water

MDPI

Supplementary Material - Tables

Table S1. Total microplastics analysis (n = 21). The table reports the obtained density value (mean, median and percentiles) for four seasons and the three sites, for all the sampled MP, and the results of statistical analysis performed through Kruskal Wallis test. In this and the following tables the sites are indicated by their acronyms, the same as those used in the text (San Rossore = SR; Marina di Vecchiano = MV; Viareggio = V).

SEASON	Density values (items/ m²)	SITE			Kruskal Wallis (p-value)
		SR	MV	V	
Spring	Mean Median Q3; Q1	326.4 ±311.6 305.3 (351,31; 291)	393.6 ±302 317.32 (529,33; 219,66)	179.6 ±126.4 228.66 (252,66; 131;33)	0.122
Summer	Mean mediana Q3; Q1	942.4 ±1130.4 286 (1356,33; 200)	163.6 ±107.2 9.32 (197; 138,22)	115.2 ±79.6 158 (164,32; 87,76)	0.084
Autumn	Mean Median Q3; Q1	2080.8±2428,4 321.32 (3045,66; 236,34)	944.8 ±1716 310 (1370,67; 201,34)	202.8 ± 167.6 210 (292,33; 117,1)	0.060
Winter	Mean Median Q3; Q1	485.2 ±464.8 488 (554,7; 417,32)	383.2 ±618 362.68 (527,32; 228,66)	204 ±132.4 282.64 (303,97; 143,32)	0.449
Kruskal Wallis (p-value)		0.295	0.100	0.177	
	Mean value for site	958.7± 792.0	471.3 ± 333,0	175.4 ± 42,0	
	Total mean value		535.13 ± 389.0		

Table S2. Analysis by type of plastic (n = 21). The three S2-tables (S2-FR, S2-RP and S2-EPS) reports the obtained density value (mean, median and percentiles) for four seasons and the three sites, for each one of the three types of samples MP, and the results of statistical analysis performed through Kruskal Wallis test. In red the significant p-value of Kruskall-Wallis test.

Table S2 – FR (FRAGMENTS)

SEASON	**Density values (items/ m²)**	**SITE**			**Kruskal Wallis (p-value)**
		SR	**MV**	**V**	
Spring	Mean Median Q3; Q1	132.4 ± 119.2 157.32 (192,33; 68,34)	40.08 ± 38.8 36.7 (45,68; 33,68)	92.04 ± 58 76.6 (105,33; 71,33)	0.008
Summer	Mean Median Q3; Q1	38.00 ± 37.2 28.0 (59,1; 17,99)	32.04 ± 21.2 34.0 (36,66; 28)	56.8 ± 42.4 66.7 (68,66; 44,99)	0.049
Autumn	Mean Median Q3; Q1	50.04 ± 22 42.68 (72,68; 36,68)	30.08 ± 30 24.66 (42; 16,67)	124.8 ± 110.8 152.66 (162,33; 5,1)	<0.001
Winter	Mean Median Q3; Q1	115.6 ± 90.4 88 (150,66; 33,66)	35.6 ± 38 36 (45,66; 18,66)	108.4 ± 74 124 (148,68; 67)	0.025
Kruskal Wallis (p-value)		0.150	0.686	0.049	
	Mean value for site	84.1 ± 67,0	34.45 ± 32,0	95.51± 71,0	
	Total mean value		71.35 ± 56.70		

Table S2 – RP (RESIN PELLETS)

SEASON	**Density values (items/ m²)**	**SITE**			**Kruskal Wallis (p-value)**
		SR	**MV**	**V**	
Spring	Mean Median Q3; Q1	92.4±77,2 94.68 (112,67; 75,67)	105.6±86,4 26.4 ± 21.6 (131,63; 64,3)	76.6±71,6 49.32 (96,99; 42,76)	0.509
Summer	Mean Median Q3; Q1	95.2±84,8 64.66 (134,34; 40,1)	59.6±36,4 52.66 (66,66; 49,33)	46.8±40,4 44.66 (56,33; 35,33)	0.487
Autumn	Mean Median	107.2±101,2 96	103.2±120,9	70±58 90.66	0.674

	Q3; Q1	(121,68; 67,32)	38 (103,2; 120,9)	(96,33; 54)	
Winter	Mean Median Q3; Q1	162.8±134 153.32 (219,32; 101,32)	120.8±147.2 52 (120,8; 147,2)	94.4±61,6 97.32 (122, 68; 110)	KW 0.516
Kruskal Wallis (p-value))	K-W	0.584	0.520	0.465	
	Mean value for site	114.4 ±99,0	97.3 ± 97,7	72 ±58	
	Total mean value		94.56 ± 84.90		

Table S2 – EPS (EXPANDED POLYSTIRENE)

SEASON	**Density values (items/ m²)**	**EPS**			
		SR	**MV**	**V**	**Kruskal Wallis (p-value)**
Spring	Mean Median Q3; Q1	101.6±107 114.68 (154,67; 58,67)	247.2±228 216.7 (336,68; 142,25)	11.2±16.4 8 (16,5; 8)	<0.001
Summer	Mean Median Q3; Q1	808.8±105 744 (1229,67;157,32)	71.6±63.6 60 (79,58; 33)	5.6±9.2 3.34 (8,67; 1,67)	<0.001
Autumn	Mean Median Q3; Q1	1923.8±23 1650.66 (2951,1; 509,34)	810.4±1604,8 230 (1178,67; 152)	8±15.2 2.68 (10,67; 5,1)	<0.001
Winter	Mean Median Q3; Q1	207.2±293 156 (37,34; 81,34)	230.8±489.2 17.32 (345,32; 9,32)	1.2±2.8 1.32 (2; 1, 66)	0.042
Kruskal Wallis (p-value)		0.044	0.038	0.127	
	Mean value for site	760.3 ± 836.0	340 ±323.4	6.5 ± 4.2	
	Total mean value		368.83 ± 387.86		

Table S3. Zonal Analysis (n = 21). The three S3 tables (S3-FR, S3-RP and S3-EPS) reports, for the sampled MP all together, the obtained density value (mean, median and percentiles) for the three sites and the three zone selected, and the results of statistical analysis performed through Kruskal Wallis test. In red the significant p-value of Kruskall-Wallis test.

Table S3 – FR (FRAGMENTS)

SITE	Density values (items/m²)	FRAGMENTS			Kruskal Wallis (p-value)
		D	I	S	
SR	Mean Median Q3-Q1	112±68 82.68 (16.7; 51)	78 ±66 42.68 (8.7; 33.3)	49.2±608.3 33.32 (4.3; 11.3)	0.046
MV	Mean Median Q3-Q1	52.4±15,2 49.32 (63,32; 42)	32.4±13,6 36 (40,66; 23, 34)	17.6±16 12 (22,8; 68)	0.008
V	Mean Median Q3-Q1	129.6±47,6 125.3 (158; 79, 32)	104.8±84 89.32 (114,66; 56,66)	46.8±25,6 40 (56,66; 33,34)	0.014
Kruskal Wallis (p-value)		0.013	0.069	0.073	

Table S3 – RP (RESIN PELLETS)

SITE	Density values (items/m²)	PELLETS			Kruskal Wallis (p-value)
		D	I	S	
SR	Mean Median Q3-Q1	179.2±77.6 160 (29; 64.3)	100.8±45.6 86.68 (18; 38.3)	42.4±34.4 44 (3.3; 16.3)	0.003
MV	Mean Median Q3-Q1	188.8±106.4 169.32 (259,34; 104,66)	52.8±20.8 49.32 (52; 42)	40.8±20.8 45.32 (52,66; 36)	0.002
V	Mean Median Q3-Q1	111.1±36.8 108 (18.3; 36.7)	70±38.4 61.32 (9.3; 24.3)	30±22.4 30.68 (2.7; 14)	0.002
Kruskal Wallis (p-value)	Kruskal Wallis	0.176	0.080	0.579	

	(p-value))				

Table S3– EPS (EXPANDED POLYSTIRENE)

SITE	Density values (items/m²)	EXPANDED POLYSTIRENE D	I	S	Kruskal Wallis (p-value)
SR	Mean Median Q3-Q1	1453.6±1604.4 994.68 (1892; 311,34)	928.4±1226.8 156 (1398,66; 86)	135.6±173.6 53.32 (175,34; 23,34)	0.03
MV	Mean Median Q3-Q1	862.4±1457.2 420 (583,32; 124,68)	146.4±148.4 69.32 (216,68; 40,66)	58±44 46.68 (90; 28,66)	0.015
V	Mean Median Q3-Q1	8.8±10 2.68 (14; 1.32)	10.4±11.6 4 (15,34; 2,68)	3.2±4.4 2.68 (3,34; 0)	0.248
Kruskal Wallis (p-value)		0.001	0.001	0.005	

Table S4. Abundance of FR and EPS belonging to the different size classes in the four seasons. Data expressed as N°tot fragments collected for each site, with standard deviation D obtained by averaging on the 2 temporal replicas. In winter only one sample was taken, so D is not available. Sp = spring; Su = summer; Au = autumn; Wi = winter.

SITE	SEASON	FR				EPS			
		1–2 mm	2 -3 mm	3–4 mm	4–5 mm	1–2 mm	2–3 mm	3–4 mm	4–5 mm
SR	Sp	24.5 ±18.5	63 ±29.5	77.5 ±47.2	133.5 ±57.0	18 ±12.5	6.5 ±68.5	81.5 ±37.5	65.0 ±45.0
	Su	2.5 ±2.5	9 ±2.8	16.5 ±3.5	56.0 ±17.0	241 ±198.0	899 ±723.5	353 ±263.5	196 ±158.5
	Au	5.0 ±7.0	16.5 ±6.4	1.,5 ±3.5	67.0 ±5.5	760 ±696.0	1529 ±1042	1361 ±587.0	682.5 ±246.5
	Wi	8	35	53	161	61	163	148	64
	Yearly values	16.1 ±9.3	30.9 ±12.9	37.1 ±18.1	104.4 ±26.5	270 ±302.2	649.4 ±611.3	485.9 ±296	251.9 ±150
MV	Sp	2.5 ±3.5	17 ±17	18.5 ±16.2	50.5 ±17.7	81.5 ±27.5	134 ±98.5	184 ±34.0	127 ±14.5
	Su	4 ±1,4	8.5 ±5	8.5 ±0.7	51.5 ±10.6	16 ±4.0	36 ±5.5	59.5 ±18.0	47 ±9.5

	Au	0.5 ±0.7	6 ±8.4	8.5 ±10.6	33.5 ±41.7	697.5 ±959.5	560 ±727.0	347.5 ±436.0	218.5 ±252.5
	Wi	10	18	88	0	149	185	126	59
	Yearly values	4.2 ±1.9	12.4 ±10.1	30.9 ±9.2	33.9 ±23.3	236 ±330.3	228.7 ±277	179.2 ±162.7	112.9 ±92.2
V	Sp	14 ±10	27 ±10	35.5 ±12.4	130.5 ±33.2	2 ±1.5	6.5 ±5.0	4.5 ±2.0	12.0 ±4.5
	Su	1.5 ±0.7	8 ±5.6	30 ±4.2	99.5 ±95.4	0	2.5 ±1.0	3.0 ±2.5	4.5 ±2.0
	Au	5 ±5.6	24 ±14.1	42.5 ±30.4	209.5 ±119.5	0	1.5 ±2.0	7.5 ±10.5	8.5 ±9.0
	Wi	5	21	43	175	1	2	0	0
	Yearly values	6.4 ±5.4	20 ±9.9	37.7 ±15.7	153.6 ±82.7	0.7 ±0.5	3.1 ±2.7	3.7 ±5	6.2 ±5.2

Table S5. Seasonal and yearly abundance of resin (RP) divided into different colorimetric classes, for each beach. The data are expressed as the number of total items collected for each beach (through nine sample square of 0.25 m^2 each one). Reported values are obtained by averaging over all temporal replicas. Only one sample was taken in the winter season. Sp = spring; Su = summer; Au = autumn; Wi = winter.

SITE	SEASON	RESIN PELLETS (RP)			
		COL	WH	AM	TR-GL
SR	Sp	44.5 ± 29	120.5± 39	5.5 ± 5	20 ± 8.5
	Su	29.5 ±19.1	104.5 ±10.6	13 ±4.2	0
	Au	35.5 ±22.6	190 ±41.7	17 ±4.2	12±5
	Wi	42	271	27	29
	Yearly values	37.9±17.7	171.5±22.8	15.6±3.5	15.4±3.4
	Yearly values in %	16	71	7	6
MV	Sp	46.5 ± 9.2	161.5 ± 14.9	18.5 ±6.4	1.5 ± 0.7
	Su	29.5 ±19.1	104.5 ±10.6	13 ±4.2	0
	Au	48 ±27	164 ±77,8	19.5±6.4	0.5±0.7
	Wi	51	256	23	15
	Yearly values	43.7±13.8	171.5±25.8	18.5±4.3	4.2±0.4
	Yearly values in %	18	72	8	2
V	Sp	59 ±29.6	89.5 ±6.4	12.5 ±3.5	9 ±8.5
	Su	29±19.8	64±28.3	8.5±5	3.5±5
	Au	52±3.5	101.5±35.3	9 ±4.2	6.5±7.1
	Wi	73	115	19	5
	Yearly values	53.2 ±13.2	92.5 ±17.5	12.2±3.2	6.0±5.15
	Yearly values in %	32	56	7	4

Table S6. a. Seasonal abundance of fragments (FR) divided into different colorimetric classes, for each beach. The data are expressed as the number of total fragments collected for each beach (through nine sample square of 0,25 m^2 each one). Reported values are obtained by averaging over temporal replicas. Only one sample was taken in the winter season. Sp = spring; Su = summer; Au = autumn; Wi = winter.

SITE	SEASON	FRAGMENTS (FR)

		TR-GL	AM	WH-GL	WH-OD	BL	GR	RE	YE	GY	BK	OT
SR	Sp	12 ±15.5	16 ± 10	86 ±65	35.57 ±7	59.0 ±11.5	19.5 ±3.5	13.5 ±2.5	7.0 ±1.5	10 ±3	12 ±2.5	3.5 ±0.5
	Su	5 ±4.5	4.5 ±5	43.52± 1.5	10 ±0.6	16.5 ±3	5 ±0.8	3.5 ±0.5	2 ±0.5	2.5 ±1.5	3.0 ±0.5	1.5 ±0.5
	Au	5.5 ±2	5.5 ±3.5	24 ±4.5	18.5 ±9.7	30 ±15.5	9 ±4.8	7 ±3.5	3.5 ±2	5.0 ±2.5	6 ±3.5	1,5 ±1
	Wi	21	4	83	48	67	15	9	5	6	5	3
	Yearly values	10.9 ±5.5	7.7 ±4.6	59.1 ±17.7	28 ±4.3	43.2 ±7.5	12.2 ±7.2	8.5 ±1.6	4.2 ±1.0	6.1 ±1.8	6.7 ±1.6	2.4 ±0.5
	Yearly values in %	5.8	4.1	31.5	14.9	22.9	6.5	4.5	2.3	3.3	3.6	1.3
MV	Sp	2 ± 2.5	2 ± 1.5	36 ±26.5	10.5 ±7.1	17.5 ±11.5	5.3 ±3.5	4 ±2.5	2 ±1.3	3 ±2	3.5 ±2.5	1.0 ±0.5
	Su	0.5 ±0.5	6 ±3	28 ±7	15 ±8.5	0	2	0	0	0	0	0
	Au	3.5 ±3.5	3 ±1.5	27.5 ±8	8 ±4.5	12.8 ±7.9	3.9 ±2.4	2.5 ±1.8	1.5 ±0.9	2.0 ±1.5	2.5 ±1.5	0.5 ±0.5
	Wi	7	4	28	19	25	12	6	3	6	4	2
	Yearly values	3.2 ±1.6	3.7 ±1.5	29.7 ±10.4	13.2 ±5.0	13.5 ±4.9	5.7 ±1.5	3.2 ±1.1	1.5 ±0.6	2.7 ±0.9	2.5 ±1.0	0.9 ±0.3
	Yearly values in %	3.9	4.5	35.9	15.8	16.1	7.0	3.8	1.9	3.3	3.0	1.1
V	Sp	2 ±29.6	6 ±3	66 ±12	27.5 ±13.0	44.8 ±21.2	13.7 ±6.5	10.0 ±4.5	5.0 ±2.4	7.5 ±3.5	9 ±4.5	2.5 ±1.5
	Su	29 ±19.8	4 ±3	59 ±52.5	15.0 ±12.6	24.7 ±20.6	7.5 ±6.3	5.5 ±4.5	2.5 ±2.3	4.0 ±3.5	4.5 ±4.0	1.5 ±1.5
	Au	52 ±3.5	4.5 ±1.5	93.5 ±54.5	38 ±23.7	62.1 ±38.9	19 ±11.9	13.5 ±8.5	7 ±4.3	10.5 ±7.0	12.0 ±7.6	3.5 ±2.5
	Wi	73	8	92	30	49	22	11	5	7	11	4
	Yearly values	8 ±13.6	5.5 ±1.9	77.5 ±29.8	26.7 ±12.3	44.9 ±25.5	15.7 ±6.2	9.9 ±4.4	5 ±2.8	7.2 ±3.5	9.1 ±4.0	2.9 ±1.4
	Yearly values in %	3.7	2.6	36.5	13.1	21.2	7.3	4.7	2.3	3.4	4.3	1.3

Table S6. b. Percentage abundance of fragments (FR) divided into different colorimetric classes, for each beach, for the total sample and for the selected representative subsample for which we have the polymer characterization. The data are obtained calculating the number of total fragments collected yearly for each beach (through nine sample square of 0,25 m^2 each one), averaged over the seasonal replicas, and reporting them as percentage (Yearly values in %).

SITE	SAMPLE	FRAGMENTS (FR)										
		TR-GL	AM	WH-GL	WH-OD	BL	GR	RE	YE	GY	BK	OT
SR	TOTAL	5.8	4.1	31.5	14.9	22.9	6.5	4.5	2.3	3.3	3.6	1.3

	SUB	5.3	7.6	28.2	15.3	22.9	9.9	7.2	2.6	0.2	1.2	0.8
MV	TOTAL	3.9	4.5	35.9	15.8	16.1	7.0	3.8	1.9	3.3	3.0	1.1
	SUB	5.6	4.6	31.1	14.8	19.4	12.2	6.5	4.4	0	0	4.1
V	TOTAL	3.7	2.6	36.5	13.1	21.2	7.3	4.7	2.3	3.4	4.3	1.3
	SUB	7.2	8.8	27.1	11.6	15	11.9	8.5	5.2	0	0.5	6.6

Table S7. Main polymers detected in fragments (FR) and resin pellets (RP) for the items analyzed by infrared spectroscopy (sub-sample). The total numerical values of EPS fragments collected is 6849. Sampling dates are 12/14/2016 and 5/29/2017. Sp = spring; Au = autumn.

SITE	SEASON	FR				RP			
		PE*	**PP**	**PS***	**OTHER*****	**PE***	**PP**	**PS***	**OTHER*****
SR	Sp	104	38	0	25	129	48	6	0
	Au	73	37	0	10	144	17	0	0
MV	Sp	82	38	0	2	162	41	0	0
	Au	33	12	4	9	173	35	5	0
V	Sp	96	34	0	28	114	34	0	0
	Au	138	44	5	13	136	21	7	0
TOT		526	203	9	87	858	254	18	0

* No distinction was made between HDPE (high density polyethylene) and LDPE (low density polyethylene). ** Polystyrene is understood in this paragraph and in the results reported in the table in Appendix B as a fragment, at real density.*** "Other" includes epoxy resin, EthylenVinyl Acetate (EVA), and dyestuffs.

Table S8_a. Number of fragments (FR) of different polymeric type for each dimensional category (as absolut value and as value normalized within dimensional category). Dim 1 include fragments with major linear dimension between 1cm and 2 cm; Dim 2 between 2 cm and 3 cm; Dim 3 between 3 cm and 4 cm and Dim 4 between 4 cm and 5 cm.

SIZE	**Number of fragments**							
	PE	**PE *nor**	**PP**	**PP *nor**	**PS**	**PS *nor**	**OTHER**	**OTHER *nor**
Dim 1	3	0.06	33	0.33	0	0	18	0.33
Dim 2	143	0.64	62	0.08	0	0	17	0.08
Dim 3	172	0.68	57	0.09	4	0.02	24	0.09
Dim 4	208	0.71	51	0.09	5	0.02	28	0.09

*nor It means normalized.

Table S8. b. Number of fragments (FR) of different color classes for each dimensional category (as absolut value and as value normalized within dimensional category). Dim 1 include fragments with major linear dimension between 1cm and 2 cm; Dim 2 between 2 cm and 3 cm; Dim 3 between 3 cm and 4 cm and Dim 4 between 4 cm and 5 cm.

SIZE	**Number of fragments**																				
	TR-GL	**TR GL *nor**	**AM**	**AM *nor**	**WH-GL**	**WH-GL *nor**	**WH-OD**	**WH-OD *nor**	**BL**	**BL *nor**	**GR**	**GR *nor**	**RE**	**RE *nor**	**YE**	**YE *nor**	**GY**	**GY *nor**	**BK**	**BK *nor**	OT	OT nor
Dim 1	3	0.06	4	0.08	13	0.25	4	0.08	8	0.15	10	0.02	5	0.1	2	0.04	0	0	1	0.02	2	0.04
Dim 2	11	0.05	15	0.07	59	0.26	33	0.15	35	0.16	27	0.12	16	0.1	10	0.04	0	0	4	0.02	12	0.05
Dim 3	21	0.08	23	0.09	58	0.22	35	0.14	39	0.15	23	0.09	22	0.09	13	0.04	0	0	3	0.01	9	0.03
Dim 4	19	0.07	16	0.06	86	0.29	45	0.15	56	0.19	34	0.12	16	0.06	13	0.04	0	0	2	0.01	9	0.03

*nor It means normalized.

Table S9. The table shows, for Polyethylene, the molecular vibrations, δ = bending, ν = stretching, ϱ = rocking, τ = twisting, ω = wagging, while the abbreviations in the peaks concern the intensity m = medium, s = strong, vs= very strong, w= weak, vw= very weak. The results show that 357 out of 526 (67%) PE samples had a spectrum very similar to that of the reference sample, where no further bands were found. The only differences concern the intensity of the individual peaks. In contrast, 21 fragments (4% PE samples) have bands similar to titanium oxides (TiO2) generally found in white samples, while 80 fragments (15% PE samples) have the characteristic bands of blue phthalocyanine and 54 fragments (10% PE samples) of green phthalocyanine. The phthalocyanines in fact are very resistant dyes, often used for the staining of MPs. The spectra are reported in Figure S5, S6, S7 and S8.

Raman shift (cm^{-1})	**Molecular group vibrations**
2880vs	νCH2 asym
2847s	νCH2 sym
1459w	δCH2
1438m	δCH2
1415w	δCH2, ωCH2
1293m	νCC, τCH2
1167vw	νCC
1127m	νCC sym.
1060m	νCC asym.

Table S10. The table shows, for Polypropylene, the molecular vibrations, δ = bending, ν = stretching, ϱ = rocking, τ = twisting, ω = wagging, while the abbreviations in the peaks concern the intensity m = medium, s = strong, vs= very strong, w= weak, vw= very weak. The results show that a total of 136 fragments out of 203 (66%) PP samples have a spectrum traceable to the PP reference. The only differences concern the intensity of the individual peaks. In contrast, 5 fragments (2.5% PP samples) show bands of titanium oxides (TiO2) generally found in white samples, while 42 fragments (21% PP samples) show the presence of blue phthalocyanine and 17 fragments (8% PP samples) of green phthalocyanine. The spectra are shown in Figures S9, S10, S11 and S12.

Raman shift (cm^{-1})	Molecular group vibrations
2952m	νCH3 asym.
2905m	νCH
2883s	νCH3 sym.
287lw	νCH2 sym
2840m	νCH2 sym
1458vs	δCH3 asym., δCH2
1435w	δCH3 asym.
1371m	δCH3 sym., ωCH2, δCH, νCC
1360s	δCH3 sym., δCH
1330	δCH, τCH2
1306	ωCH2, τCH2
1296	ωCH2, δCH , τCH2
1257	δCH, τCH2, ϱCH3
1219s	τCH2, δCH,, νCC
1167sh	νCC ϱCH3, δCH
1152vs	νCC νC-CH3, δCH, ϱCH3
1102w	νCC, ϱCH3, ωCH2, τCH
1040s	νC-CH3, νCC, δCH
998m	ϱCH3, δCH, ωCH2
973s	ϱCH3, νCC
94lm	ϱCH3 νCC
900m	ϱCH3, ϱCH2, δCH
84lvs	ϱCH2, νCC, νC-CH3, ϱCH3
809vs	ϱCH2, νCC, νC-CH3
530m	ϱCH2, νC-CH3, ϱCH2
458m	ωCH2
398s	ωCH2, δCH
321m	ωCH2
252m	ωCH2, δCH

Table S11. The table shows, for Polystyrene, the molecular vibrations, δ = bending, ν = stretching, ϱ = rocking, τ = twisting, ω = wagging, while the abbreviations in the peaks concern the intensity m = medium, s = strong, vs= very strong, w= weak, vw= very weak. Excluding expanded polystyrene (EPS), whose polymeric identification was already certain, nine polystyrene compounds were identified within the fragments (FR), out of a total of 816 analysed. The Spectra is reported in Figure S13.

Raman shift (cm^{-1})	Molecular group vibrations
3053vs	νCH.
2900m	νCH3, νCH.asym
2849w	νCH
1602vs	ν-ring skeletal
1583w	νC=C
1450w	δCH2
1196m	νCC, νC-O.
1182m	νCC, νC-O.
1153m	νCC, νC-O.
1031s	τ τCH2
1001vs	νCC aromatic ring
793m	C-H out of plane

621m	ν-ring deformation, νCH

Table S12. The table shows, for Ethylene, the molecular vibrations, δ = bending, ν = stretching, ϱ = rocking, τ = twisting, ω = wagging, while the abbreviations in the peaks concern the intensity m = medium, s = strong, vs= very strong, w= weak, vw= very weak. In the analysis made, 3 fragments traceable to this polymer were identified. The Spectra is reported in Figure S14.

Raman shift (cm^{-1})	Molecular group vibrations
2880s	νCH.
2846vs	νCH2,
1438m	δCH
1290m	τCH2
1130vw	δCC asym
1060w	δCC asym

Table S13. The table shows, for Ethylene Vinyl Acetate (EVA)**,** the molecular vibrations, δ = bending, ν = stretching, ϱ = rocking, τ = twisting, ω = wagging, while the abbreviations in the peaks concern the intensity m = medium, s = strong, vs= very strong, w= weak, vw= very weak. The Spectra is reported in Figure S15.

Raman shift (cm^{-1})	Molecular group vibrations
2883vs	νCHx
2847vs	νCH2, νCH
1738w	νC=O
1438m	δCHx
1290m	δCH
1126vw	νC-C asym
1061w	νC-C asym
628	δOCO

Table S14. The table shows, for Epoxy Resin, the molecular vibrations, δ = bending, ν = stretching, ϱ = rocking, τ = twisting, ω = wagging, while the abbreviations in the peaks concern the intensity m = medium, s = strong, vs= very strong, w= weak, vw= very weak.The main bands were allocated with reference to the literature, in particular Vašková et al. [122]. The Spectra is reported in Figure S16.

Raman shift (cm^{-1})	Molecular group vibrations
1608vs	backbone vibration
1252vw	epoxide vibration band
1186w	backbone vibration
1112vw	backbone vibration
916w	epoxy ring deformation

Supplementary Material - Figures

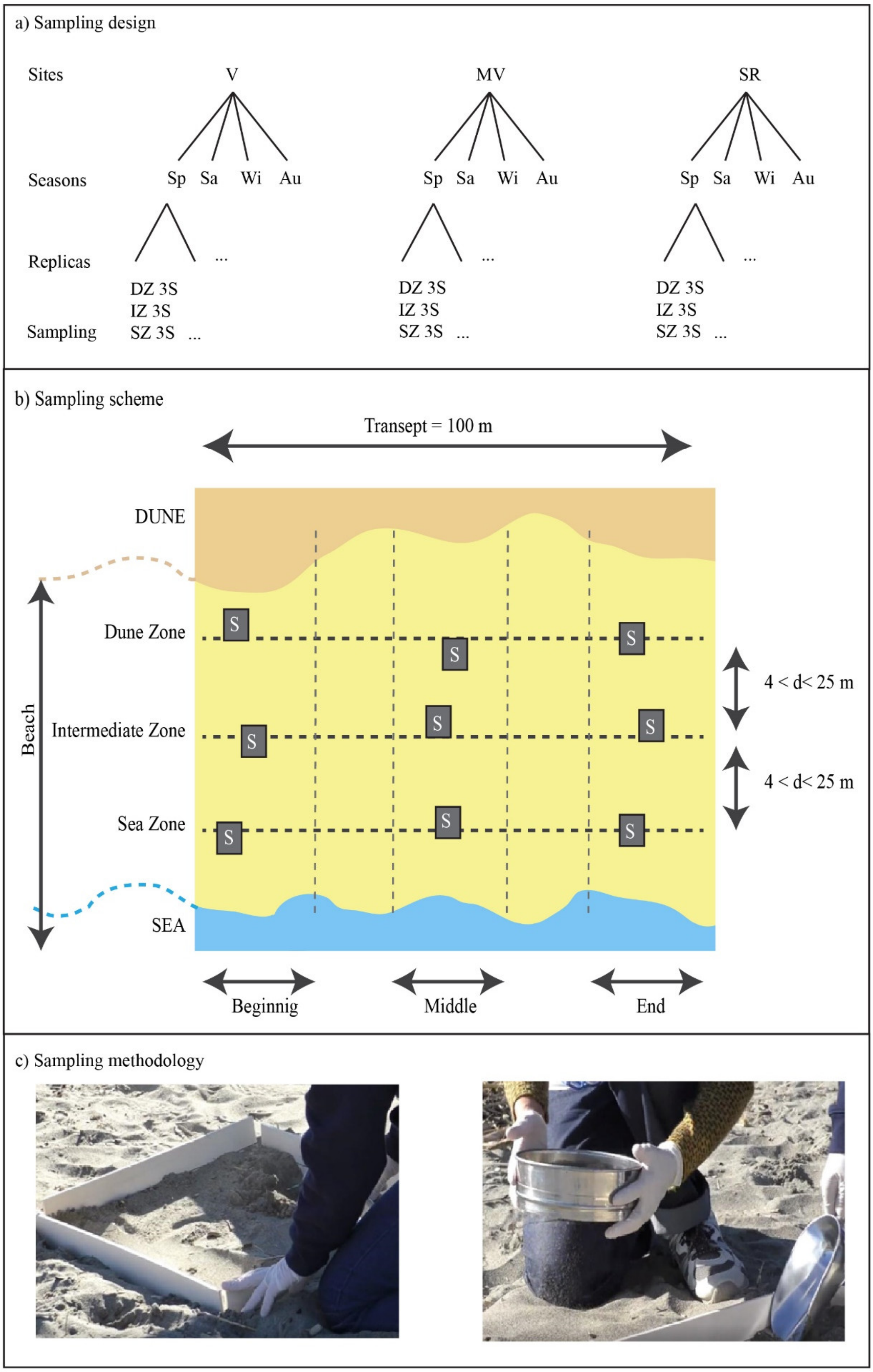

Figure S1. The sampling design is multifactorial, where the site factor is crossed (orthogonal) with the seasonality, and the Zone factor is hierarchical. The dates of the sampling are: 7/25/2016, 8/25/2016, 10/31/2016; 12/14/2016; 2/16/2017; 5/29/2017; 6/21/2017.

Figure S2. Beaches images. SR is San Rossore beach; MV is Marina di Vecchiano beach; V is Viareggio beach. Colored polygons on the left are the monitored stretch of beach. GPS coordinates of the 4 polygon' summit are: for SR 10.278038E, 43.714856N; 10.278176E, 10.278176N; 10.278436E, 43.713871N; 10.278577E, 43.713872N. For MV 10.264421E, 43.795011N; 10.264751E, 43.795694N; 10.264742E, 43.794168N; 10.265135E, 43.794242N. For V 10.244156E, 43.845173N; 10.244828E, 43.845338N; 10.244575E, 43.844218N; 10.278577E, 43.713872N.

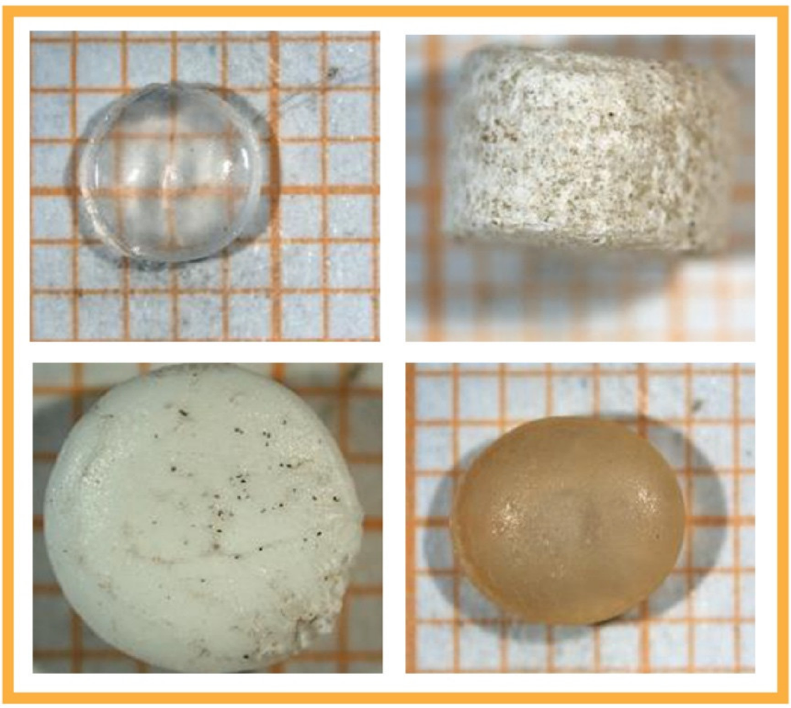

Figure S3. A few other examples of the RP type of the sampled MP, with the different colour shades due to ageing, from Transparent-Glossy (TR-GL), to White (WH), and then Amber (AM). Most of them have a round shape, but some also have other shapes, including the cylindrical one.

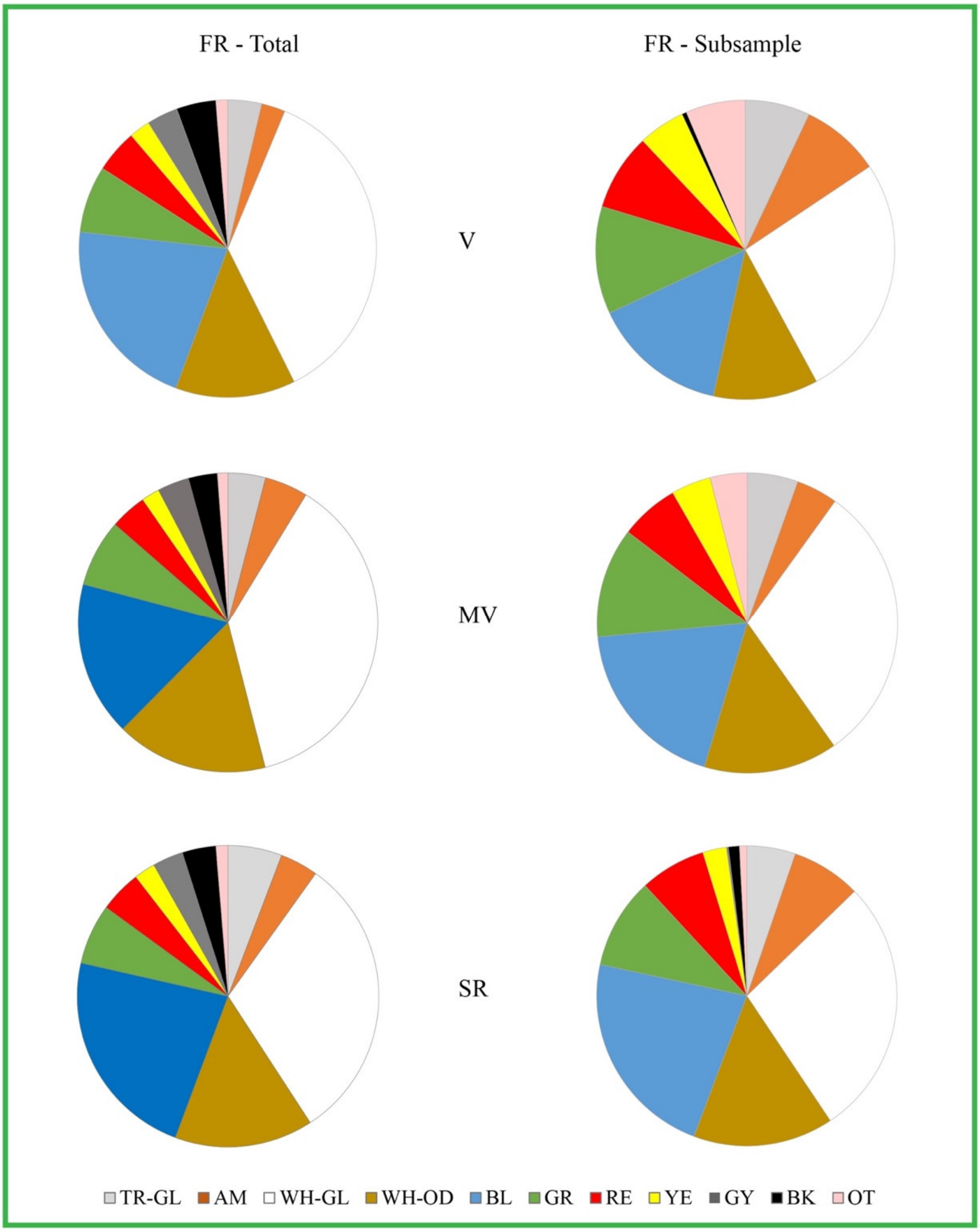

Figure S4. Frequencies of color classes for the three sites. At the left for the all FR (total sample) and at the right for the sub-sample of FR with polymeric characterization. Frequencies are very similar (Table S6_b for values), a part the low presence of black fragments in the sub-sample. Blue and green fragments are the most abundant amongst the colored ones.

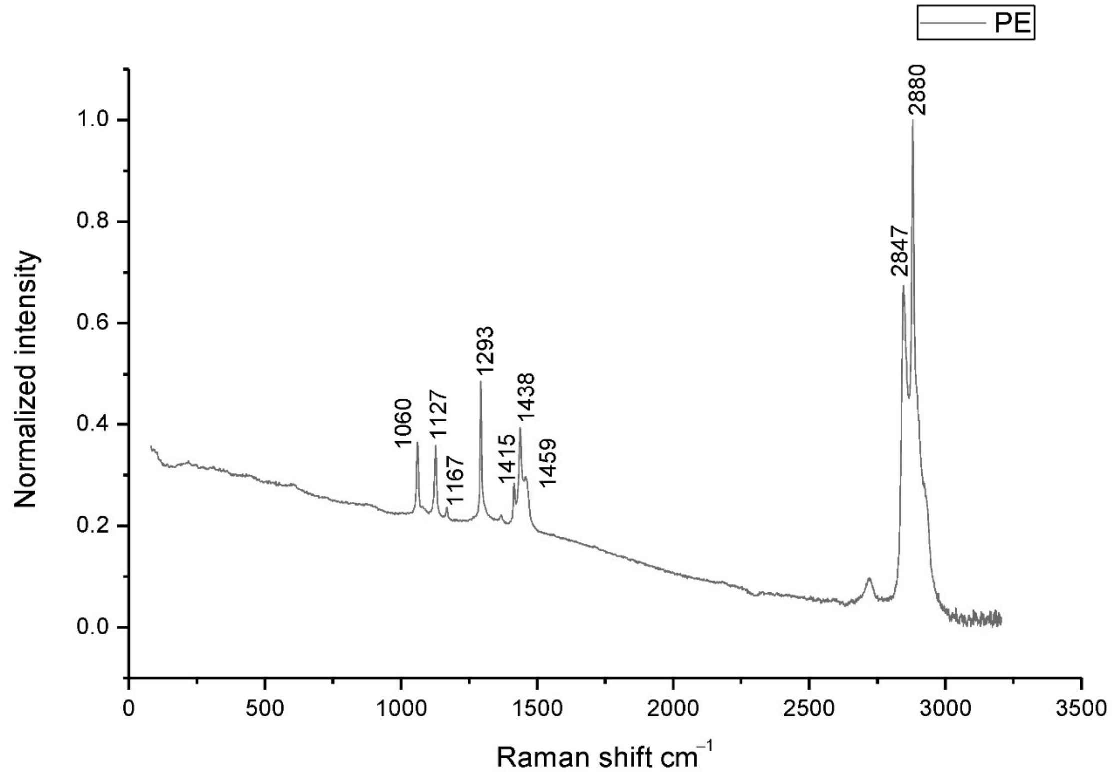

Figure S5. Raman spectrum from a fragment of polyethylene.

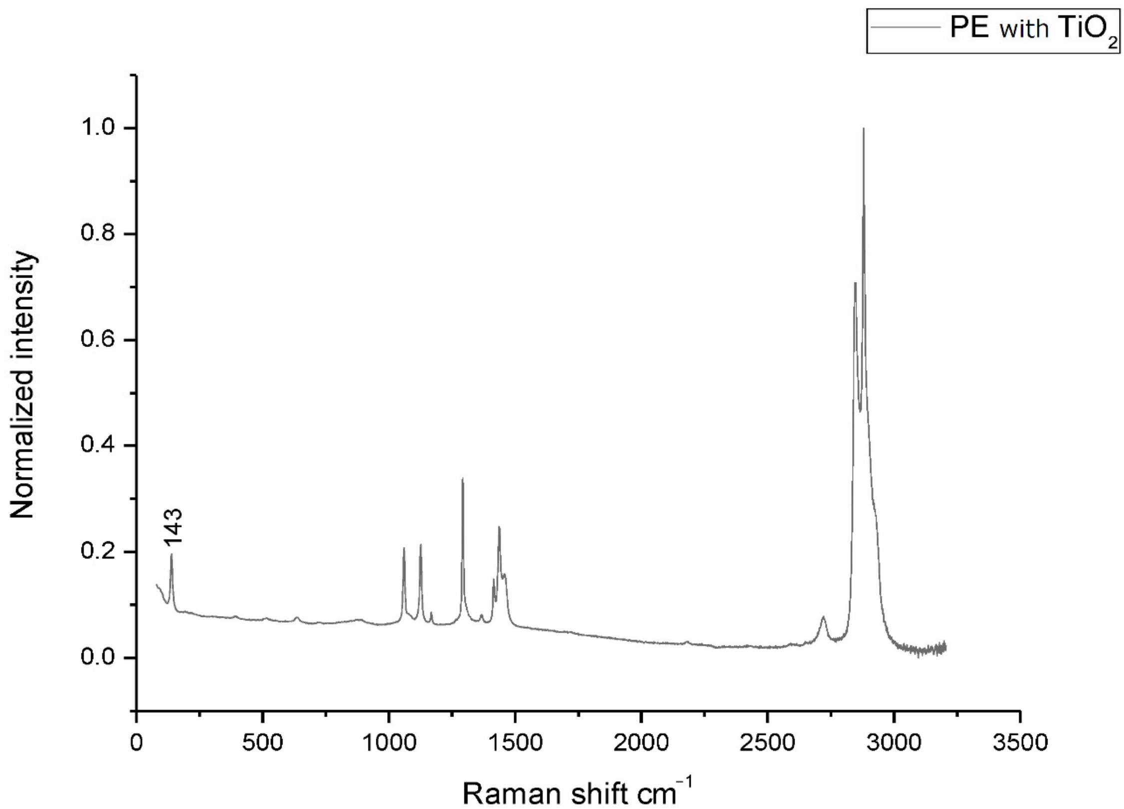

Figure S6. Raman spectrum of a fragment of Polyethylene with the characteristic peak of Titanium Oxide (TiO2) at 143 cm $^{-1.}$

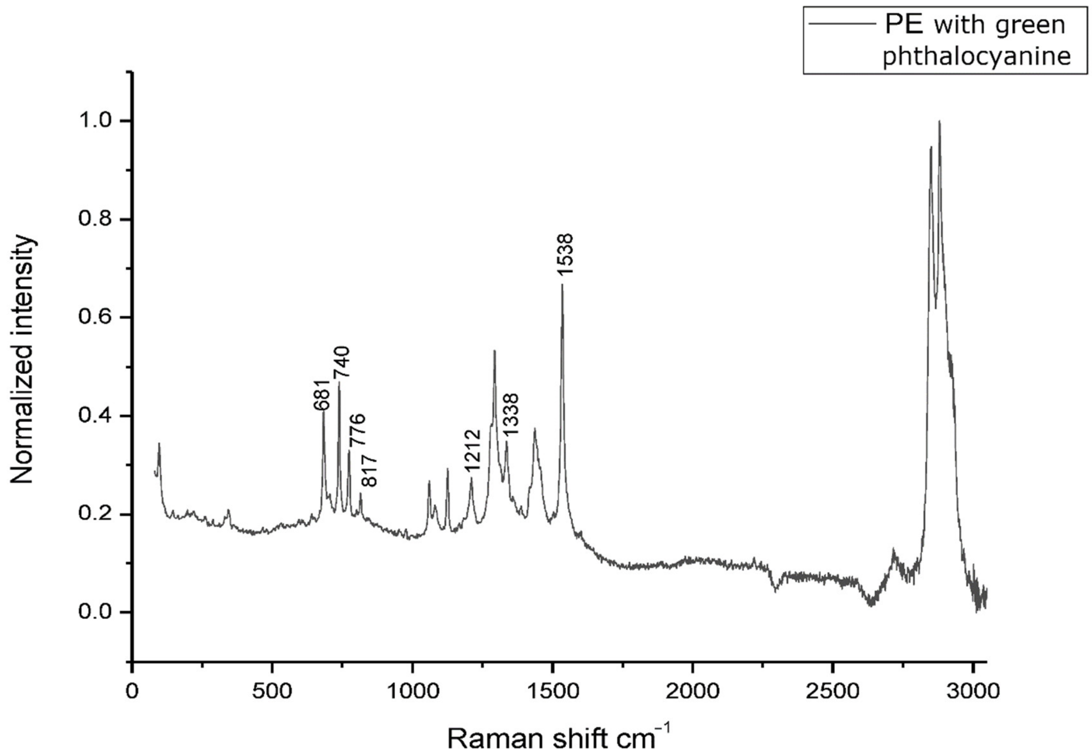

Figure S7. Spectrum of a fragment of Polyethylene with green pigment, green phthalocyanine Cu(C32H16N8) characteristic peaks at 681 cm $^{-1}$,740 cm^{-1}, 776 cm^{-1}, 817 cm^{-1}, 1212 cm^{-1}, 1338 cm^{-1}, 1538 cm^{-1}.

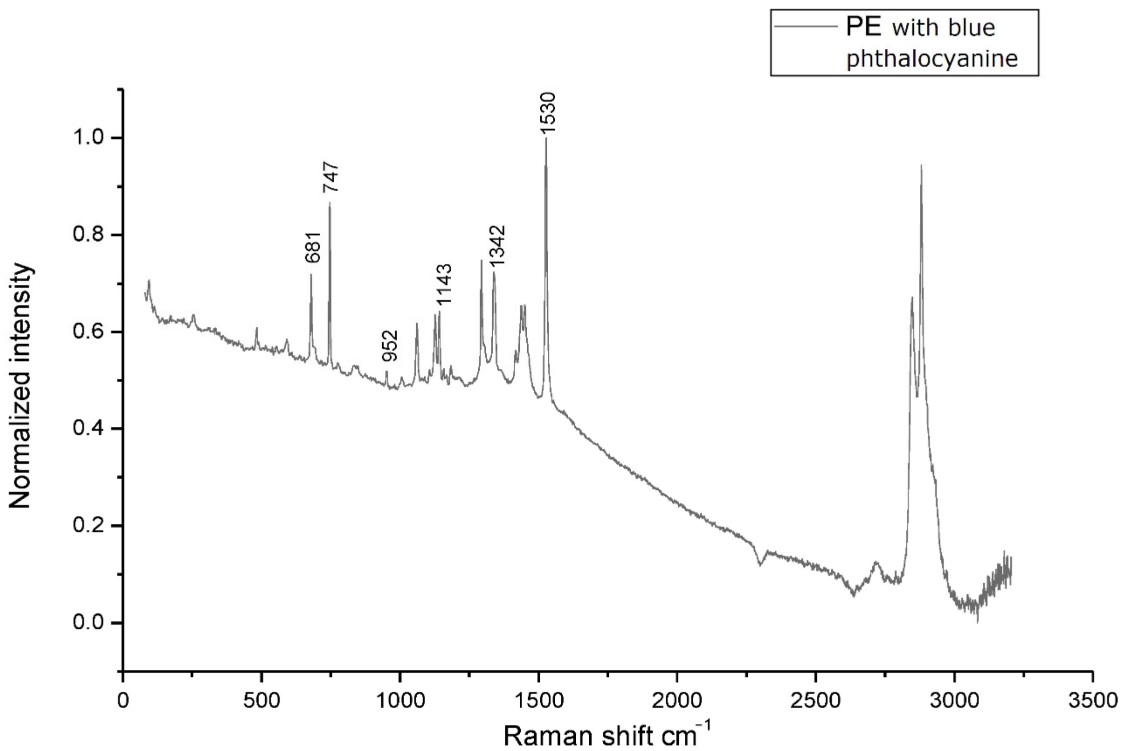

Figure S8. Spectrum Raman of a fragment of Polypropylene with blue phthalocyanine Cu(C32H16N8). The characteristic peaks are present at 747 cm^{-1}, 952 cm^{-1}, 1342 cm^{-1}, 1530 cm^{-1}.

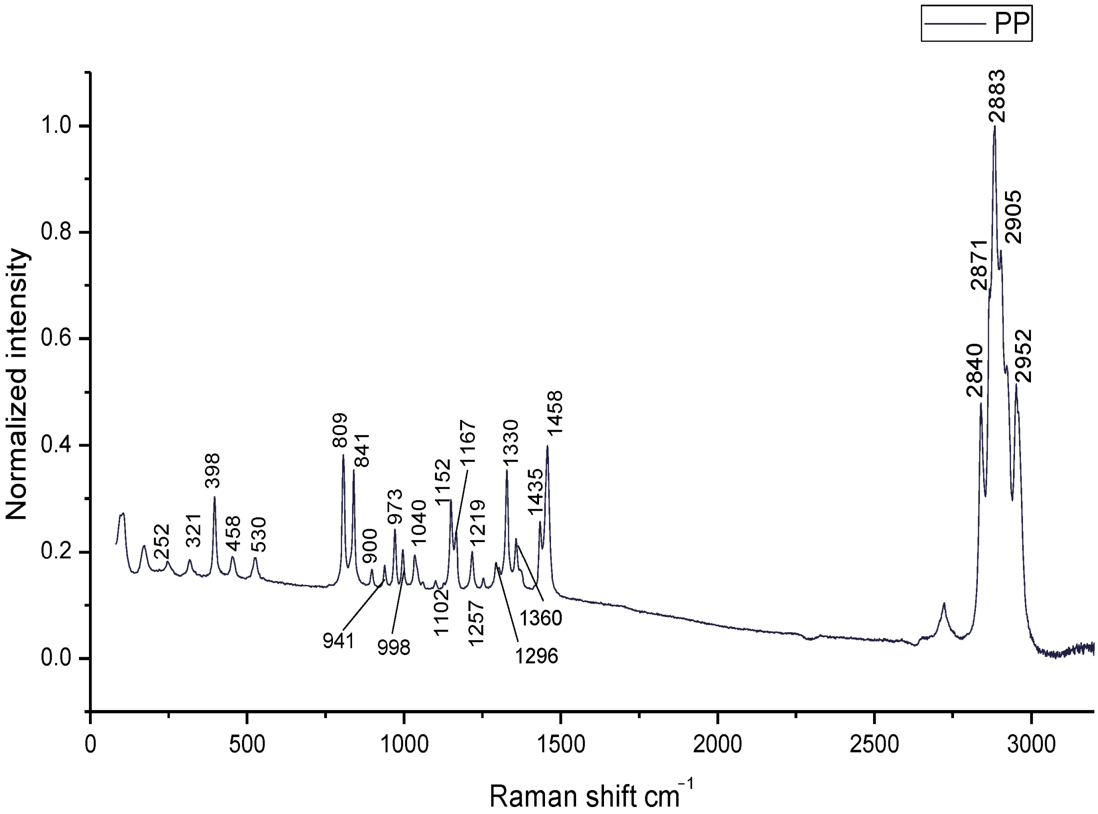

Figure S9. Raman spectrum of a fragment of Polypropylene.

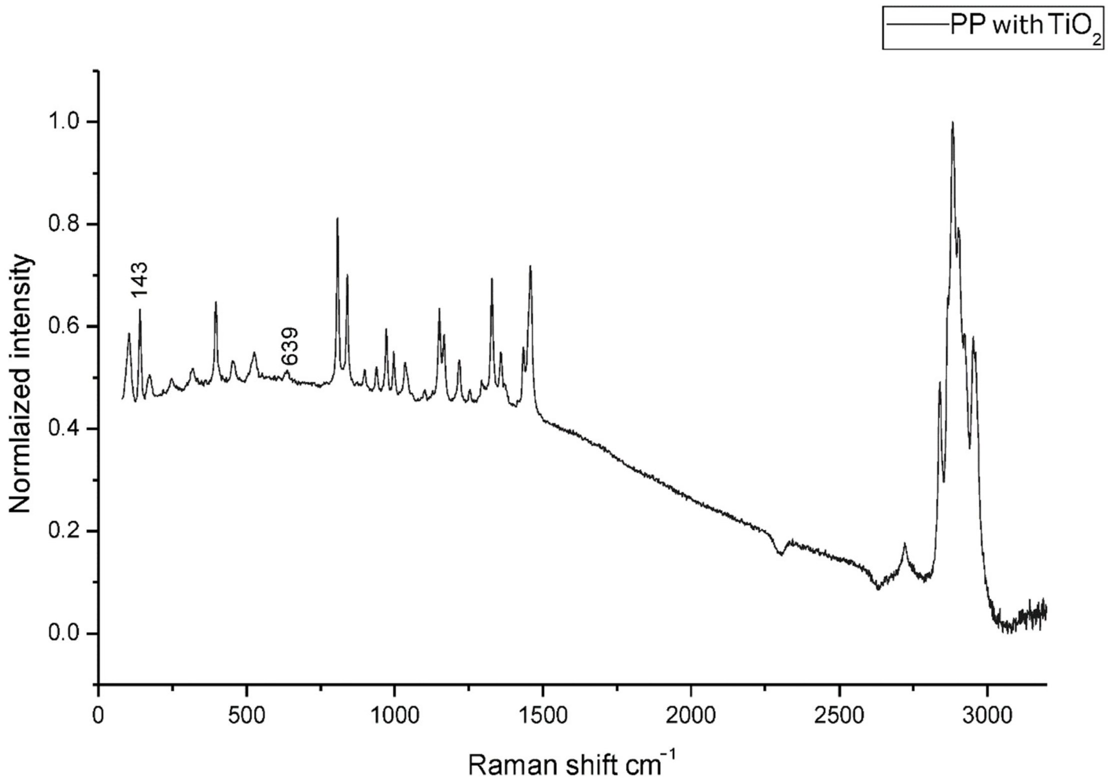

Figure S10. Spectrum Raman of a fragment of Polypropylene with Titanium Oxide (TiO2), peaks at 143 cm^{-1} and 639 cm^{-1}.

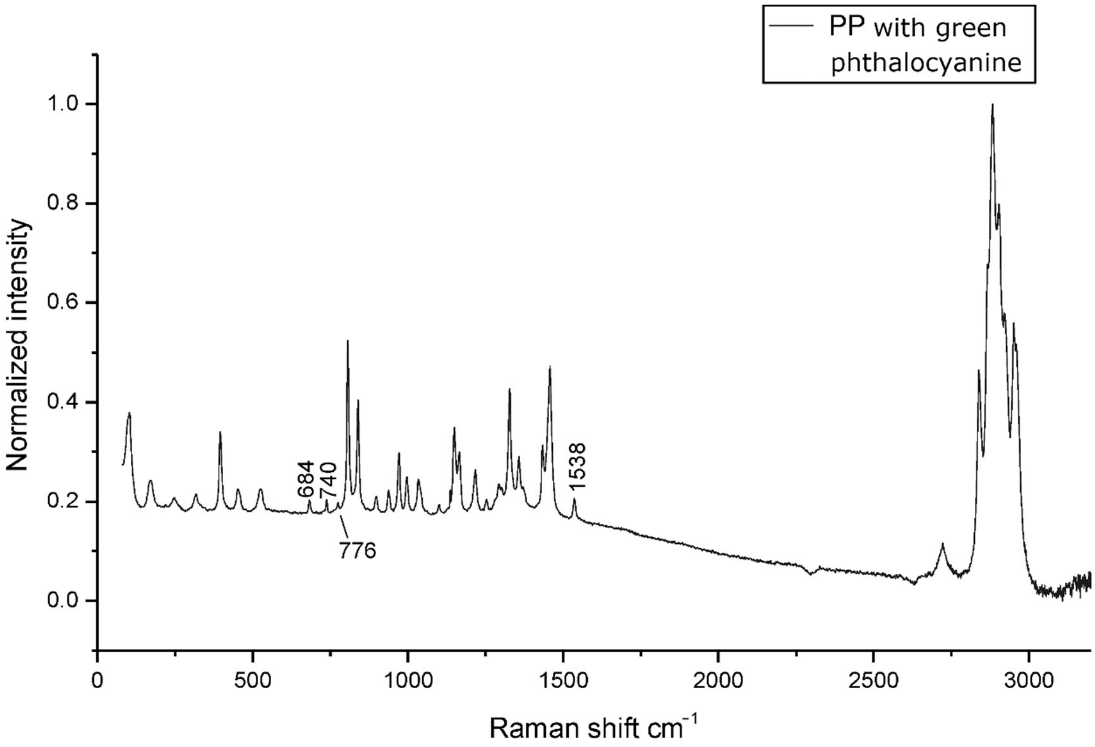

Figure S11. Raman spectrum of a fragment of Polypropylene with green phthalocyanine Cu(C32H16N8). The characteristic peaks are present at 1538 cm^{-1}, 776 cm$^{-1,}$ 740 cm^{-1}, 684 cm$-^{1.}$

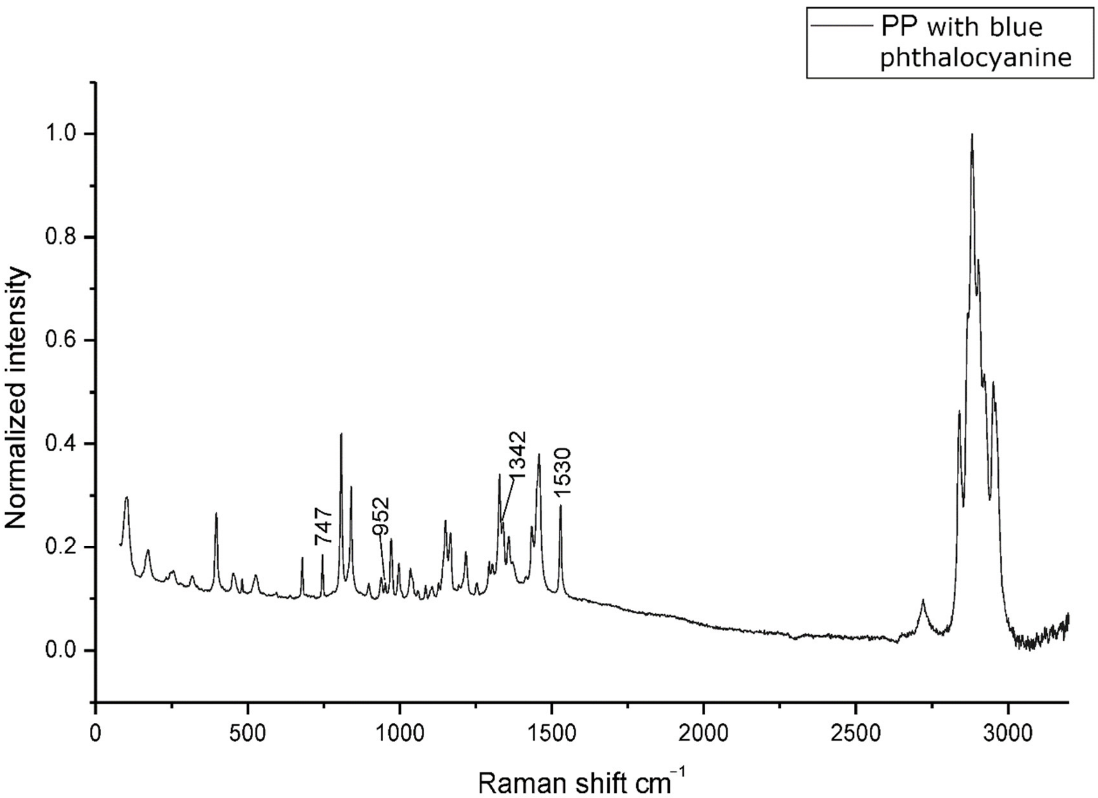

Figure S12. Spectrum Raman of a fragment of Polypropylene with blue phthalocyanine Cu(C32H16N8). Characteristic peaks are present at 747 cm^{-1}, 952 cm^{-1}, 1342 cm^{-1}, 1530 cm$^{-1.}$

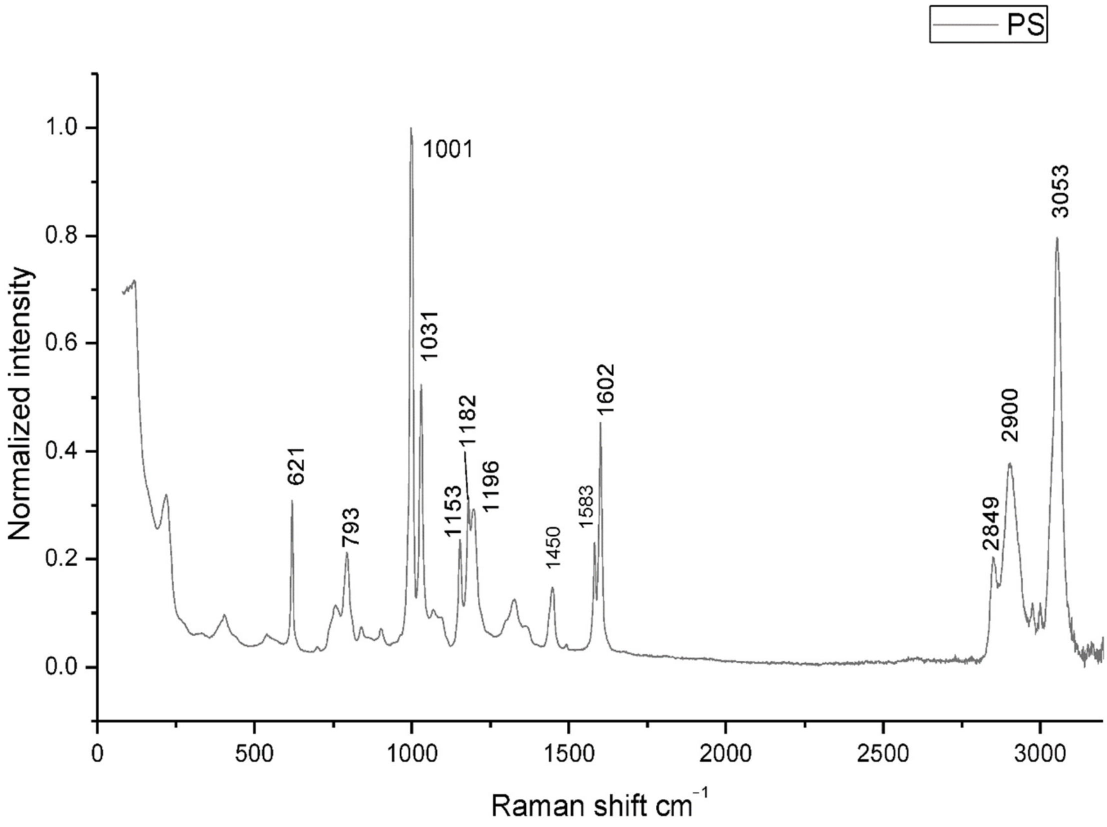

Figure S13. Raman Spectrum of a fragment of Polystyrene.

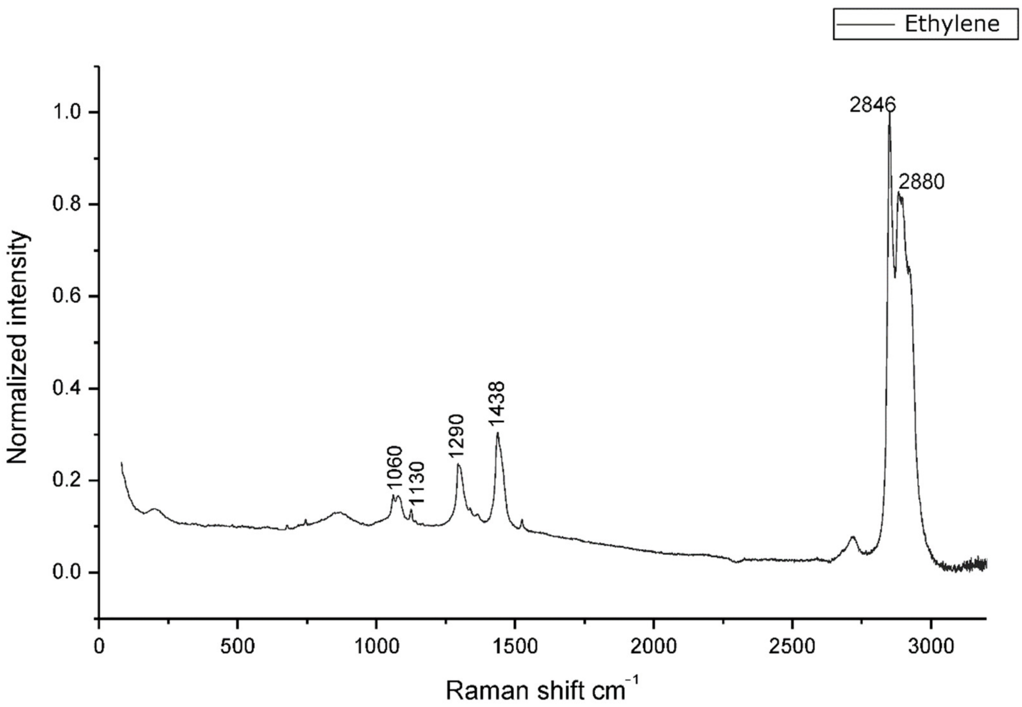

Figure S14. Ethylene Raman Spectrum.

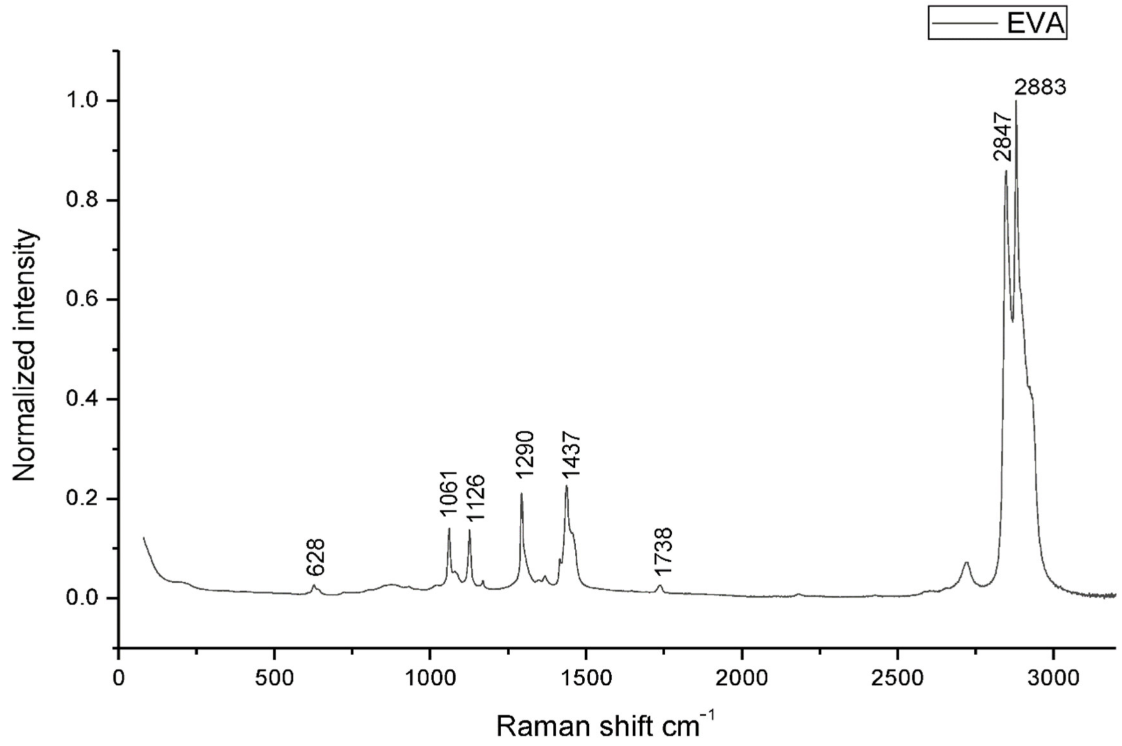

Figure S15. Raman spectrum of a fragment of ethylene vinyl acetate.

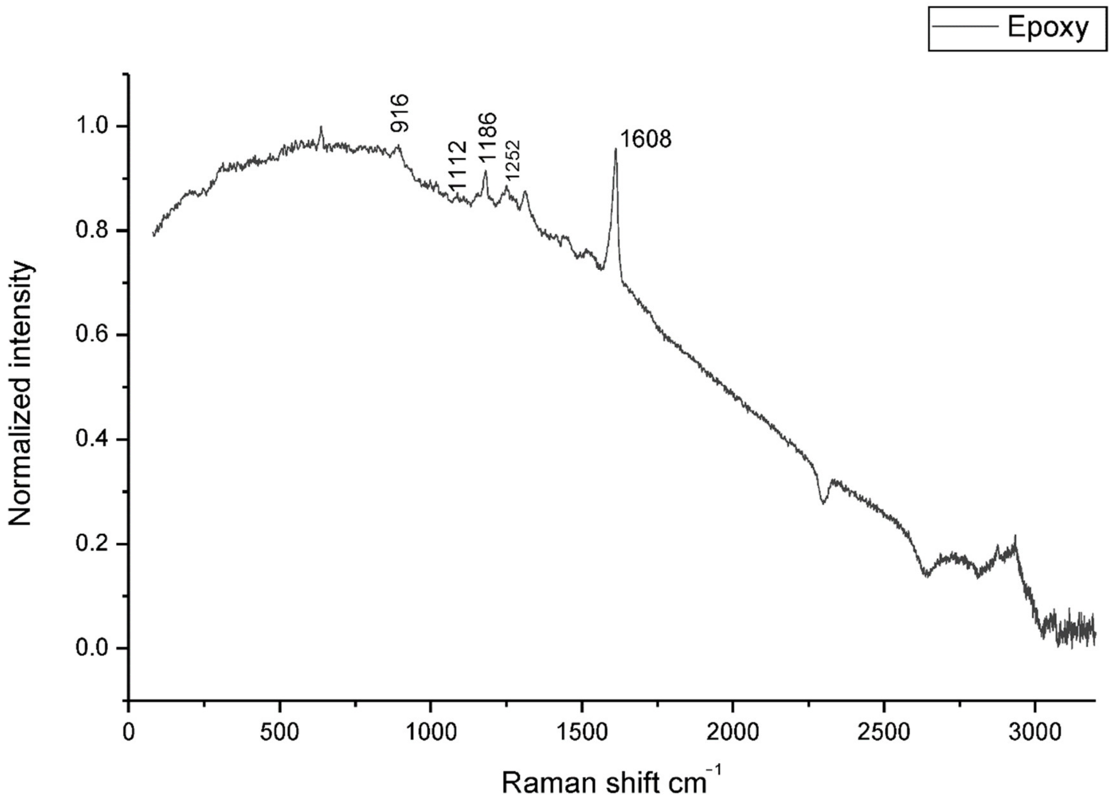

Figure S16. Raman spectrum of an epoxy resin fragment.

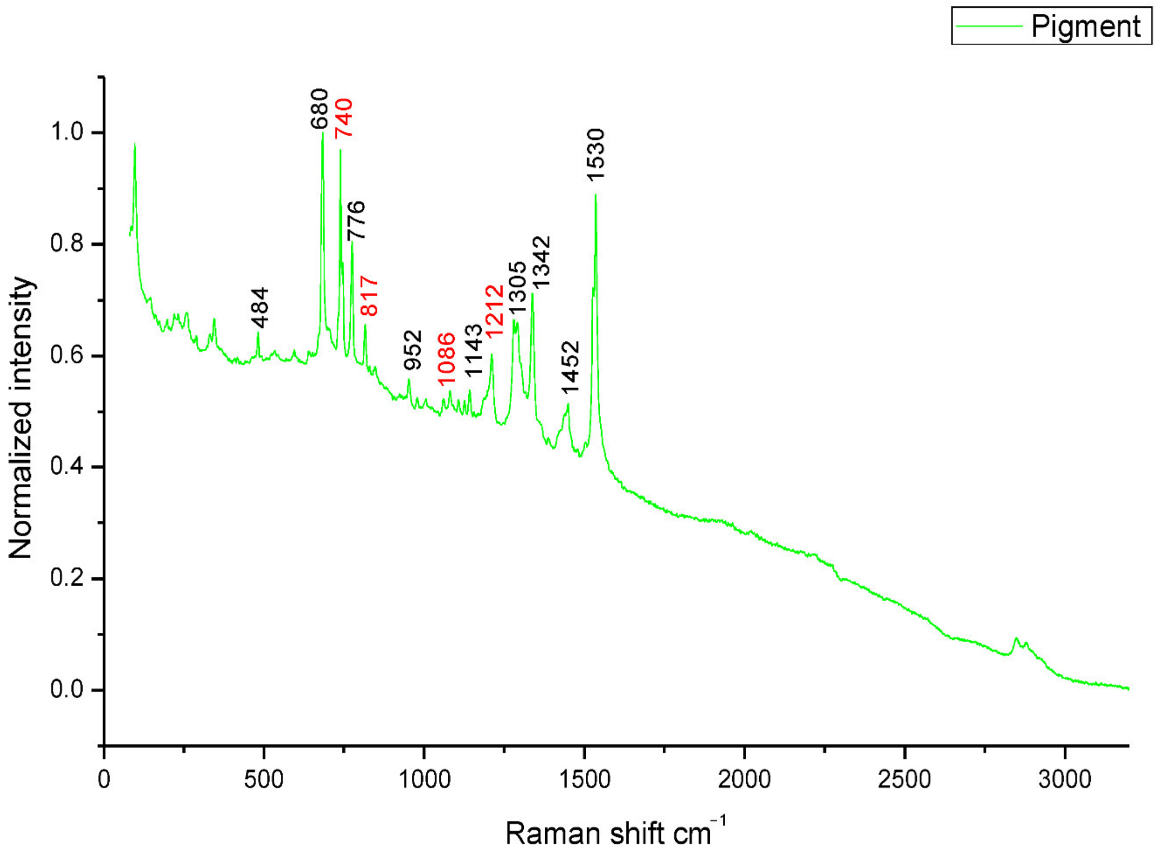

Figure S17. Example of a fragment classified as a pigment. In this case the spectrum has both a blue phthalocyanine (black numbers) and a green phthalocyanine (red numbers). Phthalocyanines are organic dyes that resist colour loss very well even in unfavorable environments such as at sea or on beaches under solar radiation, better than dyes of different nature, as the ones used for red and yellow pigments.