Supplementary information for:

Solventless Metallation of Low Melting Porphyrins Synthesised by the Water/Microwave Method

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1. Experimental Section

General procedure Water/MW method: The mixture of pyrrole (9.8 mmol; 0.68 mL), aldehyde (or mixture of aldehydes) (9.8 mmol) and water (0.2 mL) were mixed in a 10 mL microwave vessel. If the aldehyde was a solid, ultrasound was applied to the closed vessel for 10 minutes. The mixture was subsequently subjected to microwave irradiation for 10 minutes at 200 ºC and 300W initial power. After cooling, methyl acetate (~10 mL) was added and the resulting mixture was then washed with water (10 mL). The porphyrin isolated yields obtained either after column chromatography on silica gel using different mixtures of methyl acetate/n-hexane as eluent or recrystallisation.

1.1. *5-(4-hydroxyphenyl)-10,15,20-tris-(4-(2-ethyl-hexyloxy)phenyl)porphyrin (2)*

Via MW-Water method[1]

Were used 0.299 g (2.45 mmol) of 4-hydroxybenzaldehyde and 1.72 g (7.35 mmol) of 4-(2-ethyl-hexyloxy)benzaldehyde). As eluent was used methyl acetate/n-hexane (1:3), to elute 5,10,15,20-(4-(2-ethyl-hexyloxy)phenyl porphyrin **3**, followed by methyl acetate to obtain 5-(4-hydroxyphenyl)-10,15,20-(4-(2-ethyl-hexyloxy)phenyl porphyrin **2** in 7% yield (192 mg). Data according to the literature.[1]

Via Adler-Longo method[2]

The condensation of the mixture of 4-hydroxybenzaldehyde (1.83 g, 0.015 mol), 4-(2-ethyl-hexyloxy)phenyl (10 mL, 0.045 mol) with 4.1 mL pyrrole (0.059 mol), in propionic acid (315 mL) was carried out of at 150ºC (2h). The reaction was cooled till ~65ºC and the reflux condenser was substituted by a distillation apparatus, for low pressure solvent removal. The solid product obtained was dissolved in dichloromethane (100 mL) and washed with saturated solution of sodium bicarbonate (3x 100 mL). The crude reaction mixture was purified by column chromatography with CH_2Cl_2:n-hexane (2:1) initially, to elute porphyrin **3**, followed by CH_2Cl_2 as eluent. The porphyrin **2** was obtained with 8% (1.16 g) of yield.

Via Gonsalves-Pereira method[3]

The condensation of the mixture of 4-hydroxybenzaldehyde (1.83 g, 0.015 mol), 4-(2-ethyl-hexyloxy)benzaldehyde (10 mL, 0.045 mol) with 4.1 mL pyrrole (0.059 mol), in a mixture of acetic acid (210 mL) and nitrobenzene (105mL) was carried out of at 140 ºC (1h). The reaction was cooled till ~65ºC and the reflux condenser was substituted by a distillation apparatus, for low pressure solvent removal. Then, the crude reaction mixture was purified by column chromatography with CH_2Cl_2:n-hexane (2:1) initially,

to elute porphyrin **3** followed CH_2Cl_2 as eluent. The porphyrin **2** was obtained with 8% (1.37 g) of yield.

Via Lindsey method[4]

Samples of 4-hydroxybenzaldehyde (0.455 g, 3.75 mmol), 4-(2-ethyl-hexyloxy)phenyl (2.58 mL, 11 mmol) and pyrrole (1.04 mL, 15 mmol) were dissolved in CH_2Cl_2 (1L) at room temperature under inert atmosphere. Then, TFA (1 mL, 11 mmol) was added, and the mixture was stirred. After 1h, a solution of DDQ (2.5 g, 11 mmol) was added and reaction heated to 45 ºC for 1 hour. In finally, the reaction mixture was neutralized with 20 mL triethylamine and the solvents were evaporated. The crude reaction mixture was dissolved in CH_2Cl_2 (150 mL) and washed with 1 M NaOH solution (5 x 200 mL) to remove DDQ rests, dried with Na_2SO_4, evaporated and purified by column chromatography with CH_2Cl_2:n-hexane (2:1) initially, to elute porphyrin **3**, followed CH_2Cl_2 as eluent. The porphyrin **2** was obtained with 10% (400 mg) of yield.

1.1.1. Up-scaled synthesis of porphyrin 2, *via* MW-Water method

Were used 1.2 g (9.8 mmol) of 4-hydroxybenzaldehyde and 6.9 g (29.4 mmol) of 4-(2-ethyl-hexyloxy)benzaldehyde) and 2.62 mL (39 mmol) of pyrrole dissolved in 1 mL deionized water, using a 35 mL MW vessel. Reaction and work-up proceeded as for general procedure. As eluent was used methyl acetate/n-hexane (1:3), to elute 5,10,15,20-(4-(2-ethyl-hexyloxy)phenyl porphyrin **3**, followed by methyl acetate to obtain 5-(4-hydroxyphenyl)-10,15,20-(4-(2-ethyl-hexyloxy)phenyl porphyrin **2** in 6.8% yield (765 mg).

1.2. *Meso*-substituted symmetrical porphyrins (using MW/Water method)

5,10,15,20-(4-(2-ethyl-hexyloxy)phenyl porphyrin (**3**)

4-(2-ethyl-hexyloxy)benzaldehyde) was used (2.30 g, 9.8 mmol). Methyl acetate/n-hexane (1:3) was used as eluent for column chromatography. 5,10,15,20-(4-(2-ethyl-hexyloxy)phenyl porphyrin was obtained in 14% yield (389 mg). Data is according to the literature.[1]

5,10,15,20-tetra(dodecyl)porphyrin (**4**)

n-Tridecanal (1.94g, 9.8 mmol) was used in this reaction. As eluent was used methyl acetate/n-hexane (1:3) and **4** was obtained in 11% yield (268 mg).

^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): δ = 9.45 (s,8H), 4.92 (t, J=8Hz, 8H), 2.57-2.47 (m, 8H), 1.86-1.77 (m,8H), 1.57-1.51 (m,8H), 1.31-1.21(m, 56H), 0.89 (t, J=8Hz, 12H), -2.63 (s, 2H). Data is according to the literature.[5]

5,10,15,20-tetra(tridecyl)porphyrin (**5**)

n-Tetradecanal (2.08g, 9.8 mmol) was used in this reaction. As eluent was used methyl acetate/n-hexane (1:3) and **5** was obtained in 12% yield (292 mg).

^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): δ = 9.44 (s,8H), 4.91 (t, J=8Hz, 8H), 2.55-2.45 (m, 8H), 1.83-1.76 (m,8H), 1.69-1.63 (m,8H, 1.40-1.21 (m, 64H), 0.87 (t, J=8Hz, 12H), -2.65 (s, 2H). Data is according to the literature.[6]

1.3. Characterization of metalloporphyrins

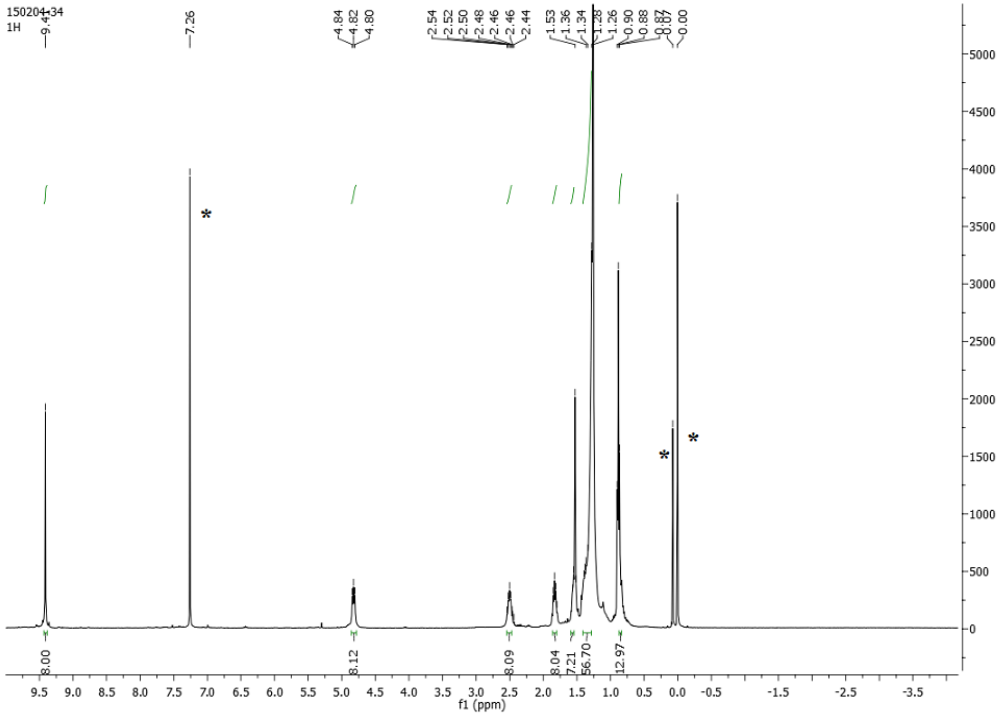


Fig. SI1. 1H-NMR spectrum of 5,10,15,20-tetra(dodecyl)porphyrinato zinc(II) (4a). (*-solvents)

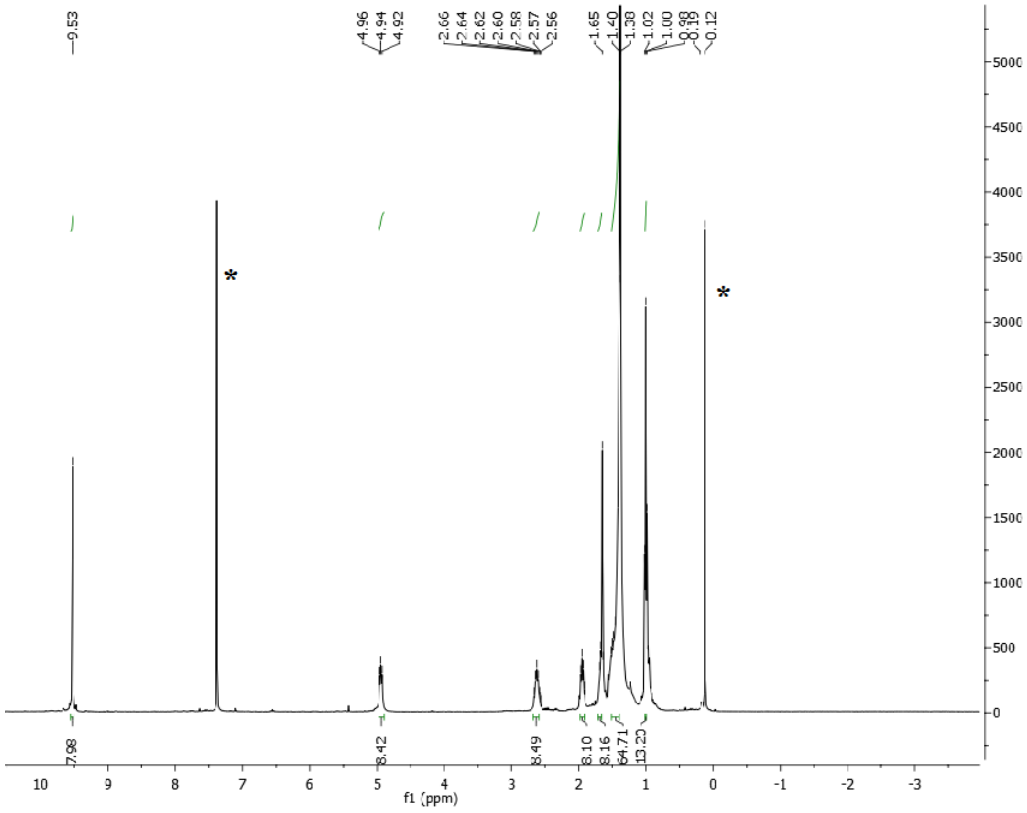


Fig. SI2. 1H-NMR spectrum of 5,10,15,20-tetra(tridecyl)porphyrinato zinc(II) (5[a]). (*-solvents)

2. Typical Microwave apparatus reaction report (Temperature, pressure and power *vs* time)

Method Parameters

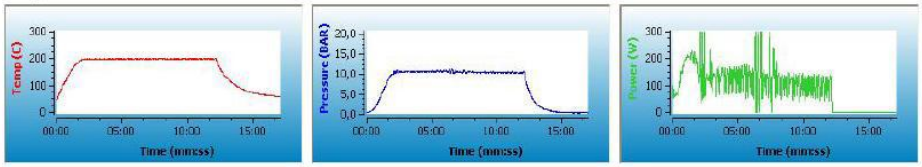
Name: cesar

Type: Dynamic

Prestirring(mm:ss):	01:00

Stage	Temp(C)	Time(mm:ss)	Pressure(BAR)	Power(W)	PowerMAX	Stirring
1	200	10:00	20,7	300	No	High

Graphs



3. Calculation of sustainability factors (E Factor and EcoScale)

Density of chemicals used for the calculation of residues (d = density)

Propionic acid d= 990 g/L
Methanol d=792 g/L
Nitrobenzene d= 1200 g/L
Acetic acid d= 1050 g/L
Dichloromethane d= 1330 g/L
Chloroform d= 1489 g/L
n-Hexane d= 655 g/L
Water d= 1000g/L
Ethanol d= 789 g/L
Ethyl acetate d= 897 g/L
Triethylamine d= 725.5 g/L
Pyridine d= 982 g/L
Diethyl ether = 713.4 g/L
Saturated sodium acetate solution d= 1528 g/L
Saturated sodium bicarbonate solution d= 2200 g/L
DBU (1,8-Diazabicyclo[5.4.0]undec-7-ene) d= 1018 g/L
Butyl acetate d= 883 g/L
Petrol ether d= 640 g/L
[bmim][BF_4] d=1210 g/L
DMF d= 948 g/L
Acetonitrile d= 786 g/L
1-bromo-2-ethylhexane d = 1086 g/L

3.1. Calculation of E Factors for the preparation of 4-(2-ethyl-hexyloxy) benzaldehyde

Conventional heating method

E = (118 g acetonitrile + 7.8 g acetonitrile + 30 g silica + 400 g dichloromethane)/9 g
E = 62

Microwave irradiation method

E = (0.78 g acetonitrile + 1.56 g acetonitrile)/0.109 g

E = 21

3.2. Calculation of E Factors for the preparation of 4-(2-ethyl-hexyloxy) benzaldehyde

Conventional Method	
Category	Penalty Points
Yield	2.5
Price of reaction components	3
Safety	10
Technical Setup	0
Temperature/Time	3
Workup/Purification	10
Total	28.5
EcoScale (100-Total)	71.5

Microwave Method	
Category	Penalty Points
Yield	1.7
Price of reaction components	3
Safety	10
Technical Setup	1
Temperature/Time	2
Workup/Purification	0
Total	16.7
EcoScale (100-Total)	83.3

3.3. Calculation of E Factors for the preparation of 5-(4-hydroxyphenyl)-10,15,20-tri-(4-(2-ethyl-hexyloxy)phenyl)porphyrin 2

Water/Microwave method

E = (0.2 g water + 10 g methyl acetate + 10 g water + 30 g silica gel + 35 g n-hexane + 60 g methyl acetate + 60 g methyl acetate)/0.192 g

E = 1069

Adler-Longo method

E = (312 g propionic acid + 133 g dichloromethane + 300 g bicarbonate+ 300 g silica + 800 g dichloromethane + 200 g n-hexane + 500 g dichloromethane)/1.16 g

E = 2193

Gonsalves-Pereira method

E = (250 g nitrobenzene + 110 g acetic acid + 850 g dichloromethane + 300 g silica+ 220 g n-hexane + 550 g dichloromethane)/1.37 g

E = 1664

Lindsey method

E = (1330 g dichloromethane + 1.4 g TFA + 2.5 g DDQ + 15 g triethylamine + 1000 g NaOH solution, 3 g Na2SO4 + 150 g silica + 532 g dichloromethane + 82 g n-hexane + 465 g dichloromethane)/ 0.4 g

E = 8950

3.4. Calculation of EcoScale values for the preparation of 5-(4-hydroxyphenyl)-10,15,20-tris-(4-(2-ethyl-hexyloxy)phenyl)porphyrin 2

MW-Water Method	
Category	Penalty Points
Yield	46.5
Price of reaction components	3
Safety	25
Technical Setup	1
Temperature/Time	3
Workup/Purification	12
Total	80.5
EcoScale (100-Total)	9.5

Adler-Longo Method	
Category	Penalty Points
Yield	46
Price of reaction components	8
Safety	30
Technical Setup	1
Temperature/Time	3
Workup/Purification	13
Total	101
EcoScale (100-Total)	-1

Gonsalves-Pereira Method	
Category	Penalty Points
Yield	46
Price of reaction components	8
Safety	30
Technical Setup	1
Temperature/Time	3
Workup/Purification	15
Total	104
EcoScale (100-Total)	-4

Lindsey Method	
Category	Penalty Points
Yield	44.5
Price of reaction components	18
Safety	50
Technical Setup	1
Temperature/Time	3
Workup/Purification	13
Total	129.5
EcoScale (100-Total)	-29.5

3.5. EHS classification Table

		Safety			**Health**			**Environment**		
Selected substance	**Vol. (m^3)**	**Release pot.**	**Fire/ explosion**	**React./ Decomp.**	**Acute toxic.**	**Irrit.**	**Chronic toxic.**	**Persistency**	**Air haz.**	**Water haz.**
Acetic acid	1	0.46	0.93	0.00	0.72	1.00	0.52	0.23	0.52	0.13
Dichloromethane	1	0.95	1.00	0.00	0.34	0.00	0.40	0.77	0.40	0.50
Nitrobenzene	1	0.10	0.69	0.00	0.49	0.39	0.66	0.54	0.66	0.35
Propionic acid	1	0.33	0.86	0.00	0.63	0.88	0.50	0.28	0.50	0.00

4. Calculation of sustainability factors for the preparation of metalloporphyrins

4.1. Calculation of E Factors

Solventless method (this work)

E = (0.9 g methyl acetate + 2 g water)/0.0103 g

E = 281

Chloroform/methanol method

E = (45 g chloroform + 4 g methanol + 5 g Na_2SO_4 + 50 g water + 20 g silica gel + 150 g chloroform)/0.135 g

E = 2030

DMF method

E = (1500 g DMF + 4000 g water)/11.4 g

E = 482

Pyridine method

E = (98.2 g pyridine + 713 g diethyl ether + 2292 sodium acetate solution + 2854 g diethyl ether + 2000 g 0.1M HCl + 2200 g $NaHCO_3$ + 1000 g water)/0.85 g

E = 13126

DBU/Microwave method

E = (5 g DBU + 8 g ethanol + 9 g butyl acetate + 6 g petrol ether + 10 g methanol + 30 g Al_2O_3 + 200 g chloroform)/0.6 g

E = 447

Ionic liquid/Microwave method

E = (1.21 g ionic liquid + 15 g ethyl acetate + 10 g silica gel + 75 g dichloromethane)/0.006 g

E = 16868

DMF/Microwave method

E = (5 g DMF + 50 g water + 50 g water)/0.105 g

E = 1000

4.2. Calculation of EcoScale values

Solventless method (this work)	
Category	Penalty Points
Yield	1
Price of reaction components	3
Safety	10
Technical Setup	1
Temperature/Time	2
Workup/Purification	1
Total	18
EcoScale (100-Total)	**82**

Chloroform/methanol method	
Category	Penalty Points
Yield	3
Price of reaction components	3
Safety	20
Technical Setup	0
Temperature/Time	3
Workup/Purification	14
Total	43
EcoScale (100-Total)	**57**

DMF method	
Category	Penalty Points
Yield	3
Price of reaction components	5
Safety	20
Technical Setup	0
Temperature/Time	2
Workup/Purification	14
Total	44
EcoScale (100-Total)	**56**

Pyridine method	
Category	Penalty Points
Yield	2
Price of reaction components	5
Safety	25
Technical Setup	0
Temperature/Time	8
Workup/Purification	1
Total	41
EcoScale (100-Total)	**59**

DBU/Microwave method	
Category	Penalty Points
Yield	17.5
Price of reaction components	5
Safety	15
Technical Setup	1
Temperature/Time	2
Workup/Purification	11
Total	51.5
EcoScale (100-Total)	**48.5**

Ionic liquid/Microwave method	
Category	Penalty Points
Yield	2
Price of reaction components	5
Safety	10
Technical Setup	1
Temperature/Time	2
Workup/Purification	13
Total	33
EcoScale (100-Total)	**67**

DMF/Microwave method	
Category	Penalty Points
Yield	2.5
Price of reaction components	5
Safety	15
Technical Setup	1
Temperature/Time	2
Workup/Purification	13
Total	38.5
EcoScale (100-Total)	**61.5**

5. Thermomicroscopy

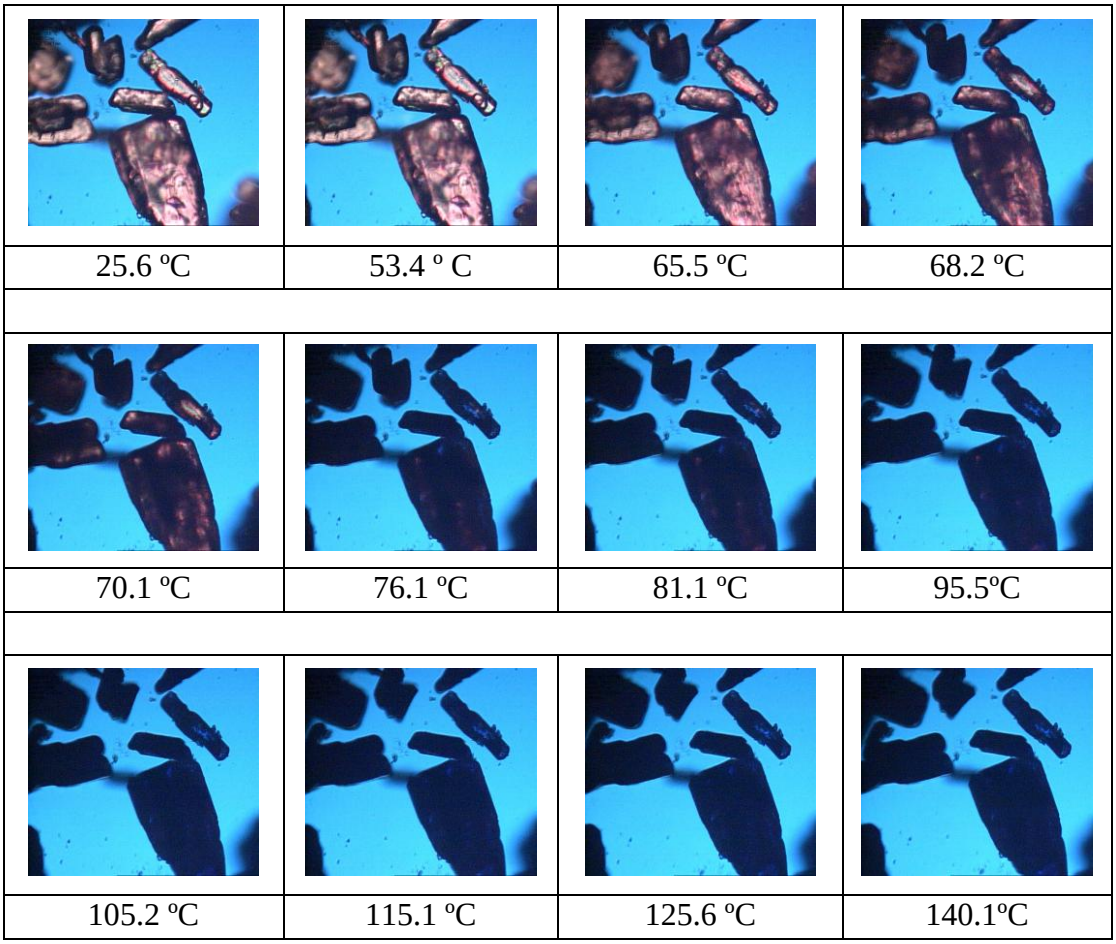


Fig. SI3- Polarized light thermomicroscopy images obtained in a heating run cobalt (II) acetate tetrahydrate (5 equivalent) mixture**.** Magnification 200x; β= 10ºC min^{-1}.

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