Supporting Information

A. Phenolic compounds

A.1. ESs screening

Table S.1. Results of the total phenolic content (TPC), total flavonoids content (TFC) and the antioxidant activity in inhibition percentage for all the solvents tested as extraction solvents: water, ethanol and other 26 ESs with 30% (v/v). LD: detection limit

Solvent	TPC (mg/g)	TFC (mg/g)	TEAC (mg/g)
Water	5.64±0.03	10.17±0.14	0.50±1.50
Ethanol	3.70±0.13	7.40±0.20	1.86±0.18
Bet:Gly (1:4)	9.38±0.63	9.50±0.14	1.76±0.11
Bet:PPG (1:4)	7.33±0.18	10.57±0.31	1.85±0.12
Bet:1.2-But (1:3)	5.29±1.36	13.89±0.06	1.30±0.37
Bet:1.2-But (1:4)	5.60±0.99	11.09±0.17	1.86±0.10
Bet:1.3-But (1:4)	2.92±1.32	7.36±0.17	1.67±0.34
Bet:LA (1:1)	2.90±1.26	4.75±0.09	1.69±0.25
Bet:LA (1:2)	2.29±1.42	2.40±0.15	1.34±2.79
Bet:LA (1:3)	8.22±0.38	6.58±0.01	1.22±1.06
Pro:Gly (1:4)	14.14±0.03	9.72±0.85	1.34±0.84
Pro:PPG (1:4)	15.26±0.08	13.66±0.22	0.63±0.55
Pro:1.2-But (1:3)	15.30±0.06	15.26±0.40	0.78±0.80
Pro:1.2-But (1:4)	14.84±0.10	20.61±0.02	<LD
Pro:1.3-But (1:4)	8.30±0.07	12.68±0.01	<LD
Pro:LA (1:1)	11.48±0.01	7.32±0.03	0.18±4.50
Pro:LA (1:2)	9.75±0.03	6.09±0.17	0.65±3.50
Pro:LA (1:3)	10.99±0.05	5.55±0.02	0.70±2.298
ChCl:Gly (1:4)	10.88±1.26	11.88±0.09	2.12±0.21
ChCl:PPG (1:4)	<LD	9.15±0.09	1.99±0.07
ChCl:1.2-But (1:3)	0.20±7.39	11.64±0.02	2.05±0.10
ChCl:1.3-But (1:4)	3.71±0.43	7.49±0.05	1.75±0.21
ChCl:LA (1:1)	<LD	6.10±0.07	0.60±1.95
ChCl:LA (1:2)	<LD	3.72±0.05	0.49±2.36
ChCl:LA (1:3)	0.23±1.46	3.00±0.16	<LD
ChCl:CA (2:1)	0.49±4.54	2.46±0.69	0.35±2.52
ChCl:CA (1:1)	0.93±6.69	1.78±0.42	0.62±1.14
ChCl:CA (1:2)	0.33±2.66	1.85±0.06	0.57±0.52

Table S.2. HPLC results in µg/g of dry weight for each of the ESs with 30% (v/v) of water tested on the screening. BD: Bellow detection.

Solvent	Gallic acid	3,4-Dihydroxybenzoic acid	Catechin	Caffeic acid	Syringic acid	Coumaric acid	Ferulic acid	Salicylic acid	Quercetin
Water	6.14±0.09	7.32±0.10	BD	BD	2.52±0.23	BD	BD	7.01±3.78	0.36±0.55
Ethanol	6.26±0.22	8.10±0.33	BD	BD	BD	BD	BD	5.14±2.40	BD
Bet:Gly (1:4)	6.07±0.01	9.53±0.81	BD	BD	2.46±0.12	BD	BD	4.98±5.07	BD

Bet:PPG (1:4)	6.07±0.04	8.23±0.33	BD	BD	BD	BD	BD	3.07±0.29	BD
Bet:1.2-But (1:3)	8.74±0.07	8.06±0.45	BD	BD	2.33±0.07	BD	BD	13.63±0.31	BD
Bet:1.2-But (1:4)	17.73±0.30	8.20±0.26	BD	BD	2.39±0.11	BD	BD	24.73±9.15	BD
Bet:1.3-But (1:4)	6.21±0.13	8.26±0.05	BD	BD	2.42±0.28	BD	BD	27.16±3.18	BD
Bet:LA (1:1)	6.20±0.04	10.45±0.28	BD	BD	2.53±0.21	BD	BD	6.94±0.31	0.75±0.09
Bet:LA (1:2)	6.09±0.01	10.10±0.11	BD	BD	2.48±0.10	BD	BD	14.41±0.20	0.90±0.54
Bet:LA (1:3)	6.08±0.02	11.20±1.28	BD	BD	2.80±0.69	BD	BD	27.25±1.14	0.54±0.74
Pro:Gly (1:4)	6.11±0.03	8.68±0.28	BD	BD	2.36±0.43	BD	BD	12.17±0.79	BD
Pro:PPG (1:4)	6.17±0.20	10.85±0.31	9.48±0.89	BD	2.30±0.06	BD	BD	181.67±1.46	BD
Pro:1.2-But (1:3)	15.21±0.38	8.22±0.41	BD	BD	BD	BD	BD	17.06±0.58	BD
Pro:1.2-But (1:4)	28.98±0.30	8.63±0.17	BD	BD	12.91±0.74	BD	BD	69.29±0.04	BD
Pro:1.3-But (1:4)	6.07±0.07	7.94±0.39	BD	BD	2.37±0.21	BD	BD	26.30±6.85	0.51±0.29
Pro:LA (1:1)	9.65±0.35	8.49±1.76	BD	BD	2.43±0.80	BD	BD	17.35±1.24	0.04±7.99
Pro:LA (1:2)	9.64±1.20	8.31±0.40	BD	BD	2.59±0.13	BD	BD	18.44±1.30	0.02±10.29
Pro:LA (1:3)	9.16±1.30	8.84±0.37	BD	BD	2.65±0.71	BD	BD	27.51±1.98	1.56±1.11
ChCl:Gly (1:4)	BD	8.23±0.27	BD	BD	BD	BD	BD	4.59±7.87	BD
ChCl:PPG (1:4)	6.18±0.02	8.38±0.39	BD	BD	2.40±0.08	BD	BD	5.31±1.25	BD
ChCl:1.2-But (1:3)	19.39±0.70	8.22±0.32	BD	BD	BD	BD	BD	17.24±0.31	BD
ChCl:1.3-But (1:4)	6.31±0.05	8.00±0.35	BD	BD	2.33±0.61	BD	BD	15.44±2.43	0.61±4.28
ChCl:LA (1:1)	BD	10.57±1.29	BD	BD	2.44±0.36	BD	BD	26.35±0.55	0.18±1.38
ChCl:LA (1:2)	6.17±0.14	9.64±1.92	BD	BD	2.61±0.12	BD	BD	36.41±10.37	0.67±0.65
ChCl:LA (1:3)	6.08±0.01	11.42±1.92	BD	BD	2.78±0.18	BD	BD	21.12±0.85	1.69±2.44
ChCl:CA (2:1)	43.17±0.20	9.76±0.08	BD	BD	BD	BD	BD	13.65±0.15	1.52±065
ChCl:CA (1:1)	29.52±0.62	9.68±0.43	BD	BD	2.26±0.33	BD	BD	9.07±1.20	19.47±0.82
ChCl:CA (1:2)	28.76±0.23	9.623±0.74	BD	BD	2.32±0.70	BD	BD	10.01±3.98	4.81±0.22

Table S.3. Dissociation constants for the nine phenolic compounds characterized in the HPLC.

Phenolic Compounds	**pKa**	**Reference**
Gallic acid	pKa_1 = 4.4±0.1 pKa_2 = 8.8 ±0.1 pKa_3 = 10.0 ±0.1 pKa_4 = 11.4 ±0.1	1
3,4-Dihydroxybenzoic acid	pKa_1 = 4.35 ± 0.05 pKa_2 = 8.79 ± 0.05 pKa_3 = 13.0± 0.1	2
Catechin	pKa_1 = 8.68±0.23 pKa_2 = 9.70±0.24	3

	pKa_3 = 11.55±0.20	
Caffeic acid	pKa_1 = 4.43 ± 0.02 pKa_2 = 8.69 ± 0.03	4
***p*-Coumaric acid**	pKa_1 = 4.360 ± 0.003 pKa_2 = 8.982 ± 0.001	4
Ferulic acid	pKa_1 = 4.52 pKa_2 = 9.39	4
Salicylic acid	pKa_1 = 2.80±0.04 pKa_2 = 13.4±0.2	2
Syringic acid	pKa_1 = 4.30 pKa_2 = 9.10	5
Quercetin	pKa_1 = 7.10±0.12 pKa_2 = 9.09±0.11 pKa_3 = 11.12±0.36	6

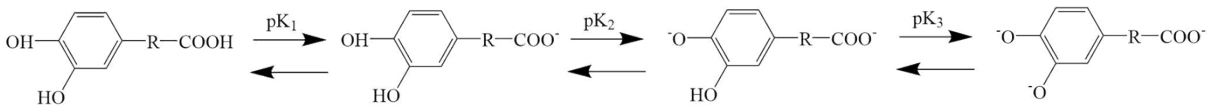

Fig S.1. Deprotonation step for a general phenolic acid. Adapted from Beltran et al. [4].

The ChCl:CA (2:1) with 30% (v/v) of water presents a very low pH (pH = 0.60), and thus all the PCs evaluated are in their protonated form, considering the pKa values present in **Table S.3**. On the other hand, the aqueous solutions of the two selected proline-based ESs have a neutral pH, 6.68 and 6.46 for Pro:PPG (1:4) and Pro:1,2-But (1:4), respectively. At neutral pH only catechin and quercetin are fully protonated and both gallic acid and salicylic acid are deprotonated.

A.3. Optimization

Water optimization

Table S.4. Results of TPC, TFC and TEAC percentage for the optimization of water content. LD: detection limit

Solvent	Water content %(v/v)	TPC (mg/g)	TFC (mg/g)	TEAC (mg/g)

Pro:PPG (1:4)	10	4.80±0.08	1.36±1.41	1.03±0.37
	20	10.46±0.05	10.69±0.20	0.82±0.88
	40	12.33±0.01	14.77±0.35	0.39±1.45
	50	13.25±0.08	14.76±0.05	<LD
Pro:1,2-But (1:4)	10	5.74±0.50	5.51±0.23	<LD
	20	7.96±0.07	10.79±0.45	<LD
	40	13.72±0.10	15.38±0.40	<LD
	50	12.45±0.07	20.31±0.04	<LD
ChCl:CA (2:1)	10	3.14±2.13	2.33±0.16	0.39±5.41
	20	6.04±1.65	2.00±0.15	0.81±3.24
	40	8.50±0.26	5.62±0.16	0.25±3.54
	50	7.44±2.26	7.82±0.05	0.59±3.08

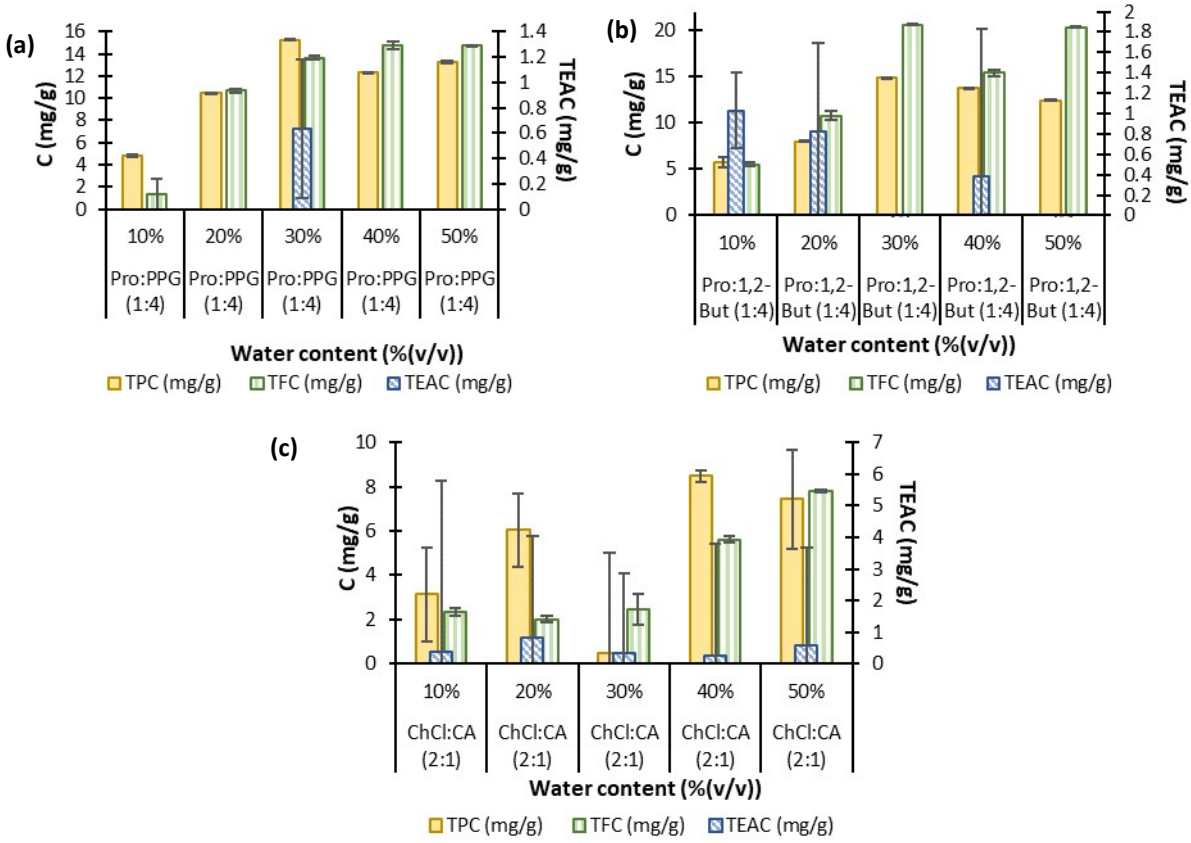

Fig S.2. Evaluation of TPC (yellow), TFC (green) and TEAC (blue) for water content optimization for (a) Pro:PPG (1:4), (b) Pro:1,2-But (1:4), (c) ChCl:CA (2:1).

Table S.5. HPLC results in µg/g of dry weight for the water content optimization for the three best ES chosen. BD: Bellow detection.

Water content %(v/v)	10%	20%	40%	50%
	Pro:PPG (1:4)			
Gallic acid	BD	BD	6.09±0.08	6.07±0.01
3,4-Dihydroxybenzoic acid	7.58±0.22	8.99±0.19	9.97±0.07	10.21±0.24
Catechin	BD	BD	32.51±0.45	30.12±0.29

Caffeic acid	BD	BD	BD	BD
Syringic acid	BD	BD	2.45±0.14	2.48±0.48
Coumaric acid	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD
Salicylic acid	77.09±0.22	69.33±0.60	48.14±0.63	41.08±0.98
Quercetin	BD	BD	BD	BD
	Pro:1.2-But (1:4)			
Gallic acid	23.68±0.74	19.42±0.37	9.11±0.40	8.88±1.68
3,4-Dihydroxybenzoic acid	7.90±0.14	8.52±0.03	9.20±0.56	9.51±0.76
Catechin	BD	BD	BD	BD
Caffeic acid	BD	BD	BD	BD
Syringic acid	BD	BD	2.53±0.19	2.52±0.31
Coumaric acid	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD
Salicylic acid	30.57±1.00	80.76±0.14	16.76±1.27	53.11±2.46
Quercetin	0.07±22.27	0.31±0.65	0.85±0.73	0.46±3.01
	ChCl:CA (2:1)			
Gallic acid	9.72±0.58	9.17±0.37	9.92±0.66	8.38±0.70
3,4-Dihydroxybenzoic acid	7.40±0.77	7.72±0.01	7.80±0.14	8.18±0.12
Catechin	BD	BD	BD	BD
Caffeic acid	BD	BD	BD	BD
Syringic acid	BD	2.33±0.03	BD	BD
Coumaric acid	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD
Salicylic acid	6.31±4.50	9.59±4.10	5.73±5.05	6.16±8.71
Quercetin	BD	BD	BD	BD

Temperature optimization

Table S.6. Results of the TPC, TFC and TEAC for the temperature optimization.
LD: detection limit

ES	T (ºC)	TPC (mg/g)	TFC (mg/g)	TEAC (mg/g)
Pro:PPG (1:4)	50	10.18±0.10	11.67±0.09	23.40±5.58
	70	11.84±0.36	15.88±0.18	57.55±1.18
Pro:1,2-But (1:4)	50	5.93±0.06	12.25±0.13	47.18±4.27
	70	12.29±0.05	21.21±0.10	<LD
ChCl:CA (2:1)	50	3.20±2.83	4.32±0.06	<LD
	70	7.59±1.91	7.63±1.91	40.93±0.56

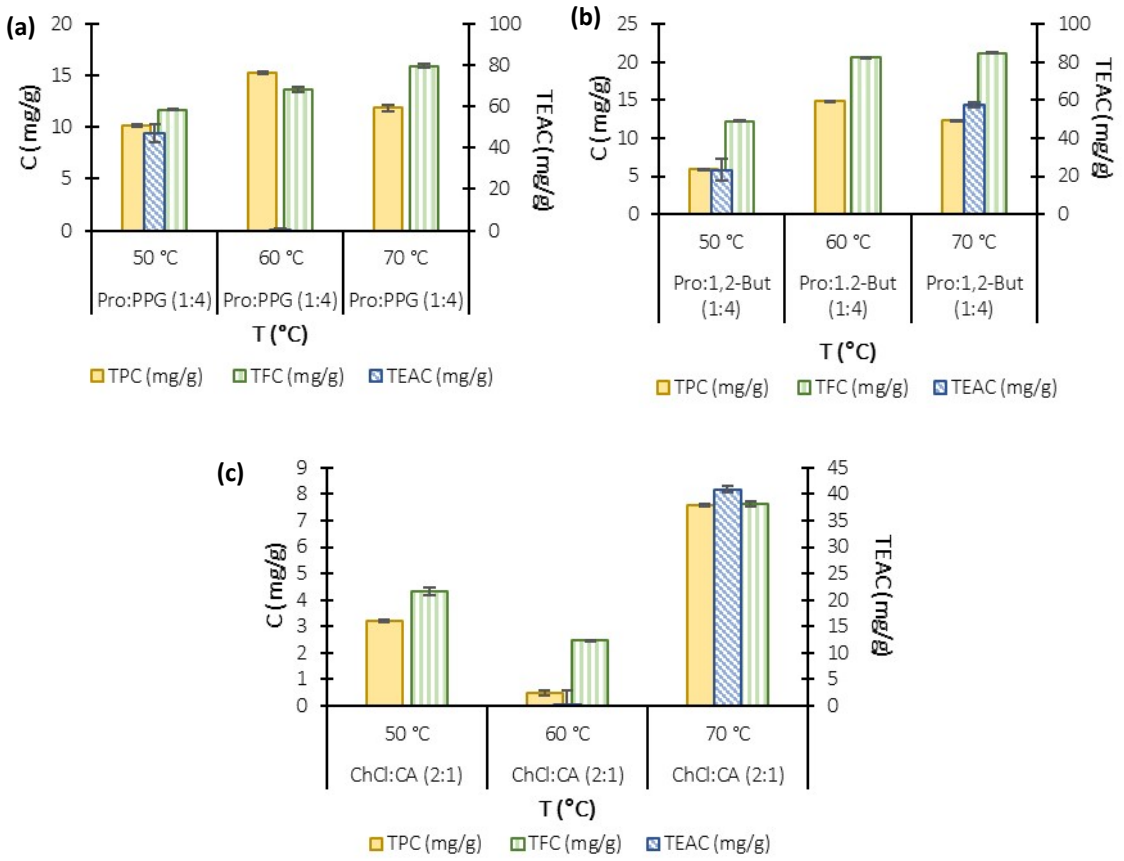

Fig S.3. Evaluation of the TPC (yellow), TFC (green) and TEAC (blue) for the temperature optimization in the orbital shaker: (a) Pro:PPG (1:4), (b) Pro:1,2-but (1:4) and (c) ChCl:CA (2:1) all with 30% (v/v)

Table S.7. HPLC results in µg/g of dry weight for the temperature optimization. BD: Bellow detection.

Temperature (ºC)	50	70
	Pro:PPG (1:4)	
Gallic acid	BD	BD
3,4-Dihydroxybenzoic acid	9.24±0.03	9.14±0.06
Catechin	BD	BD
Caffeic acid	BD	BD
Syringic acid	BD	BD
Coumaric acid	BD	BD
Ferulic acid	BD	BD
Salicylic acid	27.13±0.22	130.97±0.30
Quercetin	BD	BD
	Pro:1.2-But (1:4)	
Gallic acid	14.86±0.09	28.07±2.12
3,4-Dihydroxybenzoic acid	8.97±0.06	9.06±0.50
Catechin	BD	BD
Caffeic acid	BD	BD
Syringic acid	BD	2.51±0.07

Coumaric acid	BD	BD
Ferulic acid	BD	BD
Salicylic acid	59.45±1.94	69.64±0.89
Quercetin	BD	BD
	ChCl:CA (2:1)	
Gallic acid	10.16±0.31	8.68±0.68
3,4-Dihydroxybenzoic acid	7.62±0.26	8.00±0.23
Catechin	BD	BD
Caffeic acid	BD	BD
Syringic acid	BD	2.32±0.08
Coumaric acid	BD	BD
Ferulic acid	BD	BD
Salicylic acid	6.06±2.25	7.28±6.87
Quercetin	BD	BD

A.4. Intensification techniques

UAE

Table S.8. Results of the total phenolic content (TPC), total flavonoids content (TFC) and the antioxidant activity in inhibition percentage for the ultrasound assisted extractions.
LD: detection limit

ES	Conditions	TPC (mg/g)	TFC (mg/g)	TEAC (mg/g)
Pro:PPG (1:4)	UAE 20W, 1,5min	10.85±6.98	10.11±0.94	<LD
	UAE 20W, 3min	18.30±3.76	16.35±0.19	<LD
	UAE 10W, 3min	14.33±4.61	11.22±1.01	<LD
	UAE 10W, 6min	22.94±3.03	16.76±0.18	<LD
	UAE 10W, 9min	27.94±5.65	20.57±0.30	<LD
Pro:1.2-But (1:4)	UAE 20W, 1,5min	13.86±4.07	12.57±0.24	<LD
	UAE 20W, 3min	20.20±2.83	17.62±0.17	<LD
	UAE 10W, 3min	16.98±3.44	14.98±0.13	<LD
	UAE 10W, 6min	20.11±2.90	19.81±0.28	<LD
	UAE 10W, 9min	38.12±1.51	23.98±0.11	<LD
ChCl:CA (2:1)	UAE 20W, 1,5min	8.73±6.12	4.90±0.23	0.26±1,95
	UAE 20W, 3min	4.62±8.96	4.26±0.27	<LD
	UAE 10W, 3min	12.27±1.43	5.41±0.31	<LD
	UAE 10W, 6min	8.99±5.17	6.57±0.78	<LD
	UAE 10W, 9min	8.74±5.16	9.38±0.10	<LD

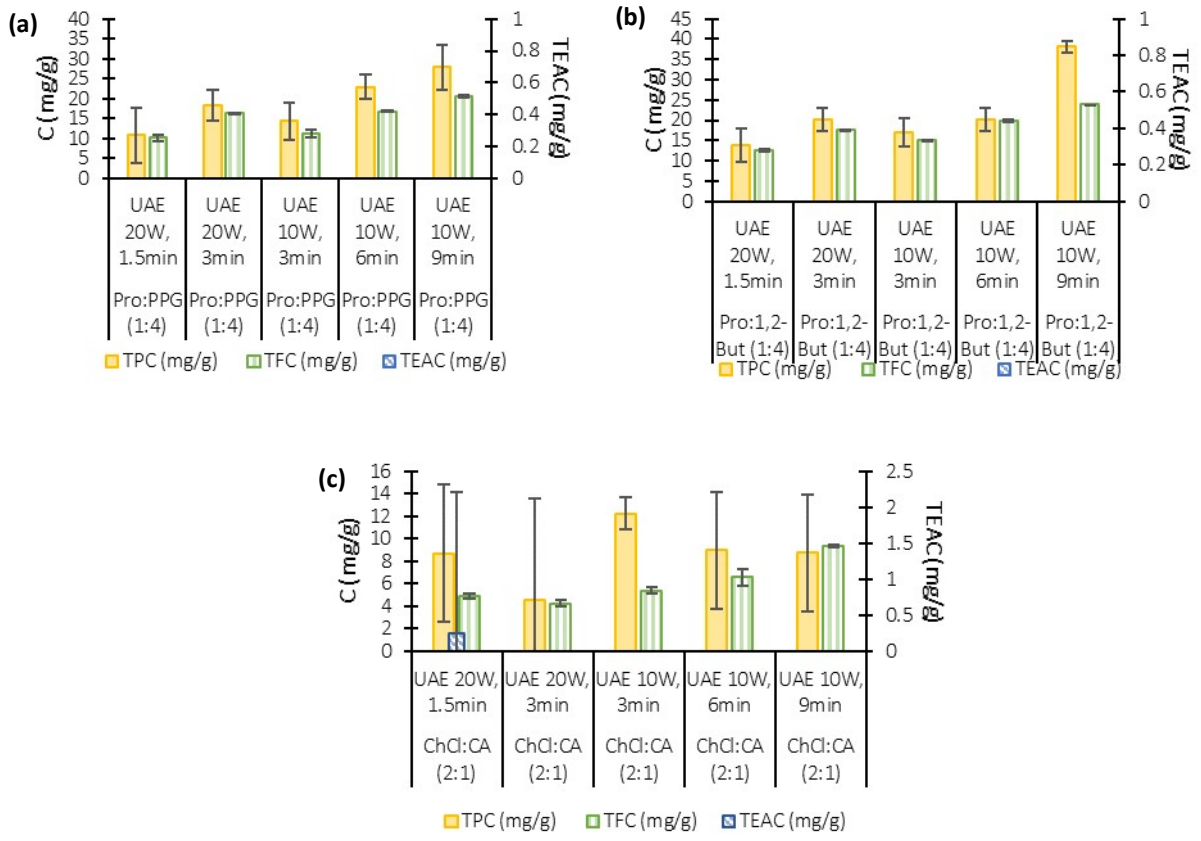

Fig S.4. UAE results of TPC (yellow), TFC and TEAC (blue) for the three chosen DES with 30% (v/v) of water: (a) Pro:PPG (1:4) (b) Pro:1,4-But (1:4), (c) ChCl:CA (2:1).

Table S.9. HPLC results in µg/g of dry weight for the ultrasound assisted extraction for the three best ESs containing 30% (v/v) of water. BD: Bellow detection.

UAE conditions	1.5 min, 20W	3 min, 20W	3 min, 10W	6 min, 10W	9 min, 10W
			Pro:PPG (1:4)		
Gallic acid	BD	BD	BD	BD	BD
3,4-Dihydroxybenzoic acid	7.22±0.08	7.33±0.09	7.24±0.04	7.33±0.20	7.38±0.01
Catechin	BD	BD	BD	BD	BD
Caffeic acid	BD	BD	BD	BD	BD
Syringic acid	BD	2.44±0.13	BD	2.37±0.12	2.38±1.76
Coumaric acid	BD	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD	BD
Salicylic acid	14.23±1.24	29.49±3.31	23.42±4.99	130.44±1.76	160.30±1.76
Quercetin	BD	BD	BD	BD	BD
			Pro:1.2-But (1:4)		
Gallic acid	17.46±0.82	22.45±1.10	18.40±0.98	25.26±1.18	30.94±0.31
3,4-Dihydroxybenzoic acid	7.06±0.03	7.22±0.01	7.27±0.02	7.21±0.03	7.09±0.03
Catechin	BD	BD	BD	BD	BD
Caffeic acid	BD	BD	BD	BD	BD

Syringic acid	BD	BD	2.33±0.06	2.32±0.07	2.30±0.06
Coumaric acid	BD	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD	BD
Salicylic acid	21.30±2.82	28.54±1.25	18.60±0.48	28.66±2.16	29.63±1.40
Quercetin	BD	BD	BD	BD	BD
			ChCl:CA (2:1)		
Gallic acid	6.05±0.02	6.08±0.03	6.29±0.10	6.20±0.05	6.35±0.09
3,4-Dihydroxybenzoic acid	7.34±0.10	7.45±0.03	7.13±0.04	7.40±0.11	7.58±0.13
Catechin	BD	BD	BD	BD	BD
Caffeic acid	BD	BD	BD	BD	BD
Syringic acid	2.43±0.10	2.52±0.12	2.34±0.04	2.49±0.12	2.67±0.27
Coumaric acid	BD	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD	BD
Salicylic acid	11.31±5.77	18.63±0.85	12.24±1.24	21.80±1.23	28.26±0.70
Quercetin	BD	BD	BD	BD	BD

Table S.10. Temperatures measured after the UAE extraction.

Power (W)	Time (min)	Temperature (°C)
10	9	103.9
10	6	96.3
10	3	83.4
20	3	98.6
20	1.5	98.4

MAE

Table S.11. Results of the TPC, TFC and TEAC for the microwave assisted extractions.
LD: Limit detection

ES	Conditions	TPC (mg/g)	TFC (mg/g)	TEAC (mg/g)
Pro:PPG (1:4)	MAE 100 °C, 1,5min	22.59±2.55	23.41±0.25	<LD
	MAE 100 °C, 3min	20.86±2.86	18.78±0.03	<LD
	MAE 100 °C, 6min	24.43±2.36	21.77±0.61	0.34±2.17
	MAE 60 °C, 3min	9.89±5.78	8.41±0.33	<LD
	MAE 60 °C, 6min	12.28±4.89	11.79±0.36	<LD
	MAE 60 °C, 9min	13.29±4.30	9.07±0.14	<LD
Pro:1,2-But (1:4)	MAE 100 °C, 1,5min	17.82±3.35	19.25±0.05	<LD
	MAE 100 °C, 3min	23.86±2.43	19.88±0.56	<LD
	MAE 100 °C, 6min	19.96±2.96	18.96±0.27	0.50±0.60
	MAE 60 °C, 3min	12.91±4.43	9.02±0.17	<LD
	MAE 60 °C, 6min	9.31±6.17	7.71±0.40	<LD
	MAE 60 °C, 9min	8.70±6.80	11.29±0.22	<LD

ChCl:CA (2:1)	MAE 100 °C, 1,5min	4.71±9.43	8.85±0.13	0.07±4.92
	MAE 100 °C, 3min	6.79±7.30	8.65±0.16	<LD
	MAE 100 °C 6min	2.71±0.80	11.02±0.18	0.77±0.19
	MAE 60 °C, 3min	3.90±12.64	3.55±0.15	0.32±4.29
	MAE 60 °C, 6min	4.24±11.14	3.56±0.11	0.40±2.56
	MAE 60 °C, 9min	4.05±11.80	3.91±0.13	0.23±10.85
	MAE 60 °C, 12min	1.66±26.17	3.99±0.20	0.70±3.62

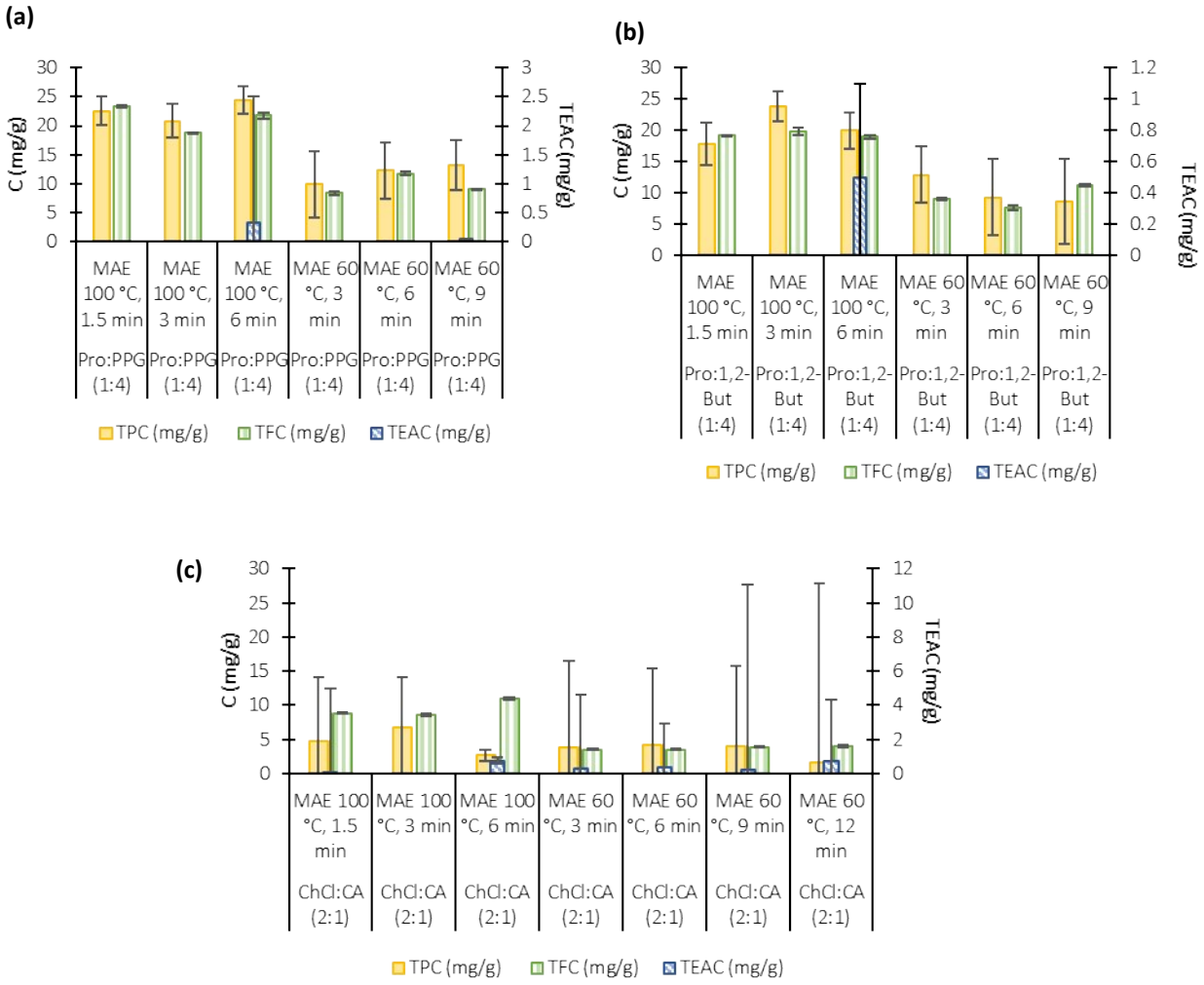

Fig S.5. Evaluation of the TPC, TFC (green) and TEAC (blue) for the microwave assisted extractions for the three chosen ESs with 30% (v/v) of water: (a) Pro:PPG (1:4), (b) Pro:1,4-But (1:4), (c) ChCl:CA (2:1).

Table S.12. HPLC results in µg/g of dry weight for the microwave assisted extractions for the three best ESs. BD: Bellow detection.

MAE conditions	1.5 min, 100 °C	3 min, 100 °C	6 min, 100 °C	3 min, 60 °C	6 min, 60 °C	9 min, 60 °C	12 min, 60 °C
	Pro:PPG (1:4)						
Gallic acid	BD	BD	6.60±0.18	BD	BD	BD	--
3,4-	7.75±0.05	7.52±0.04	7.58±0.21	7.18±0.08	7.32±0.14	7.17±0.06	--

Dihydroxybenzoic acid							
Catechin	BD	BD	10.09±1.40	BD	3.90±0.30	BD	--
Caffeic acid	BD	BD	BD	BD	BD	BD	--
Syringic acid	BD	BD	BD	BD	BD	BD	--
Coumaric acid	BD	BD	BD	BD	BD	BD	--
Ferulic acid	BD	BD	BD	BD	BD	BD	--
Salicylic acid	170.92±2.28	190.87±3.25	261.14±0.63	16.69±0.30	26.94±0.42	19.57±0.61	--
Quercetin	BD	BD	BD	BD	BD	BD	--
	Pro:1.2-But (1:4)						
Gallic acid	27.51±0.27	31.65±0.83	40.56±0.40	18.56±0.22	17.51±0.95	13.48±0.03	--
3,4-Dihydroxybenzoic acid	7.55±0.18	7.44±0.10	7.59±2.61	7.08±0.02	7.17±0.06	7.22±0.02	--
Catechin	BD	BD	BD	BD	BD	BD	--
Caffeic acid	BD	BD	BD	BD	BD	BD	--
Syringic acid	BD	BD	2.65±0.10	BD	BD	BD	--
Coumaric acid	BD	BD	BD	BD	BD	BD	--
Ferulic acid	BD	BD	BD	BD	BD	BD	--
Salicylic acid	25.84±3.39	24.59±0.51	25.92±2.57	3.98±3.29	26.29±0.25	24.37±1.27	--
Quercetin	BD	BD	BD	BD	BD	BD	--
	ChCl:CA (2:1)						
Gallic acid	6.25±0.05	BD	7.68±0.74	6.08±0.17	6.09±0.10	6.06±0.03	6.64±0.13
3,4-Dihydroxybenzoic acid	7.70±0.19	7.89±0.06	8.68±0.19	7.46±0.14	7.35±0.20	7.46±0.16	7.70±0.12
Catechin	BD	BD	BD	BD	BD	BD	BD
Caffeic acid	BD	BD	BD	BD	BD	BD	BD
Syringic acid	BD	2.57±0.07	BD	2.86±0.39	2.33±0.09	2.41±0.47	2.66±0.28
Coumaric acid	BD	BD	BD	BD	BD	BD	BD
Ferulic acid	BD	BD	BD	BD	BD	BD	BD
Salicylic acid	26.19±2.40	10.67±2.39	23.44±1.20	18.47±2.17	14.56±0.40	16.74±0.99	8.77±2.38
Quercetin	0.34±1.77	BD	0.38±4.33	BD	BD	BD	BD

A.5. Extraction with cycles

Table S.13. Results of the TPC, TFC and TEAC for the extractions performed with cycles.
LD: detection limit

3rd Cycle	TPC (mg/L)	TFC (mg/L)	TEAC (mg/g)
w/out combination	5398.66±1.29	5469.09±0.04	37.18±0.82
Combination w/ cycles	6649.71±1.03	6012.84±0.09	<LD

Table S.14. HPLC results in mg/L of the extraction cycles performed without combination of extracts between the cycles.
BD: Bellow detection

Cycle	1	2	3

S:L	1.3 g/13 mL	0.8 g/8 mL	0.45 g/4.5 mL
Gallic acid	0.63±0.14	0.64±0.20	0.79±0.85
3,4-Dihydroxybenzoic acid	0.76±0.22	0.80±0.18	0.72±0.26
Catechin	BD	BD	2.29±1.06
Caffeic acid	BD	BD	BD
Syringic acid	0.23±0.22	0.24±0.17	0.31±0.57
Coumaric acid	BD	BD	BD
Ferulic acid	BD	BD	BD
Salicylic acid	4.45±2.92	7.49±0.64	72.16±0.59
Quercetin	BD	BD	0.02±28.77

Table S.15. HPLC results in mg/L of the extraction cycles performed with the combination of extracts between the cycles. BD: Bellow detection

Cycle	1	2	3
S:L	3x0,5g/5mL	2x0,4g/4mL	0,46g/4.6mL
Gallic acid	BD	0.62±0.11	0.73±1.68
3,4-Dihydroxybenzoic acid	0.75±0.21	BD	BD
Catechin	2.59±2.21	BD	0.43±6.66
Caffeic acid	BD	BD	BD
Syringic acid	0.25±0.53	0.26±0.50	0.59±1.08
Coumaric acid	BD	BD	BD
Ferulic acid	BD	BD	BD
Salicylic acid	44.11±1.09	81.93±0.29	156.30±0.39
Quercetin	BD	0.02±8-85	0.06±12.36

A.6. COSMO-RS

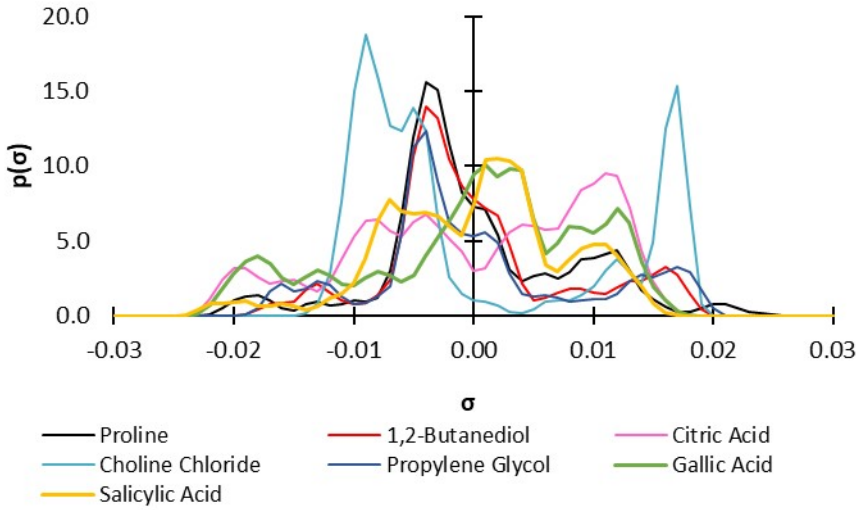

Fig S.6. σ-profiles of salicylic acid (yellow) gallic acid (green) and of the compounds that compose the three best ESs selected: proline (black), choline chloride (light blue), propylene glycol (dark blue) 1,2-butanediol (red) and citric acid (pink)

B. Characterization of ESs and polarity

B.1. ES densities & viscosities

Pro:PPG (1:4)

The densities of the ES made with proline and propylene glycol with a 1:4 ratio were measured at different temperatures in order to have the variation of the density with the temperature.

Table S.16. Densities measure at different temperatures for the pure ES Pro:PPG (1:4).

T (K)	Density (g/cm³)
293.15	1.0994±0.0053
298.15	1.0957±0.0053
303.15	1.0921±0.0053
308.15	1.0886±0.0053
313.15	1.0854±0.0053

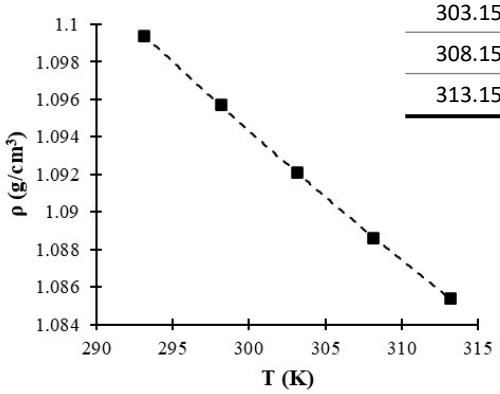

Fig S.7. Densities at different temperature from 293.15 to 313.15 K for the pure ES: ρ= (3.14±1.63)x10^{-6} T^2 + (-89.06±9.81)x10^{-5} T + (1159.71±1.41)x10^{-3} with R^2=0.9999

Table S.17. Densities measured for different contents of water at 25 °C for Pro:PPG (1:4).

Water content %(v/v)	Density (g/cm³)
10.08	1.0942±0.0053

20.10	1.0911±0.0053
30.11	1.0856±0.0053
40.17	1.0776±0.0054
50.24	1.0670±0.0054

Table S.18. Viscosities measure at different temperatures for the pure ES Pro:PPG (1:4) and with 30% (v/v) of water.

T (K)	η pure ES (mPa.s)	η ES 30% (v/v) water (mPa.s)
293.15	--	21.30±0.40
298.15	175.98±0.77	16.65±0.34
303.15	128.11±0.77	13.26±0.28
308.15	95.19±0.81	10.73±0.21
313.15	72.09±0.86	8.84±0.15
318.15	55.57±0.90	7.34±0.10
323.15	43.54±0.96	6.18±0.06
328.15	34.63±1.07	--
333.15	27.93±1.17	--
338.15	22.81±1.24	--
343.15	18.84±1.24	--
348.15	15.73±1.18	--
353.15	13.25±1.09	--

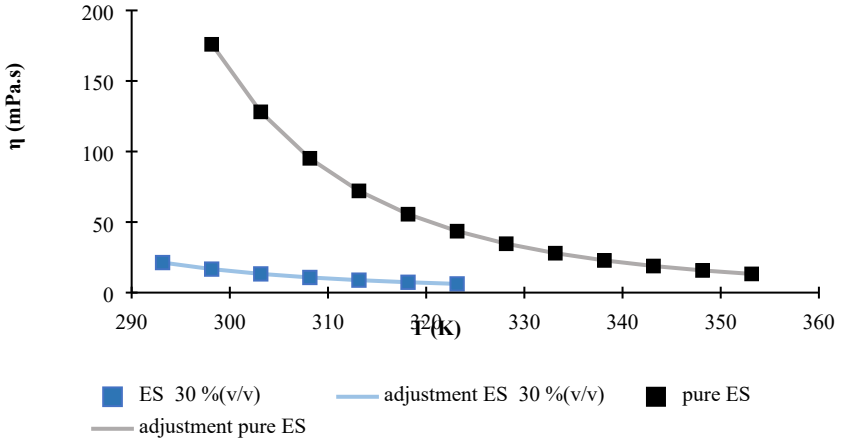

Fig S.8. Viscosities at different temperature for the pure ES Pro:PPG (1:4) (black) and with 30% (v/v) of water (blue).

Table S.19. VFT fitting parameters for the viscosity adjustment for Pro:PPG (1:4) without water and with 30% (v/v).

	pure Pro:PPG (1:4)	Pro:PPG (1:4) with 30% (v/v) of water
A_η	-10.662	-3.371
B_η	1201.973	809.636
C_η	163.483	167.218
R^2	0.99999	0.99997

Pro:1.2-But (1:4)

Table S.20. Densities measure at different temperatures for the pure ES Pro:1,4-But (1:4).

T (°C)	Density (g/cm³)
20	1.0626±0.0054
25	1.0589±0.0055
30	1.0552±0.0055
35	1.0517±0.0055
40	1.0484±0.0055

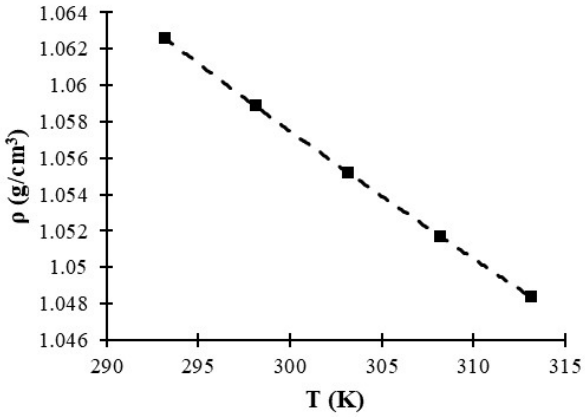

Fig S.9. Pure ES Pro:1,2-But (1:4) densities variations with temperature: $y = (31.43\pm5.75)\times10^{-7}\,x^2 + (-89.86\pm3.47)\times10^{-5}\,x + (10793.11\pm5.00)\times10^{-4}$ with R^2=0,99999

Table S.21. Densities measured for different contents of water at 25 °C for Pro:1,4-But (1:4).

Water content %(v/v)	Density (g/cm³)
10.18	1.0603±0.0054
21.12	1.0597±0.0055
30.45	1.0573±0.0055
40.27	1.0538±0.0055
50.27	1.0482±0.0055

Table S.22. Viscosities measure at different temperatures for the pure ES Pro:1,4-But (1:4) and with 30% (v/v) of water.

T (K)	η pure ES (mPa.s)	η ES 30% (v/v) water (mPa.s)
293.15	--	22.57±0.06
298.15	172.05±1.26	17.58±0.12
303.15	124.02±1.05	13.96±0.15
308.15	91.31±0.88	11.26±0.25
313.15	68.52±0.72	9.24±0.28
318.15	52.36±0.64	7.65±0.32
323.15	40.68±0.55	6.42±0.35
328.15	32.21±0.10	--
333.15	25.78±0.09	--
338.15	20.91±0.10	--
343.15	17.17±0.11	--
348.15	14.28±0.29	--

353.15	11.98±0.20	--

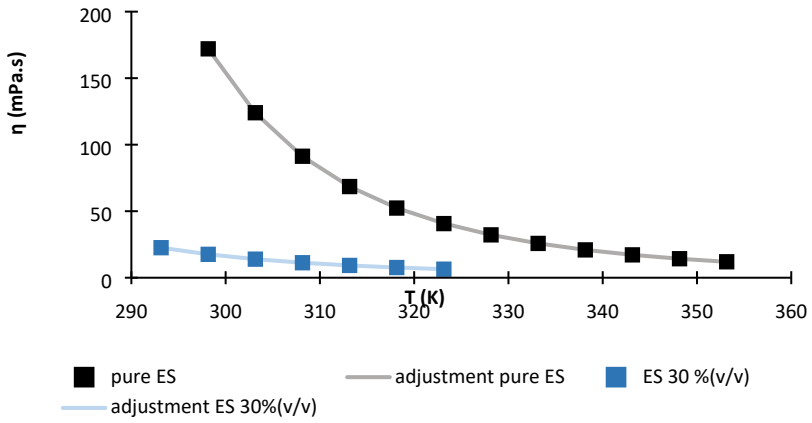

Fig S.10. Viscosities at different temperature for the pure ES Pro:1,2-But (1:4) (black) and with 30% (v/v) of water (blue).

Table S.23. Parameters obtained with the VFT adjustment for viscosity for the pure Pro:1,2-But (1:4) and with 30% (v/v) of water.

	pure Pro:1,2-But (1:4)	**Pro:1,2-But (1:4) with 30% (v/v) of water**
A_η	-10.997	-10.368
B_η	1250.875	835.455
C_η	162.724	166.120
R^2	0.999996	0.999997

ChCl:CA (2:1)

The ES composed by ChCl and CA in a ratio of 2:1 was so viscous that It was nearly impossible to handle it without adding a little amount of water. Also, the densimeter used only presented good measurements until 1.3 g/cm^3, therefore, water was added in order to reduce the density that was above 1.3 g/cm^3. An attempt to add the smallest amount of water was made to have the ES the nearest possible from the pure ES. The amount of water added to perform the measurements in was 6.4% (w/w).

Table S.24. Densities measure at different temperatures for the ES ChCl:CA (2:1) with 6.4% (w/w).

T (ºC)	**Density (g/cm^3)**
293.15	1.2545±0.0092
295.15	1.2529±0.0092
297.15	1.2513±0.0092
299.15	1.2497±0.0092
301.15	1.2481±0.0093
303.15	1.246±0.0046
305.15	1.2443±0.0046
307.15	1.2423±0.0047
309.15	1.2405±0.0093
311.15	1.2389±0.0047

313.15	1.2373±0.0047

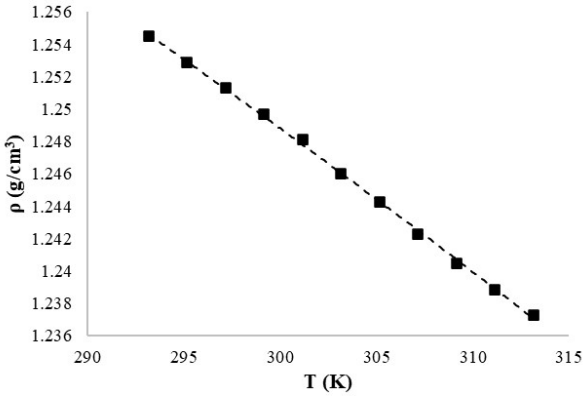

Fig S.11. Densities at different temperature from 293.15 to 313.15 K for the pure ES ChCl:CA (2:1): y = (-2.38±5.08) x10^{-6} x^2 + (--7.34±3.06) x10^{-5} x + (1270.25±4.46) x10^{-3} with R^2= 0.99897

Table S.25. Viscosities values of ChCl:CA (2:1) at different temperatures with only 6.4% (w/w) of water and with 30% (v/v).

T (K)	η ES 6.4% (w/w) (mPa.s)	η ES 30% (v/v) water (mPa.s)
293.15	--	62.48±0.03
298.15	8877.27±3.40	49.11±0.03
303.15	5706.73±3.48	39.22±0.02
308.15	3767.40±3.51	31.77±0.02
313.15	2551.90±3.52	26.09±0.02
318.15	1769.03±3.58	21.67±0.02
323.15	1253.10±3.64	18.21±0.02
328.15	906.11±3.76	--
333.15	666.44±3.56	--
338.15	499.34±3.54	--
343.15	379.83±3.35	--
348.15	292.74±2.83	--
353.15	228.89±2.39	--

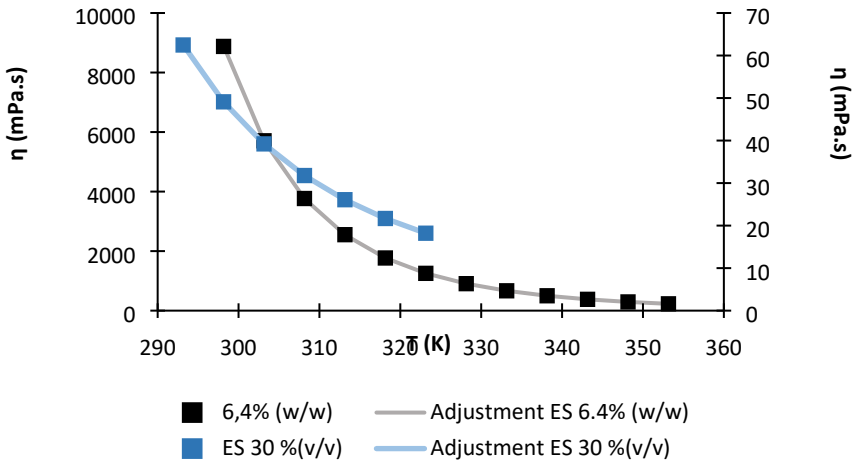

Fig S.12. Variation of viscosity with temperature for the ES ChCl:CA (2:1) with only 6.4% (w/w) (black-left axis) and with 30% (v/v) of water (blue-right axis).

Table S.26. Parameters for the VFT model adjusting the viscosity variation with temperature of ChCl:CA (2:1) with 6.4% (w/w) and with 30% (v/v) of water.

	ChCl:CA (2:1) with 6.4% (w/w) of water	ChCl:CA (2:1) with 30% (v/v) of water
A_η	-11.034	-9.684
B_η	1898.62216	954.377
C_η	154.528	155.073
R^2	0.999999	1.0000

B.2. Excess volumes

An excess property (X^E) is given by the different of the real value and the value corresponding to ideality, equation (S.7) [7].

$$X^E = \Delta_{mixure} X^{Real} - \Delta_{mixture} X^{Ideal} \quad \text{(S.7)}$$

The molar volume (V_m) of a pure compound i can be determined by expression (S.8) where MW is the molecular weight (g/mol) and ρ is the density (g/cm³). The ideal V_m of a mixture of two compounds is given the sum of V_m of each one.

$$V_{mi} = \frac{MW_i}{\rho_i} \quad \text{(S.8)}$$

To calculate the real V_m of a mixture of compound i and j, it is necessary to be aware of the exact composition and have the value of the density for the mixture. Further the real V_m can be easily calculated using expression (S.9). Note that one of the compounds if the ES and the other one is water, so there is a need to determine the exact MW of the ES.

$$V_m = \frac{x_i MW_i + x_j MW_j}{\rho_{mixture}} \quad \text{(S.9)}$$

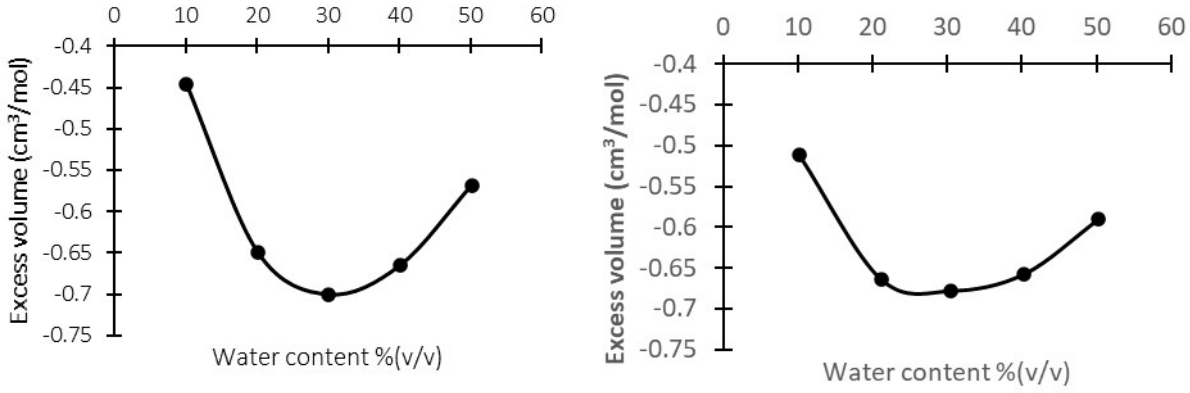

Fig S.13. Variation of the excess volumes with water content for two of the three best ESs: (a) Pro:PPG (1:4), (b) Pro:1,4-But (1:4)

B.3. Polarity essay - Solvatochromic probes

Table S.27. Polarity results from the solvatochromic probes for the betaine scale (E_TN) and fot Kamlet-Taft scale (α, β, π*).

		α	β	π*	E_T(33) (kcal/mol)	E_TN
Pro:PPG (1:4)	0%	0.478	0.729	0.873	56.709	0.544
	10%	0.432	0.686	0.959	56.954	0.552
	20%	0.393	0.599	1.034	57.182	0.559
	30%	0.387	0.574	1.102	57.857	0.579
	40%	0.300	0.470	1.162	57.182	0.559
	50%	0.328	0.438	1.205	58.092	0.587
Pro:1,2-But (1:4)	0%	0.613	0.799	0.776	57.721	0.575
	10%	0.540	0.749	0.889	57.837	0.579
	20%	0.493	0.695	0.959	57.896	0.581
	30%	0.427	0.541	1.052	57.916	0.581
	40%	0.446	0.621	1.034	58.014	0.584
	50%	0.392	0.555	1.134	58.290	0.593
ChCl:CA (2:1)	20%	2.454	0.032	1.409	93.282	1.668
	30%	2.603	0.411	1.202	93.282	1.668
	40%	2.592	0.346	1.236	93.486	1.674
	50%	2.612	0.318	1.264	94.101	1.693

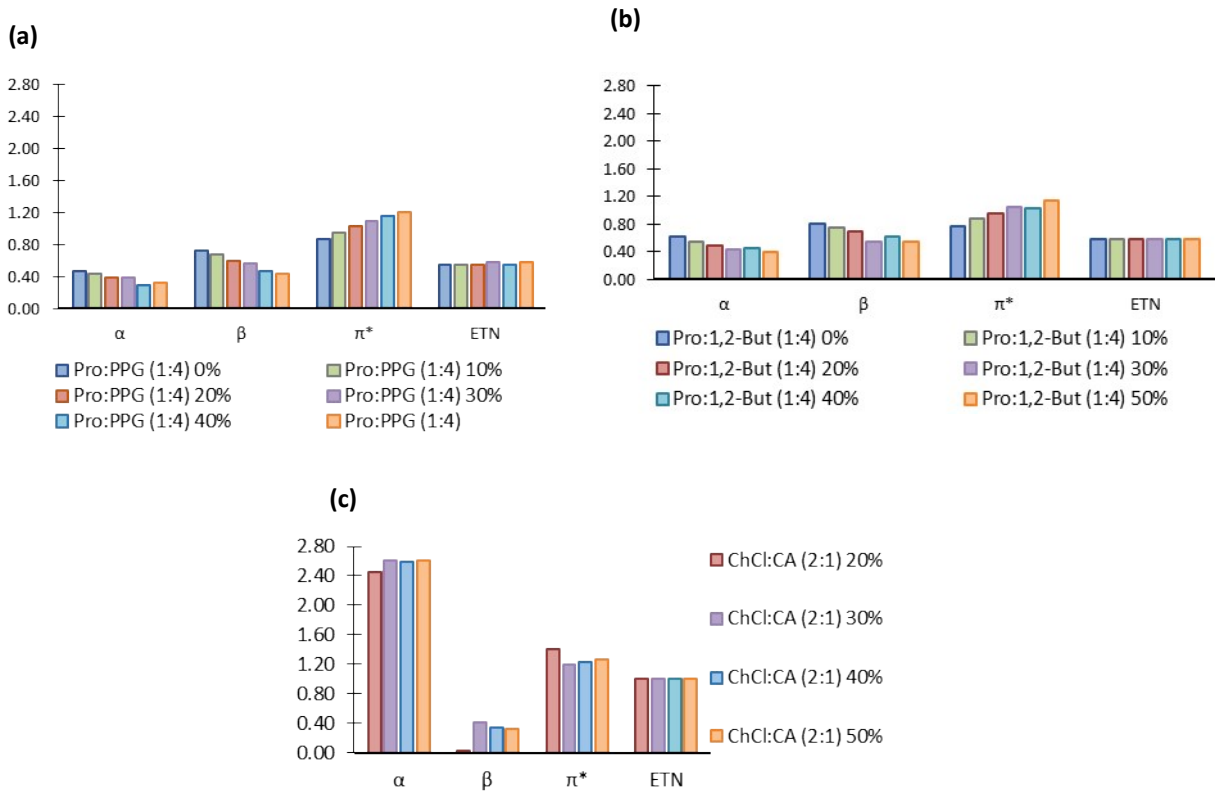

Fig S.14. Solvatochromic results for the proline-based ESs (a) Pro:PPG (1:4), (b) Pro:1,2-But (1:4) and (c) ChCl:CA (2:1) for the different water contents.

The overall polarity can be quantified through betaine scale with the E_TN parameter that ranges between 0 and 1.

Since a single polarity probe is not enough to understand the polarity of aqueous solutions of ESs, a more complete system as the Kamlet-Taft, which has three parameters, needs to be considered. Pro:1,2-But (1:4) presents a higher HBD ability, α, in comparison with Pro:PPG (1:4) for all water contents, which might indicate that 1,2-Butanediol has a slightly higher HBD capacity than propylene glycol. These two molecules have the same quantity of hydroxyl groups placed in the same positions, the difference is one additional methyl group attached to the end of the chain for 1,2-Butanediol, which can be related with a slightly higher HBD capacity.

Since the same HBA is present in both Pro:PPG (1:4) and Pro:1,2 But (1:4), it would be expected that these two ESs have similar HBA ability. This is confirmed through the similar values of the β values for both Pro:PPG (1:4) and Pro:1,2-But (1:4). Both ESs show the same tendency for β that was observed for α, a decrease the HBA ability with water content. Basically, the addition of water decreases the HBA and HBD abilities of both proline-based ESs. The β values for ChCl:CA (2:1) and its aqueous solutions are very low compared with the α values, 6 to 8 times lower. This indicates that the polarity of this ES is mainly due to its HBD ability. For 20% (v/v) water content in ChCl:CA(2:1), the β value determined is practically null. This is probably due to the high viscosity of this ES even with 20% (v/v) of water. Neglecting this value, a decrease behaviour of the β for ChCl:CA (2:1) with the increase of water content, just like the proline-based ESs.

The π* Kamlet-Taft parameters give a quantitative information about the polarizability and dipolarity. The π* values for Pro:PPG (1:4) were slightly higher than those of Pro:1,2-But (1:4), while ChCl:CA (2:1) shows higher π* values. Once again, ChCl:CA (2:1) with 20% (v/v) does not follow the trend, which can be again related with the viscosity and difficult solubilization of the probes.

In **Fig S.14** (a), the α value for Pro:PPG (1:4) with 40% (v/v) is lower than the α value for Pro:PPG (1:4) with 50% (v/v). This creates an incoherency in the trend observed, which is that α values decrease with the increase of water content. However, this incoherency only happens in α, which can mean that this may be due to experimental errors. On the other hand, this behaviour is seen for Pro:1,2-But with 30% (v/v) for all Kamlet-Taft parameters (α, β and π*), where its values are lower than Pro:1,2-But (1:4) with 40% (v/v). The way how the probes interact with the solvent has a great impact on these parameters. As mentioned before, the maximum volume contraction occurs at 30% (v/v) of water, due to the formation of strong hydrogen bonds between ESs and water. This can generate a robust hydrogen bond matrix, hindering the probe interaction with the ES, returning lower values than expected. Although the Pro:PPG (1:4) also has its maximum volume contraction at 30% (v/v), the trend seen of all Kamlet-Taft parameters for Pro:1,2-But (1:4) it is not observed for Pro:PPG (1:4). The 1,2-Butanediol possesses one additional methyl group than propylene glycol, providing two more hydrogens to its structure which can have influence on the results seen in **Fig S.14**.

C. Statistical treatment of results

C.1. ES screening

Table S.28. Tukey HSD test for ES screening.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
ChCl:Gly (1:4)	12.82													
Bet:PPG (1:4)		17.37												
ChCl:PPG (1:4)		17.49												
Ethanol		19.50												
Bet:Gly (1:4)			23.05											
Water			23.36											
Bet:LA (1:1)				26.88										
Pro:Gly (1:4)				29.31										
Bet:1.2-But (1:3)					32.75									
ChCl:1.3-But (1:4)					33.08									
Bet:LA (1:2)					33.97									
Pro:LA (1:1)						37.97								
Pro:LA (1:2)						38.99								
ChCl:LA (1:1)						39.54								
Pro:1.2-But (1:3)						40.48	40.48							
ChCl:LA (1:3)							43.09	43.09						
Pro:1.3-But (1:4)							43.18	43.18						
Bet:1.3-But (1:4)								44.05						
ChCl:1.2-But (1:3)								44.85	44.85					
Bet:LA (1:3)									47.87	47.87				
Pro:LA (1:3)										49.71				
Bet:1.2-But (1:4)											53.05			
ChCl:LA (1:2)											55.50			
ChCl:CA (1:2)											55.53			
ChCl:CA (2:1)												68.11		
ChCl:CA (1:1)												70.01		
Pro:1.2-But (1:4)													119.81	
Pro:PPG (1:4)														210.48
Sig.	1	0.73	1	0.48	1.00	0.41	0.28	0.94	0.12	0.91	0.44	0.88	1	1

C.2. UAE

Table S.29. Tukey HSD test for UAE using Pro:PPG (1:4).

UAE	**N**	**Subset for alpha = 0.05**				
		A	B	C	D	E
20 W, 1,5min	3	21.4507				
20 W, 3min	3			39.2617		
10 W, 3min	3		30.6597			
10 W, 6min	3				140.1407	
10 W, 9min	3					170.0563
Sig.		1.000	1.000	1.000	1.000	1.000

a. Uses Harmonic Mean Sample Size = 3.000; b. Alpha = .05.

Table S.30. Tukey HSD test for UAE using Pro:1,2-But (1:4).

UAE	**N**	**Subset**

		A	B	C	D
20 W, 1,5min	3	45.8200			
20 W, 3min	3		58.2137		
10 W, 3min	3	46.5990			
10 W, 6min	3			63.4497	
10 W, 9min	3				69.9553
Sig.		0.459	1.000	1.000	1.000

a. Uses Harmonic Mean Sample Size = 3.000; b. Alpha = .05.

Table S.31. Tukey HSD test for UAE using ChCl:CA (2:1).

UAE	**N**	**Subset**		
		A	B	D
20 W, 1,5min	3	27.1100		
20 W, 3min	3		34.6827	
10 W, 3min	3	27.9957		
10 W, 6min	3			
10 W, 9min	3			44.8553
Sig.		0.101	1.000	1.000

a. Uses Harmonic Mean Sample Size = 3.000;. b. Alpha = .05

C.3. MAE

Table S.32. Tukey HSD test for MAE using Pro:PPG (1:4).

MAE	**N**	**Subset**				
		A	B	C	D	E
60 °C, 3min	3	23.8740				
60 °C, 9min	3	26.7358				
60 °C, 6min	3		38.1610			
100 °C, 1,5min	3			178.6694		
100 °C, 3min	3				198.3911	
100 °C, 6min	3					288.3076
Sig.		0.852	1.000	1.000	1.000	1.000

a. Uses Harmonic Mean Sample Size = 3.000; b. Alpha = .05.

Table S.33. Tukey HSD test for MAE using Pro:1,2-But (1:4).

MAE	**N**	**Subset**					
		A	B	C	D	E	F
100 °C, 1,5min	3	60.8991					
100 °C, 3min	3		63.6823				
100 °C, 6min	3			76.7210			
60 °C, 3min	3				29.6155		
60 °C, 6min	3					50.9728	

60 °C, 9min	3						45.0595
Sig.		1.000	1.000	1.000	1.000	1.000	1.000
a. Uses Harmonic Mean Sample Size = 3.000.	b. Alpha = .05.						

Table S.34. Tukey HSD test for MAE using ChCl:CA (2:1).

MAE	**N**	**Subset**					
		A	B	C	D	E	F
100 °C, 1,5min	3	40.1427					
100 °C, 3min	3		21.1369				
100 °C, 6min	3	39.7978					
60 °C, 3min	3			34.8743			
60 °C, 6min	3				30.3256		
60 °C, 9min	3					32.6631	
60 °C, 12min	3						25.7728
Sig.		0.858	1.000	1.000	1.000	1.000	1.000
a. Uses Harmonic Mean Sample Size = 3.000.	b. Alpha = .05.						

References

1 J. Huguenin, S. O. S. Hamady and P. Bourson, *Journal of Raman Spectroscopy*, 2015, **46**, 1062–1066.

2 R. M. Smith and A. E. Martell, *Critical Stability Constants*.

3 J. M. Herrero-Martínez, M. Sanmartin, M. Rosés, E. Bosch and C. Ràfols, *Electrophoresis*, 2005, **26**, 1886–1895.

4 J. L. Beltrán, N. Sanli, G. Fonrodona, D. Barrón, G. Özkan and J. Barbosa, *Anal Chim Acta*, 2003, **484**, 253–264.

5 E. Dinç, F. Selimoğlu, N. Ünal and Z. C. Ertekin, *Anal Lett*, 2021, **54**, 2624–2637.

6 J. M. Herrero-Martínez, M. Sanmartin, M. Rosés, E. Bosch and C. Ràfols, *Electrophoresis*, 2005, **26**, 1886–1895.

7 K. J. Atkins, P. W., de Paula J., *Oxford University Press, Oxford*, 2017, 944.