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Supplementary Materials

Flexible Potentiometric Sensor System for Non-Invasive Determination of Antioxidant Activity of Human Skin: Application for Evaluating Effectiveness of Phytocosmetic Products

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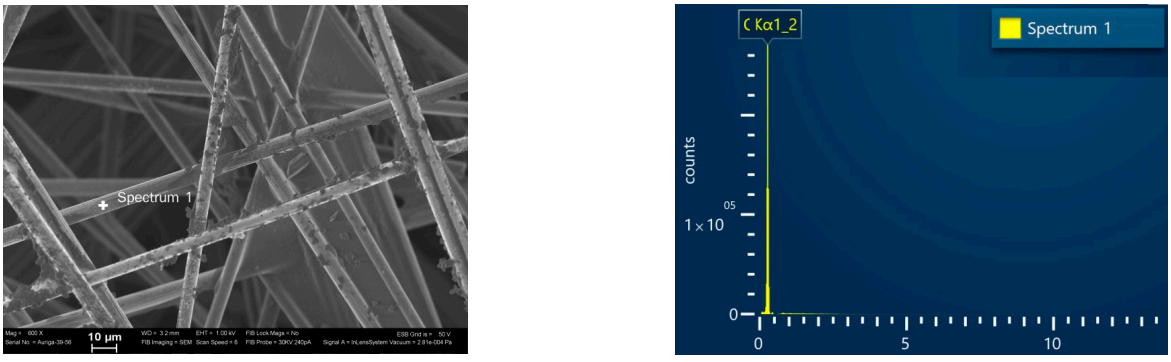
Table S1. Specification of the carbon veil used in the study.

Indicator	Value [1]
Precursor	Polyacrylonitrile
Fiber	Carbon
Binder	Polyester
Weave	Non-woven fiber
Thickness at 2 kPa	0.52 mm
Surface density	30 g m^{-2}
Specific tensile strength along and across the cloth, not less	0.5 N mm^{-2}
Specific surface resistivity along and across the cloth	8–10 Ω
Mass fraction of carbon, not less	90 %

[1] According to the M-Carbo Ltd. (Minsk, Belorussia).

Single-Sided Hot Lamination Technology

Single-sided hot lamination is achieved by thermal bonding of carbon veil (CV) with a polymer substrate based on polyethylene terephthalate (PET). A piece of CV and a sheet of paper are put in the lamination pouch, which is fed between the heated rolls of the laminator. The best degree of adhesion is observed at the maximum temperature (180 °C) recommended by the laminator manufacturer for the selected sheet thickness (0.25 mm). Next, one polymer layer and the sheet of paper are removed. The remaining part is cut into 3 × 35 mm strips. The resulting electrodes are marked CV/PET and used as indicator flexible film electrodes (FFEs) as part of a flexible potentiometric sensor system (FPSS). It is worth noting that single-sided hot lamination is a scalable technology [1]. Thus, when using a 204 × 291 mm CV, 565 3 × 35 mm CV/PET electrodes are obtained.



(**a**) (**b**)

Figure S1. SEM-images (**a**) and EDS spectrum (**b**) of CV/PET.

Table S2. Characteristics of commercially available phytocosmetic products used in this study.

Name	Ingredients with Antioxidant Properties (INCI [1])
Face **Cream-Mousse** for Dry and Sensitive Skin	Prunus Amygdalus Dulcis (Sweet Almond) Oil, Butyrospermum Parkii (Shea Butter), Chamomilla Recutita (Matricaria) Flower/Leaf Extract, Rubus Chamaemorus Seed Oil, Aloe Barbadensis Leaf Juice, Fomes Officinalis (Mushroom) Extract, Glycine Soja (Soybean) Oil, PEG-40 Hydrogenated Castor Oil, Tropaeolum Majus Flower/Leaf/Stem Extract
Face **Cream-Gel** for Normal and Combination Skin	Punica Granatum Fruit Juice, Chamomilla Recutita (Matricaria) Flower/Leaf Extract, Aloe Barbadensis Leaf Juice, Fomes Officinalis (Mushroom) Extract, Glycine Soja (Soybean) Oil, Macadamia Integrifolia Seed Oil, PEG-40 Hydrogenated Castor Oil, Prunus Amygdalus Dulcis (Sweet Almond) Oil, Tocopherol, Tropaeolum Majus Flower/Leaf/Stem Extract
Serum for Face and Neck	Prunus Amygdalus Dulcis (Sweet Almond) Oil, Rhodiola Rosea Root Extract, Avena Sativa (Oat) Kernel Protein, Panax Ginseng Root Extract, Trifolium Pratense (Clover) Flower Extract, Carum Petroselinum (Parsley) Extract, Hippophae Rhamnoides Fruit Juice, Hippophae Rhamnoides Oil, Verbena Officinalis Extract, Amorphophallus Konjac Root Extract, Hamamelis Virginiana (Witch Hazel) Water, Arnica Montana Flower Water, Niacinamide, Tocopherol Acetate, Glycine Soja (Soybean) Oil, PEG-40 Hydrogenated Castor Oil, Citric Acid
Face **Day Cream** for All Types of Skin	Butyrospermum Parkii (Shea Butter), Macadamia Integrifolia Seed Oil, Verbena Officinalis Extract, Oenothera Biennis (Evening Primrose) Oil, Linum Usitatissimum (Lineseed) Seed Oil, Hippophae Rhamnoides Fruit Juice, Hippophae Rhamnoides Oil, Rubus Chamaemorus Seed Oil, Glycine Soja (Soybean) Oil, Hydrolyzed Wheat Protein, Olea Europaea (Olive) Fruit Oil, PEG-40 Hydrogenated Castor Oil, Triticum Vulgare (Wheat) Germ Oil
Face **Nourishing Night Cream** for Dry Skin	Butyrospermum Parkii (Shea Butter), Macadamia Integrifolia Seed Oil, Triticum Vulgare (Wheat) Germ Oil, Aloe Barbadensis Leaf Juice, Bisabolol, Glycine Soja (Soybean) Oil, PEG-40 Hydrogenat-ed Castor Oil

[1] INCI: International Nomenclature of Cosmetic Ingredients.

Table S3. Composition of the buffer solution pH 5 used in the study.

Salt	Concentration	
	mmol L^{-1}	g L^{-1}
NaCl	137	8.0
KCl	2.7	0.2
Na_2HPO_4 / $Na_2HPO_4 \times 2H_2O$ / $Na_2HPO_4 \times 12H_2O$	0.63	0.09 / 0.11 / 0.23
KH_2PO_4	66	8.99

Table S4. Results of L-ascorbic acid determination using FPSS under model conditions (n = 4).

Added, μM-eq	Found, μM-eq	RSD, %	Recovery, %
10.0	14.2 ± 1.0	7.3	142 ± 10
15.0	15.8 ± 0.9	5.5	105 ± 6
20.0	20.4 ± 0.7	3.2	102 ± 3
50.0	49.0 ± 0.7	1.5	98 ± 1
100.0	98.9 ± 1.4	1.4	99 ± 1
500.0	491.5 ± 7.0	1.4	98 ± 1
990.0	955.4 ± 12.3	1.3	96 ± 1

Table S5. Effectiveness of commercially available phytocosmetic products.

Phytocosmetic Product	In vitro analysis by HPM [2, 3]	In vivo analysis by CHPM [3, 4]	
	AOA, μM-eq g^{-1} (n = 3)	ΔAOA_{max}, mM-eq	t, h
Cream-mousse	0.075 ± 0.009	0.047	≤ 5
Cream-gel	0.112 ± 0.010	0.125	≤ 5
Serum	0.213 ± 0.018	0.875	≤ 5
Day cream	0.114 ± 0.011	0.077	≤ 8
Nourishing night cream	0.145 ± 0.012	0.150	> 8

[1] HPM: hybrid potentiometric method; CHPM: contact hybrid potentiometric method; AOA: antioxidant activity; ΔAOA_{max}: maximum value of effectiveness of the phytocosmetic product; t: duration of effectiveness of the phytocosmetic product or duration of antioxidant effect.

Table S6. The theoretical range of the AOA determined values.

Mediator			Theoretical Range at 25 °C	
$K_3[Fe(CN)_6]$, mM	$K_4[Fe(CN)_6]$, mM	Stability	ΔE, mV	AOA, μM-eq
1	0.01	Low	10 – 295	5 – 999
1	0.05	Good	7 – 255	15 – 999
5	0.1	High	5 – 311	21 – 4999

References

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