-up for the oxidation to diphenylsulfone 1:
A stock solution of diphenyl sulfide (5.0 g, 26.8 mmol, 1.0 eq), sulfuric acid (95-98%, 0.42 mL, 8.0 mmol, 0.3 eq) and naphthalene (internal standard, 0.224 g, 1.75 mmol) in acetic acid (>99.7%, volume made up to 20 mL) was pumped (0.277 mL/min) through PFA tubing (I.D. x O.D.: 0.8 mm x 1.58 mm) pre-heating to 60 °C by immersion in a thermostated bath. Combined with this flow in a PTFE T-piece submersed in the same bath was an aq. solution of hydrogen peroxide (30 wt.%, 8.22 mL, 80.4 mmol, 3.0 eq, pumped at 0.057 mL/min). The reaction mixture took 15 minutes to pass through the PFA tubing (10 m) until it was combined with acetonitrile (0.334 mL/min) in a second T-piece and then passed through the back-pressure regulator set to 2 bar. After steady-state the diluted reaction mixture was collected semi-batch into a satd. aq. solution of sodium sulfite. Test-strips were used to ensure the solution was free of peroxides. According to GC the *in-situ* yield of diphenylsulfone was determined as 102 m% (considered as 100 % within margin of error).

Flow set-up for the oxidation to (3-methoxyphenyl)(morpholino)methanone 2:
A stock solution of 3-methoxy benzaldehyde (3.40 g, 25.0 mmol, 1.0 eq.), morpholine (8.71 g, 100.0 mmol, 4.0 eq.) and *N,N*-dimethyloctanamide (internal standard, 0.64 g, 3.72 mmol) in acetonitrile (25 mL) was pumped (0.278 µL/min) through PFA tubing (I.D. x O.D.: 0.8 mm x 1.58 mm) immersed in a thermostated bath heated to 70 °C, and then combined in a T-piece with an aq. solution of hydrogen peroxide (30 wt.%, 5.11 mL, 50.0 mmol, 2.0 eq., pumped at 0.057 mL/min). The reaction mixture took 15 minutes to pass through the PFA tubing (10 m) and through the back-pressure regulator set to 2 bar. After steady-state the diluted reaction mixture was

collected semi-batch into a satd. aq. solution of sodium sulfite. Test-strips were used to ensure the solution was free of peroxides. According to GC the *in-situ* yield of (3-methoxyphenyl)(morpholino)methanone was determined as 72 m%.
As this product was not commercially available, it was isolated in order to have it as an analytical reference to obtain quantitiative *in-situ* yield. During the flow-experiment the output was collected into a satd. aq. solution of sodium sulfite over time (a total of approximately 100 mL). The mixture was extracted with dichloromethane (3 x 150 mL). The combined organic layers were washed with a 0.1 M aqueous solution of hydrochloric acid (3 x 150 mL) and then with brine (150 mL). The organic phase was dried over anhydrous magnesium sulfate, filtered and concentrated under reduced pressure. The product was purified by flash chromatography (heptane / ethylacetate 6:4) to afford (3-methoxyphenyl) (morpholino)methanone as a yellow oil that conformed to the desired product by ^{1}H and ^{13}C NMR on comparison with the literature.[1]

Flow set-up for the oxidation to cyclohexene oxide 6:

The table below describes the pump flow rates of the three feed-solutions for three experimental conditions. All three solutions were pumped through PFA tubing (I.D. x O.D.: 1.58 mm x 3.18 mm).

SyrDos 1 (H2O2) ml/min	SyrDos 2 (Edukt) ml/min	SyrDos 3 (Buffer) ml/min	Residence time 1 at 20 °C / minutes	Residence time 2 at 40 °C / minutes	Total residence time / minutes	Sample no.	Sampling time after last change in flow rate / mins	Steady state vols.	m% Product
0.61	1.95	0.45	3.0	15.0	18.0	1	10*	3.2	72
						2	22*	3.4	84
0.49	1.56	0.36	3.6	18.0	21.6	3	37	1.7	73
						4	55	2.5	89
0.39	1.25	0.29	4.3	21.6	25.9	5	52	2.0	100
						6	80	3.1	89
						*time after 3 volumes			

Feed solution 1: stock solution of cyclohexene (40.55 g, 0.494 mol, 1.0 eq.) and trifluoroacetophenone (4.34 g, 24.7 mmol, 0.05 eq.) in acetonitrile (322 mL). Inclusion of napthalene as internal standard (10.00 g, 78.0 mmol).

Feed solution 2: buffer solution in deionized water (90.25 g, 0.6 M K_2CO_3, 0.04 mM EDTA tetrasodium salt, pH 11).

Feed solution 3: aq. solution of hydrogen peroxide (30 wt.%, directly from the commercial bottle).

Feeds 1, 2 and 3 were combined in a PTFE 4-way mixing piece just prior to entry into the thermostated bath with a jacket temperature of 20 °C. The first tubing coil (4.59 m, 9 mL) then connected to a second coil (22.95 m, 45 mL) which immediately passed into a bath thermostated to 40 °C before exiting and passing through a needle-valve back-pressure regulator (3 bar stable pressure was selected. Bola, Germany). The outlet was collected semi-batch into Schott bottles containing a 10 w%. aq. solution of sodium sulfite, and a peroxide test was conducted on each fraction 5 minutes after the end of addition of reaction mixture. When analytical samples were taken, the approximately 6 mL of product stream was collected prior to GC analysis of a 10 uL aliquot (diluted with acetonitrile (0.5 mL)). The variability in the results shown in the publication are due to gas-release in the second reactor coil affecting the residence-time distribution.

Flow set-up for the oxidation to isoquinoline *N*-oxide 7:

The table below describes the pump flow rates of the three feed-solutions during the campaign where relative and overall flow rates were screened. All three solutions were pumped through PFA tubing (I.D. x O.D.: 0.8 mm x 1.58 mm).

Description	total time /min	temp / °C	Feedstock 1 / mL/min	Feedstock 2 / mL/min	Feedstock 3 / mL/min	Residence time / min (35 mL)	SM:Product ^{1}H NMR integration	mol% Product	Conclusion
1 CSTR volume	30	50	1.72	0.376	0.282	14.7	1.37 : 1.00	42.2	
2 CSTR volumes	45	50	1.72	0.376	0.282	14.7	0.19 : 1.00	84.0	1 residence volume was insufficient
additional 10% H2O2	75	50	1.72	0.455	0.282	14.2	0.13 : 1.00	88.5	eq. H2O2 a critical parameter
	105							88.5	stable
additional 10% H2O2	120	50	1.72	0.501	0.282	14.0	0.12 : 1.00	89.3	no advantage of the extra 10% H2O2
	150							89.3	stable
reduce H2O2 by 10%	230	50	1.72	0.455	0.282	14.2	0.13 : 1.00	88.5	return to former value: highly reliable
reduce all flows by 10%	260	50	1.55	0.41	0.254	15.8	0.13 : 1.00	88.5	reaction time was sufficient
	290							88.5	stable

Feed solution 1: stock solution of isoquinoline (97.02 g, 0.751 mol, 1.0 eq.) and trifluoroacetophenone (13.08 g, 75.1 mmol, 0.1 eq.) in acetonitrile (451 mL).

Feed solution 2: buffer solution in deionized water (90.25 g, 0.6 M K_2CO_3, 0.04 mM EDTA tetrasodium salt, pH 11)

Feed solution 3: aq. solution of hydrogen peroxide (30 wt.%, directly from the commercial bottle)

Feeds 2 and 3 were combined in a PTFE T-piece just prior to entry into the first vessel of the jacketed glass CSTR (heated by thermostat to a jacket temperature of 51 °C). Feed 1 was pumped into the same vessel by a different opening. The vessels were stirred by individual teflon impellers, and nitrogen gas flow introduced to ensure degassing of each of the five headspaces and vessel contents. The residence volume of the CSTR was measured as 35 mL (50 mL without impellers), with the gas volume considered as negligible. The outlet of the CSTR was collected semi-batch into Schott bottles containing a satd. aq. solution of sodium sulfite/sodium chloride (1:1, 40 mL) sufficient for 30 minutes of collection time. Peroxide test was conducted on each fraction 5 minutes after the end of addition of reaction mixture (always negative).
The campaign lasted 5 hr 22 min, and fractions taken after initial steady-state were later combined for work-up and isolation of the isoquinoline *N*-oxide (theoretical yield of 76.91 g product based on the consumption of 387 mL of feed solution 1 into the retained fractions).

Work-up and isolation:
The combined fractions were rotary evaporated to remove volatiles leaving predominantly aqueous phases for further treatment. Dichloromethane was added (150 mL) and the aqueous phase extracted three times in succession. Sodium chloride was added to the aqueous phase until saturation and the solution was extracted two further times with dichloromethane. The combined organic phase was solvent-switched to ethyl acetate by repeated addition and concentration by rotary evaporation, finally resulting in a concentrated organic solution. The flask was heated to 60 °C and *n*-heptane was slowly added as anti-solvent. The solution was seeded and cooled to room temperature (crystallization started), and then to –2 °C overnight. The off-white crystals were filtered and washed with *n*-heptane and dried at 40 °C in a vacuum oven to provide isoquinoline *N*-oxide 49.03 g (64% yield). Remaining product was found in the aqueous phase, which could be partially retrieved by a second crystallization of an organic solution coming from THF extraction

(back-extracting the organic phase with brine), to provide 6.28 g as off-white crystals (combined yield 72%).

^{1}H NMR indicated good purity, with 1.5 mol% residual isoquinoline starting material.

References

1. J. R. Martinelli, T. P. Clark, D. A. Watson, R. H. Munday and S. L. Buchwald, *Angew. Chem. Int. Ed.*, 2007, **46**, 8460–8463.

4) Batch versus Flow productivity calculation

Productivity was calculated based on starting material consumed, and included reactor volume and reaction time in order to capture the essential parameters for considerations of thermal safety, i.e. volume of unquenched peroxides, and time that the peroxide-containing reaction mixture remains unquenched. To compare batch and flow productivity we calculated the volume of the reactor required to consume 1 kg of starting material within 1 hour. In the example with isoquinoline below we assumed that the batch process with a 1 L reaction mixture volume had a 0.5 hr hydrogen peroxide dosing time followed by a 0.5 hr stirring time for reaction completion. We also assumed that the residence time of the flow process would stay unchanged even at greater flow rates and reactor sizes (i.e. even chemistry in a 1 L flow reactor volume would need only 0.25 hr for completion).

1.6 M in isoquinoline (129.2)	**Reactor volume (L)**	**Cycle Time (hr)**	**kg / hr**	**kg/L.hr**	**Volume of reactor required to consume 1 kg in 1 hr (L)**
This work: CSTR flow reactor	0.035	**0.25**	0.021	0.60	1.67
CSTR flow reactor (1 L)	1.000	**0.25**	0.600	0.60	1.67
Batch reactor (1 L)	1.000	**1.00**	0.210	0.21	4.85
	Difference:	**4.0**		Difference:	**2.9**

The difference in reactor volumes (i.e. total hold-up) is approximately 3-fold. The difference in cycle-time (i.e. time the unquenched peroxides are held for) is 4-fold.

These are estimations and not absolute comparisons, but would tend towards greater differences as the scale increased due to batch operations requiring longer peroxide dosing times and extended reaction stirring times. These factors would be brought into effect in order to minimize hot-spots as well as account for the reduced mixing efficiency in larger batch reactors.

5) Calorimetry experimental

Glass-lined vessels were used for heat-flow experiments in order to avoid the peroxide-destabilizing effect of the gold-plating of the standard calorimetry capsules which we initially observed (on measurement of 30% hydrogen peroxide in a gold-plated DSC capsule the onset temperature was brought forward by 50 ^{o}C compared to a repeat analysis in a glass-lined SETARAM vessel (20 ^{o}C versus 70 ^{o}C)). Thermal safety analysis was conducted using the following three techniques.

Dynamic scanning calorimetry (DSC 1, Mettler Toledo, used to analyze trifluoroacetophenone and the buffer solution) was conducted on a sample size of approximately 5 mg in a gold-coated steel crucible (40 µl) sealed under air. The temperature range was from -10°C up to 400°C, at a heating rate of 4 K/min. A ceramic sensor determined heat-flow with a sampling rate of 50 values/second.

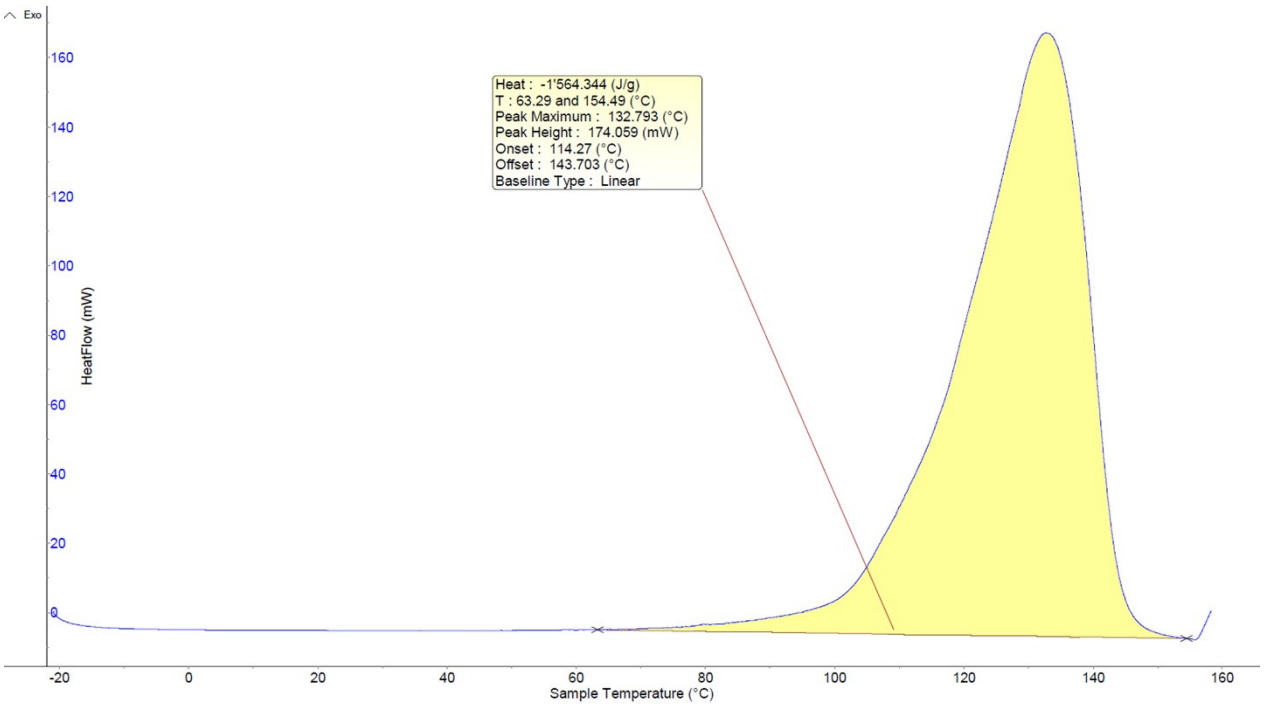
SETARAM (SETARAM Instrumentation) was conducted on a sample size of between 1.2 and 1.5 g in a glass-lined steel vessel under argon. The BT2.15 device was used to explore a temperature range from –20 °C up to 150 °C, with a heating rate of 6 K/hour. This device was also used for the isothermal measurement (30 ^{o}C). The C80 device was used for the temperature range 20 °C up to 280 °C, with a heating rate of 15 K/hour.

SEDEX (Systag) was conducted on a sample size of approximately 3 g in a stirred glass-lined steel vessel (5 mL) under argon. The temperature range was from –20°C up to 150 °C, with a heating rate of 15 K/hour.

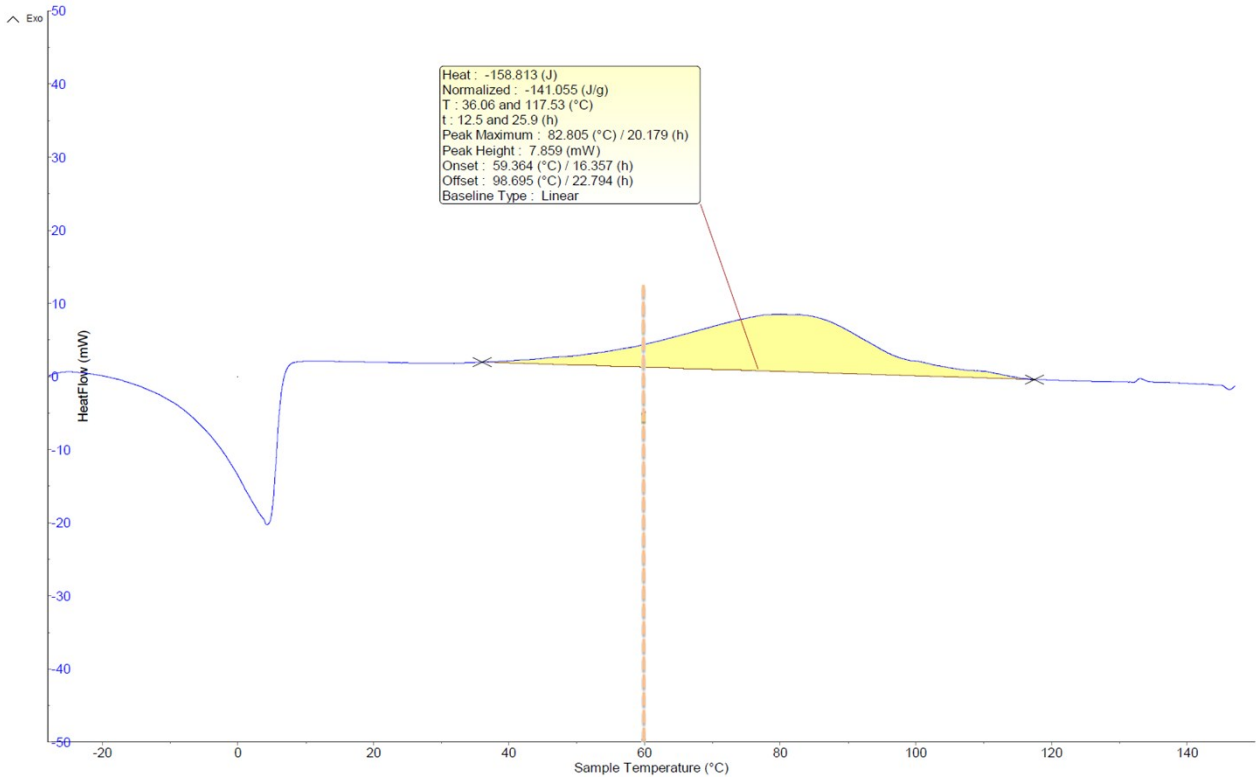
Calorimetric reports

Trifluoroacetophenone as well as the buffer solution (0.6 M K_2CO_3, 0.04 mM EDTA tetrasodium salt, pH 11) seperately provided no observable energy release on heating to 400 °C during DSC analysis.

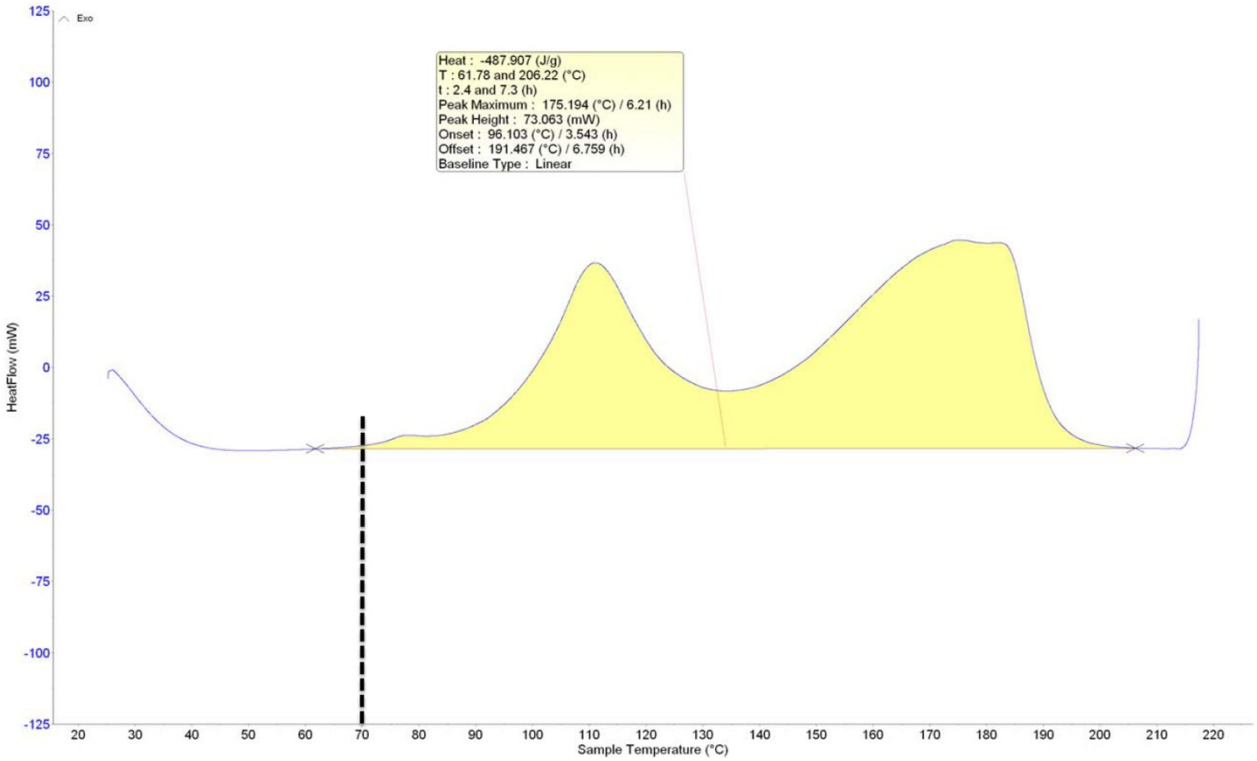
SETARAM of 30 wt.% aqueous hydrogen peroxide (1.497 g) (Sigma-Alrich)



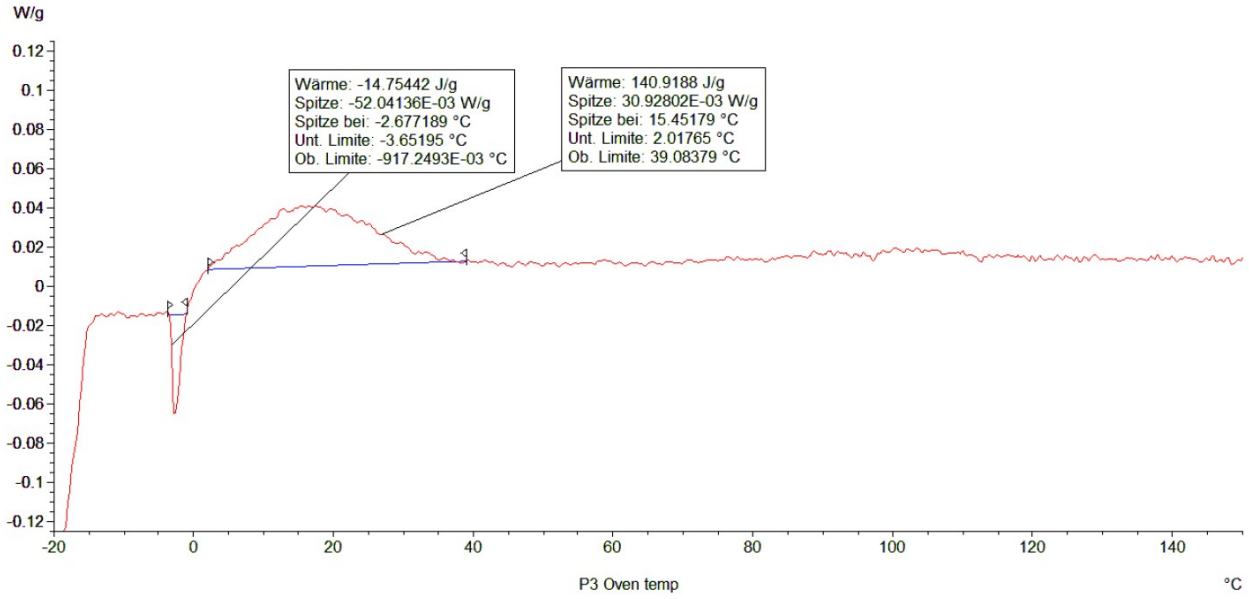
SETARAM of acetic acid (5.62 g) and sulfuric acid (0.10 g) mixed below 15 °C, then addition of 30 wt.% aqueous hydrogen peroxide (0.85 g) (*in-situ* generated 1.2 M peracetic acid). The temperature set-point of 60 °C for the subsequently planned oxidation reaction is overlayed.



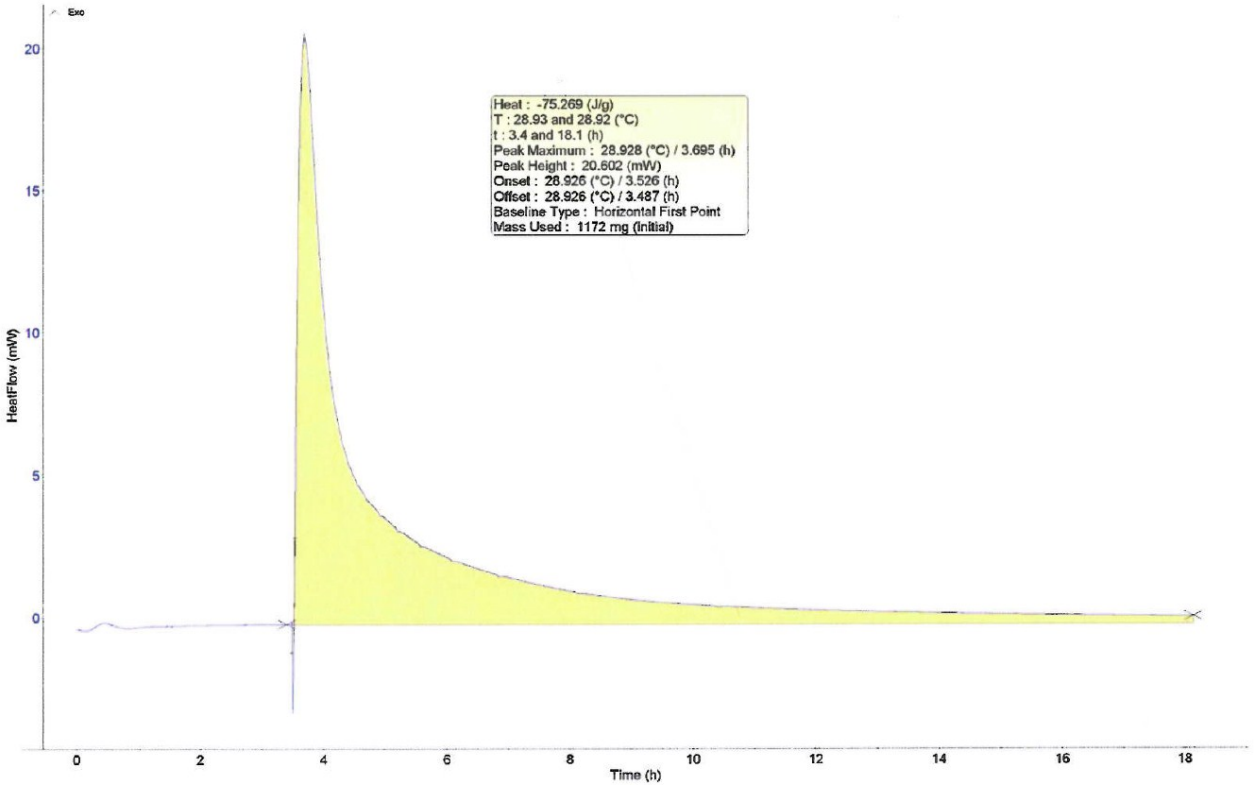
SETARAM of 30 wt.% aqueous hydrogen peroxide (0.123 mL) in acetonitrile (0.5 mL) (*in-situ* generated Payne reagent). The temperature set-point of 70 °C for the subsequently planned oxidation reaction is overlayed..



SEDEX of trifluoroacetophenone (14 mg), acetonitrile (1.17 g) and aq. buffer solution (1.50 g, containing 0.6 M K_2CO_3, 0.04 mM EDTA tetrasodium salt, pH 11) which was pre-cooled to -20 °C upon which 30 wt.% aqueous hydrogen peroxide (0.51 g) was added and the mixture heated to 150 °C.



SETARAM (with mixing-cell) of trifluoroacetophenone (70 mg), acetonitrile (7.00 g) and aq. buffer solution (1.00 g, containing 0.6 M K_2CO_3, 0.04 mM EDTA tetrasodium salt, pH 11) which was pre-heated to 30 ^oC. 30 wt.% Aqueous hydrogen peroxide (0.26 g) was placed in the breakable tube, and upon temperature equilibration this was broken to mix the reaction components. The experiment was kept isothermal (30 ^oC).



The reaction mixture from the previous experiment was then taken into an additional SETARAM experiment which heated the sample in the range of 20 °C to 280 °C.