

Electronic Supplementary Information (ESI)

Development of an Open-Source Flow-Through Cyclic Voltammetry Cell for Real-Time Inline Reaction Analytics

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General experimental details

General Remarks. HPLC was carried out on a Shimazu instrument equipped with a Macherey-Nagel Nucleodur C18 HTec column (150 mm × 4.6 mm, particle size 5 μm) at 37 °C using mobile phase A (H₂O/acetonitrile (9+1 v/v) + 0.1% TFA) and B (acetonitrile + 0.1% TFA) at a flow rate of 0.6 mL min⁻¹. The following gradient was applied: hold 5% of B for 2 minutes, then linear increase from 5% B to 20% B in 6 min, followed by a linear increase from 20% B to 100% B in 1 min, then hold 100% B for 1 min, followed by column equilibration time at 5% B for 5 min. The detection of compounds was accomplished using a diode array detector. All chemicals were obtained from standard commercial vendors and were used without any further purification. Materials for the assembly of the flow CV cell are listed in the next section.

Materials and assembly of the cell

Cell components list (see also Fig. S1):

1: Platinum wire, \varnothing 1.0 mm, 520 mg. SKU number: 327492-520MG

(inserted in a ca. 1.5 cm long PFA tubing of 1 mm i.d. and 1.6 mm o.d., which is fitted in the ferrule of a VacuTight™ Fitting 1/4-28)

2: VacuTight™ Fitting 1/4-28 - 1/8 PEEK, IDEX Part Number: P-948

(contains **1**)

3: Silver wire, \varnothing 1.0 mm, 4.1 g. SKU number: 265594-4.1G

(inserted in a ca. 1.5 cm long PFA tubing of 1 mm i.d. and 1.6 mm o.d., which is fitted in the ferrule of a VacuTight™ Fitting 1/4-28)

4: PEEK Manifold Assembly 5 Port for 1/8" OD, IDEX Part Number: P-155

The 3 ports of the manifold used for installing electrodes were drilled 4.2 mm deeper using a 5 mm diameter drill bit to reduce the inner volume of the cell and permit that the electrodes are close to the center.

The ferrules for **1** and **3** were installed with ca. 1 mm of electrode rod protruding out of the ferrule.

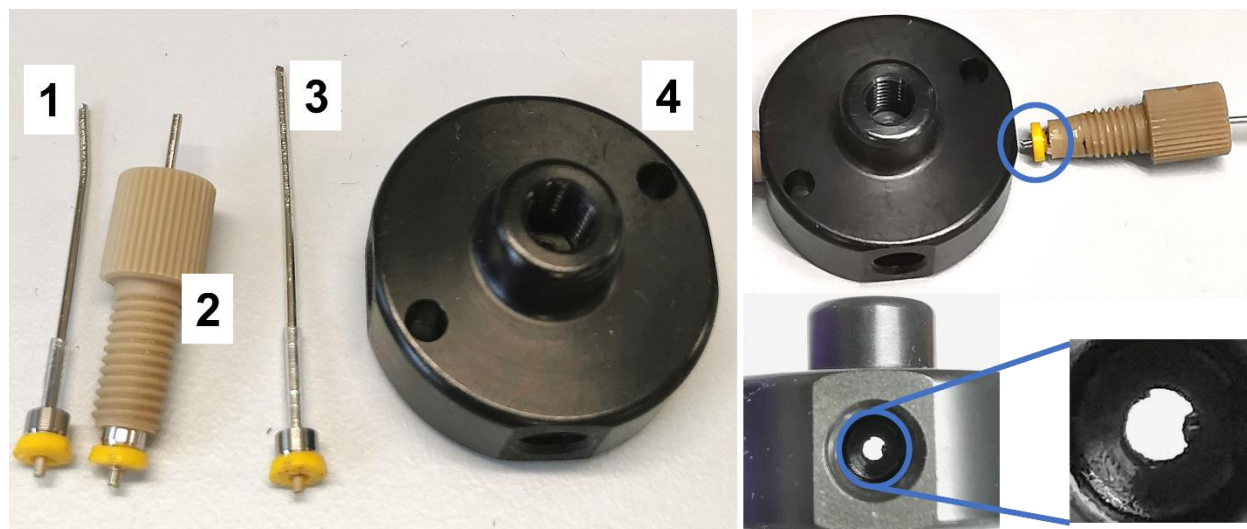


Fig. S1. Details on the components of the flow cell for inline cyclic voltammetry.

The potentiostat used is the 'Rodeostat: open source potentiostat' from IO Rodeo.

<https://iorodeo.com/products/rodeostat>

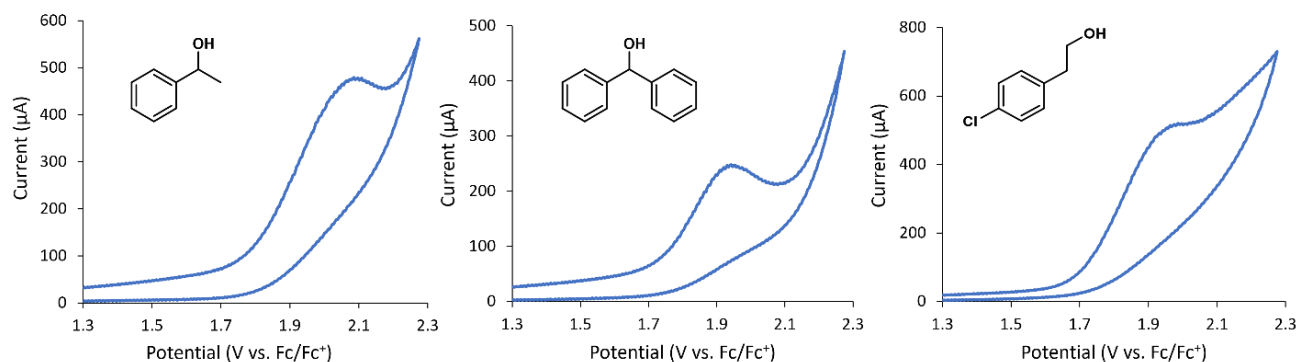


Fig. S2. Cyclic voltammograms of the three alcohols studied, recorded in-line with a flow rate of 70 μL/min; scan-rate: 0.5 V/s; 8 mM concentration of alcohol in MeCN with 0.1 M Et₄NBF₄. WE: Pt.

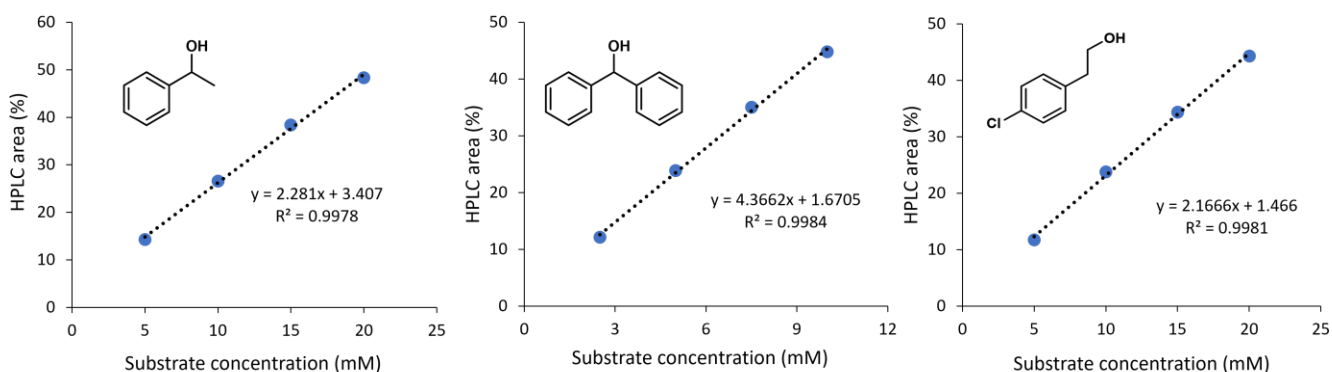


Fig. S3. Calibration of the HPLC quantification method at 215 nm for the model alcohol substrates.

Experimental procedures:

Inline CV analysis of solutions of **1a** of different concentration (Fig. 3)

- Preparation of 1-phenylethanol (**1a**) solutions:

50 mL of a stock solution containing 50 mM 1-phenylethanol (305 mg, 2.5 mmol), 50 mM trifluoroacetic acid (191 μ L, 2.5 mmol) and 100 mM Et₄NBF₄ (1.09 g, 5.0 mmol) was prepared in MeCN (in a volumetric flask) and dried over 3 Å molecular sieves. In another volumetric flask, 50 mL of a blank stock solution was prepared with the same components except 1-phenylethanol. Variable amounts of the stock solution were diluted in volumetric flasks with the blank solution to obtain a series of new solutions with different 1-phenylethanol concentrations, but with a constant concentration of Et₄NBF₄ and TFA.

- Inline cyclic voltammetry measurements:

Each of the solutions were sequentially pumped through the cell with a flow rate of 70 μ L/min using a syringe pump (Syrris Asia). The potentiostat was set to record the CV from 0 to +1.9 V vs Fc/Fc⁺, with a scan rate of 0.5 V/s. Each CV measurement was recorded under steady state conditions. The peak currents at +1.9 V vs Fc/Fc⁺ for each solution are collected in Table S1 and represented in Fig. S4. After measurement, MeCN was passed through the cell for cleaning, and blank CV measurements were recorded to ensure that the working electrode was cleaned.

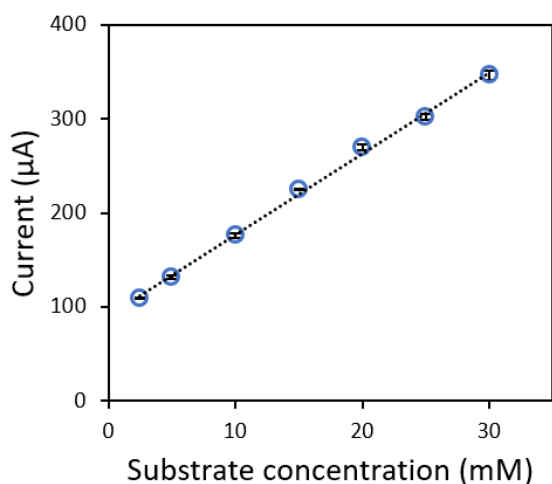


Fig. S4. Inline CV data for a series of solutions of **1a** of different concentration. Error bars represent standard deviation, as measures were taken in triplicate.

Table S1. Numerical values for the inline CV data of a series of solutions of **1a** of different concentration. Standard deviation corresponds to measured taken in triplicate.

Entry	1a (mM)	CV max. measured current (μA)	Standard deviation
1	2.5	108	1.01
2	5	132	1.67
3	10	179	2.55
4	15	226	0.71
5	20	272	3.37
6	25	301	3.22
7	30	350	5.02

Inline CV monitoring of electrochemical oxidations of alcohols in flow.

The setup depicted in Fig. 4 in the manuscript and Fig. S4 below was used in all experiments. Feed solutions containing the corresponding alcohol (0.05 M), trifluoroacetic acid (0.05 M), water (50 mM) and Et₄NBF₄ (0.1 M) in MeCN were prepared and pumped through the flow electrolysis cell at a flow rate of 124 μ L/min. Once steady state conditions were reached, a constant current was applied to the flow electrolysis cell using a BK Precision 1739 power supply. The reaction mixture from the outlet of the flow electrolysis cell, which during electrolysis consisted of a gas liquid mixture due to H₂ generation at the cathode, entered a Teflon AF2400 tube (1 mm i.d., 20 cm length). Release of the gas through the semipermeable tube could be visually observed and most of the gas segments had disappeared from the tubing before entering the flow CV cell. Inline CV of the liquid stream was carried out by scanning the cell potential from 0 to +1.9 V vs Fc/Fc⁺. All CV data were acquired under steady state conditions. To validate the inline CV data, aliquots of ca. 50 μ L were collected from the outlet of the flow setup, diluted with MeCN, and analyzed by HPLC. Each of the CV measurements were collected in triplicate.

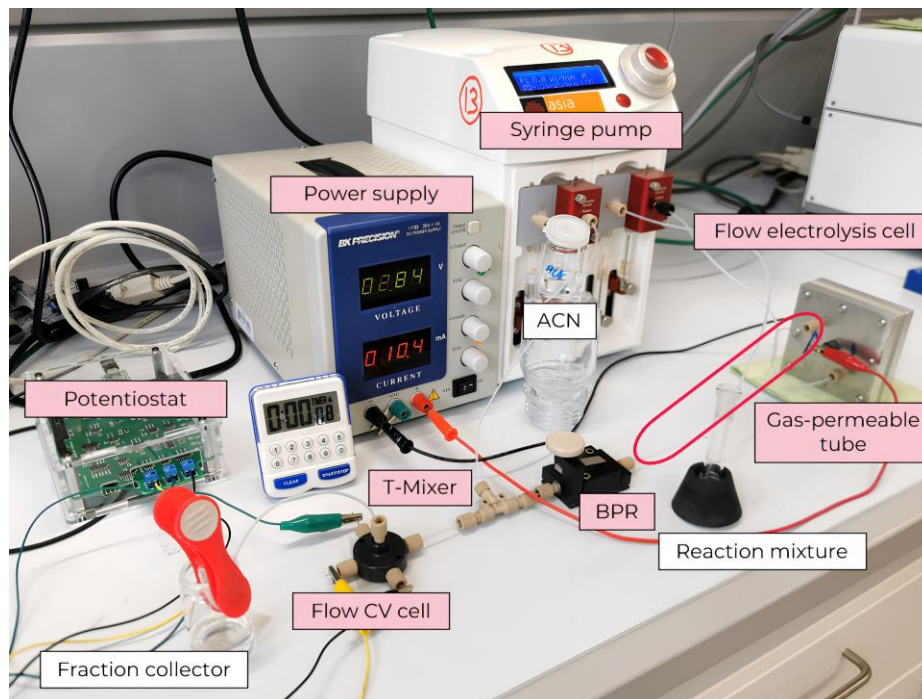


Fig. S4. Experimental setup utilized for the inline CV monitoring of electrochemical oxidations of alcohols in flow. The back-pressure regulator (BPR) can be optionally added at the end of the Teflon AF2400 tubing when high flow rates are used, to ensure that all H₂ gas is released. No back-pressure was applied in the experiments described in this work.

Table S2. Reaction parameters and inline cyclic voltammetry for the oxidation of 1-phenylethanol (**1a**) in flow mode (Fig. 5A).^a

Entry	Reactor current (mA)	Charge (F/mol)	CV max. measured current (μ A)	Conversion (%) ^b
1	15.0	1.5	410	70
2	17.5	1.8	312	84
3	20.0	2.0	237	93
4	15.0	1.5	418	68
5	17.5	1.8	342	80
6	20.0	2.0	253	93
7	15.0	1.5	407	71
8	17.5	1.8	325	83
9	15.0	1.5	417	69
10	16.0	1.6	383	74
11	17.5	1.8	311	83
12	19.0	1.9	247	91
13	16.0	1.6	395	75
14	17.5	1.8	327	83
15	19.0	1.9	245	92
16	20.0	2.0	213	94
17	22.0	2.2	208	97
18	14.0	1.4	475	64
19	17.0	1.7	367	78
20	21.0	2.1	215	95
21	19.5	2.0	283	89
22	14.5	1.5	458	67
23	18.5	1.9	278	89
24	18.2	1.8	285	88
25	16.7	1.7	391	73
26	13.5	1.4	441	65
27	17.5	1.8	317	83
28	22.0	2.2	213	96
29	17.0	1.7	337	80
30	18.0	1.8	284	86

^a Flow setup depicted in Fig. 4 and Fig. S4 used, at 124 μ L/min. ^b Determined by HPLC (215 nm).

Table S3. Reaction parameters and inline cyclic voltammetry for the oxidation of diphenylmethanol (**1b**) in flow mode (Fig. 5B).^a

Entry	Reactor current (mA)	Charge (F/mol)	CV max. measured current (μ A)	Conversion (%) ^b
1	8.0	1.6	322	77
2	7.0	1.4	390	70
3	6.0	1.2	458	59
4	6.5	1.3	426	64
5	7.5	1.5	370	72
6	9.0	1.8	255	85
7	9.2	1.8	249	86
8	10.0	2.0	201	92
9	10.4	2.1	163	95
10	10.2	2.0	178	94

^a Flow setup depicted in Fig. 4 and Fig. S4 used, at 124 μ L/min. ^b Determined by HPLC (215 nm).

Table S4. Reaction parameters and inline cyclic voltammetry for the oxidation of 4-chlorobenzyl alcohol (**1c**) in flow mode (Fig. 5C).^a

Entry	Reactor current (mA)	Charge (F/mol)	CV max. measured current (μ A)	Conversion (%) ^b
1	20.0	2.0	248	89
2	19.0	1.9	289	88
3	22.0	2.2	218	94
4	21.0	2.1	235	92
5	17.0	1.7	308	84
6	16.3	1.6	329	81
7	15.9	1.6	341	79
8	15.3	1.5	367	76
9	10.0	1.0	521	56
10	21.0	2.1	245	93
11	23.0	2.3	217	96
12	14.5	1.5	248	89
13	13.0	1.3	419	64
14	15.0	1.5	371	73
15	18.0	1.8	299	84

^a Flow setup depicted in Fig. 4 and Fig. S4 used, at 124 μ L/min. ^b Determined by HPLC (215 nm).

Table S5. Data obtained for the reactor performance monitoring by inline cyclic voltammetry and offline HPLC analysis for the oxidation of diphenylmethanol (**1b**) (Fig. 6).^a

Entry	Experiment time (min)	CV max. measured current (μA)	Conversion (%) ^b
1	6.0	266	
2	7.5	266	
3	8.7	268	
	10.9		82
4	11.1	272	
5	13.0	278	
6	14.0	279	
7	17.1	267	
8	19.1	263	
9	20.3	279	
	22.4		76
10	22.5	293	
11	25.8	296	
12	27.0	307	
13	31.3	331	
	32.4		67
14	33.6	339	
15	37.2	339	
16	38.5	348	
17	40.5	346	
	42.6		62
18	42.8	357	
19	46.8	359	
20	48.0	362	
21	49.5	373	
	54.7		57
22	54.9	404	
23	56.2	383	
24	61.1	384	
	63.9		55
25	64.1	397	
26	67.3	391	
27	68.5	395	
	69.7		53
28	70.8	402	
29	75.0	406	
30	77.0	416	
	79.3		52
31	79.4	427	
32	83.6	422	
33	85.0	423	
	87.2		49
34	87.3	432	
35	6.0	266	

^a Flow setup depicted in Fig. 4 and Fig. S4 used, at 1.9 F/mol and 124 $\mu\text{L}/\text{min}$ over the course of 90 min. ^b Determined by offline HPLC analysis (215 nm).