1.2. Which plastics are in my collection? The need for a plastic reference sample collection (SamCo)

Introduction

Knowledge of the composition of plastics in museum collections is necessary to establish a proper approach to the preservation of these materials and in understanding degradation, estimating risk and defining appropriate conservation treatments. Unfortunately identification of the plastic in an object is not a simple matter. Plastics are a huge family of materials that includes many different polymers often complex, which can make identification a real challenge. Therefore, a proper and correct identification of plastic objects requires suitable analytical techniques and needs the support of reference materials.

The SamCo

In order to evaluate suitable analytical tools for the identification of plastics and to support these analyses, one of the project's objectives was to build SamCo: a collection of well characterised reference materials representing new and degraded plastics found in museum collections. SamCo consist of almost 100 plastic reference samples and is made up of two kinds of reference materials: standards and objects.

Each standard represent the reference material of a "pure" plastic; while each object represent the reference of the same plastic as in the standards, but compounded with pigments, dyestuffs, fillers, anti-oxidants plasticisers, etc.

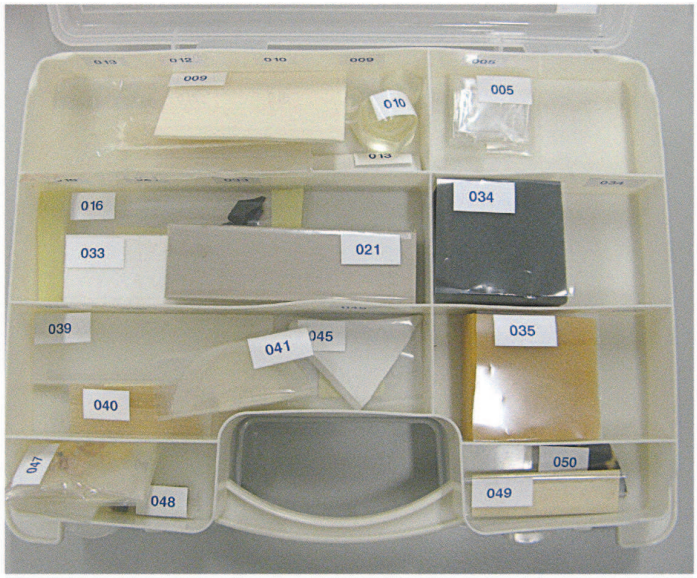

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Figure 1. SamCo kit, with reference standards
Figure 2. SamCo kit, with reference objects

SamCo was created by the Cultural Heritage Agency of the Netherlands with the assistance of the Victoria and Albert Museum and the National Museum of Denmark (Natmus) and began by selecting the most common plastics found in museum collections. 46 types of plastics were selected (including natural, semi-synthetic and synthetic polymers) and collected both as standards and objects (Figure 3).

Standards were collected from several different sources: the ResinKit™ (www.resinkit.com) which is a commercially available kit of thermoplastics resin samples; plastics manufacturers and, when all else failed, they were made in the RCE laboratory, mixing the pure components.

Plastic objects in various conditions (new and degraded) were collected from the RCE, V&A and Natmus plastic reference collections, private collections, flea markets and antique shops.

The objects and standards collected were cut into pieces in order to distribute the collection between all partners performing identification analysis.

Seven boxes, one for each partner, containing the SamCo were made. One side of each box contains the samples of standards, and the other side the samples from objects (Figure 1-2). Finally the SamCo boxes were distributed to each partner institution.

SamCo No.	ResinKit™ No.	Polymer type	Acronym	Reference Standard	Reference object	Type of Object
1.	31	Acetal resin	POM	•		
2.	9	Poly(methyl methacrylate)	PMMA	•		
3.	7	Acrylonitrile butadiene styrene	ABS	•		
4.		Casein formaldehyde	CS	•		
5.		Cellophane	CE	•		
6.	11*	Cellulose acetate propionate	CAP	•		
7.	12*	Cellulose acetate propionate	CAP	•		
8.	13*	Cellulose acetate propionate	CAP	•		
9.		Cellulose nitrate	CN	•		
10.		Epoxy	EP	•		
11.	34	Ethylene vinylaAcetate	EVA	•		
12.		Glass fibre reinforced polyester	GRP	•		
13.		Melamine formaldehyde	MF	•		
14.	16	Nylon/Polyamide (Type 6)	PA	•		
15.	15	Nylon/Polyamide (Type 6,6)	PA	•		
16.		Phenol formaldehyde	PF	•		
17.	22	Styrene butadiene Rubber	SBR	•		
18.	17	Polybutylene terephthalate	PBT	•		
19.	20	Polycarbonate	PC	•		
20.	39	Polybutylene terephthalate	PBT	•		
21.		Polyether-ether ketone	PEEK	•		
22.	25	Polyethylene (High Density)	HDPE	•		
23.	49	Polyethylene (Medium Density)	MDPE	•		
24.	24	Polyethylene (Low Density)	LDPE	•		
25.	19	Polyphenylene oxide	PPO	•		
26.	33	Polyphenylene sulfide	PPS	•		
27.	27	Polypropylene (homopolymer)	PP	•		
28.	26	Polypropylene (copolymer)	PP	•		
29.	1	Polystyrene (General Purpose)	PS	•		
30.	3	Polystyrene (High Impact)	HIPS	•		
31.	2	Polystyrene (Medium Impact)	MIPS	•		
32.	21	Polysulfone	PSU	•		
33.		Polytetrafluoroethylene (PTFE)	PTFE	•		
34.		Polyurethane flexible foam (ester)	PUR ester	•		
35.		Polyurethane flexible foam (ether)	PUR ether	•		
36.		Poly(vinyl chloride)/Poly(vinyl acetate) **	PVC/PVAC			
37.	29	Poly(vinyl chloride) (Flexible)	PVC	•		
38.	30	Poly(vinyl chloride) plasticised	PVC	•		
39.		Poly(vinylidene fluoride)	PVDF	•		
40.		Poly(vinylidene chloride)	PVDC	•		
41.		Silicone rubber	SI	•		
42.	4	Styrene acrylonitrile	SAN	•		
43.	8	Styrene butadiene Block Polymer	SBR	•		
44.	18	Thermoplastic Polyester	PETG	•		
45.		Urea Formaldehyde	UF	•		
46.	37	Urethane Elastomer Thermoplastic	TPU	•		
47.		Baltic Amber		•		
48.		Horn		•		

Figure 3. SamCo list of reference standards and reference objects

SamCo No.	ResinKit™ No.	Bone	Acronym	Reference Standard	Reference object	Type of Object
49.		Bone		•		
49. A		Ivory		•		
50.		Tortoiseshell		•		
51.		Acetal resin / Polyoxymethylene	POM		•	Sweetener Dispenser
52.		Acrylonitrile butadiene styrene	ABS		•	Lego brick
53.		Styrene Acrylonitrile	SAN		•	Egg cup
54.		Casein Formaldehyde	CS		•	Fork handle
55. A		Cellulose Acetate	CA		•	Transparent grey screwdriver handle
55. B		Cellulose acetate	CA		•	Knitting needles
56.		Cellulose acetate butyrate	CAB		•	Orange Screwdriver handle
57.		Cellulose acetate butyrate	CAB		•	Screwdriver Xcelite ®
58. A		Cellulose nitrate	CN		•	Orange ruler
58. B		Cellulose nitrate	CN		•	Ruler degraded
59.		Melamine Formaldehyde	MF		•	Light blue spoon
60. A		Nylon/Polyamide (Type 6,6)	PA		•	Construction material–degraded
60. B		Nylon/Polyamide (Type 6,6)	PA		•	IKEA spoon
61.		Phenol formaldehyde	PF		•	Lamp shade
62.		Polybutylene terephthalate	PBT		•	Textile PBT object
63.		Polycarbonate	PC		•	Drinks bottle
64.		Polyester Unsatured	UP		•	Bracelet
65.		Urethane Elastomer Thermoplastic -	TPU		•	Dutch clog
66.		Polyethylene (High Density)	HDPE		•	Green stopper
67.		Polyethylene (Low Density)	LDPE		•	Ziplock bag
68.		Polyethylene terephthalate	PET		•	Cola bottle
69.		Poly methyl methacrylate	PMMA		•	Eiffel Tower Model
70.		Polypropylene	PP		•	Shark
71. A		Polystyrene	PS		•	Cup
71. B		Polystyrene	PS		•	Disposable drinking glass
72.		Polytetrafluoroethylene	PTFE		•	Septum (red side)
73.A		Poly(vinyl chloride)/ Poly(vinyl acetate)	PVC/PVAC		•	Coin holder
73. B		Poly(vinyl chloride)/ Poly(vinyl acetate)	PVC/PVAC		•	LP record
74.		Poly(vinyl chloride) (flexible)	PVC		•	Photo pocket
75.		Poly(vinyl chloride) (rigid)	PVC		•	Mounting board
76.		Silicone rubber	SI		•	Cup cake mould
77.		Styrene acrylonitrile	SAN		•	Kitchen spoon holder
78. A		Styrene butadiene Block Polymer	SBR		•	Nuts cup
78. B		Styrene Butadiene Block Polymer	SBR		•	Cookie “Lu petit-beurre”
79.		Urea Formaldehyde	UF		•	Orange container
80. A		Urethane Elastomer Thermoplastic	TPU		•	Fake leather fabric–new
80. B		Urethane Elastomer Thermoplastic	TPU		•	Fake leather fabric–3 year old
81. A		Urethane Elastomer Thermoplastic	TPU		•	Spandex
81. B		Urethane Elastomer Thermoplastic	TPU		•	Spandex yellowed
82.		Natural Rubber		•		Coaster
83.		Shellac		•		Telefunken record
84.		Vulcanite		•		
85.		Natural Rubber		•		
86.A		Shellac yellow brown		•		
86. B		Shellac dark red		•		

* ResinKit™ samples No. 11-12-13 are listed as cellulose acetate, cellulose acetate butyrate and cellulose acetate propionate. After analysis it was found that these three samples consist of cellulose acetate propionate.

** PVC/PVAC was not available as a reference standard.

	FTIR	Py-GCMS	EGA-MS	NIR	RAMAN	DS	DSC
RCE	•	•			•		•
V&A	•						
LC2RMF	•	•					
IFAC				•		•	
UCL				•			
MORANA	•			•			
GCI	•	•	•				

Figure 4. Analytical techniques used for Round Robin test

Figure 5. SamCo Database, standard reference sample, overview content

Analysing SamCo

SamCo was analysed by each partner using several analytical techniques in order to evaluate their capabilities and suitability for the identification and characterisation of plastics (Figure 4). Non-invasive and minimally invasive analytical techniques, with and without portable devices were used, compared and assessed during an inter-laboratory round robin test coordinated by the Getty Conservation Institute.

SamCo database

Using File Maker Pro 8 software (from the company FileMaker Inc.) a database was developed by RCE to catalogue SamCo and all the analyses performed by the partners. Each plastic sample has its own record containing the following information: description, artist/designer, manufacturer, dimension, date, source/supplier, material, polymer acronyms, trade name, country and method of production (Figure 5). Moreover in each record, links are provided to the analytical techniques used to analyse the samples (e.g. FTIR, Raman, Py-GCMS) (Figure 6). A layout for each analytical technique was built in which, all the results and data obtained, are linked and can be easily compared.

Conclusion

The SamCo database has proved to be a valuable and fundamental resource to evaluate the efficiency of different analytical techniques

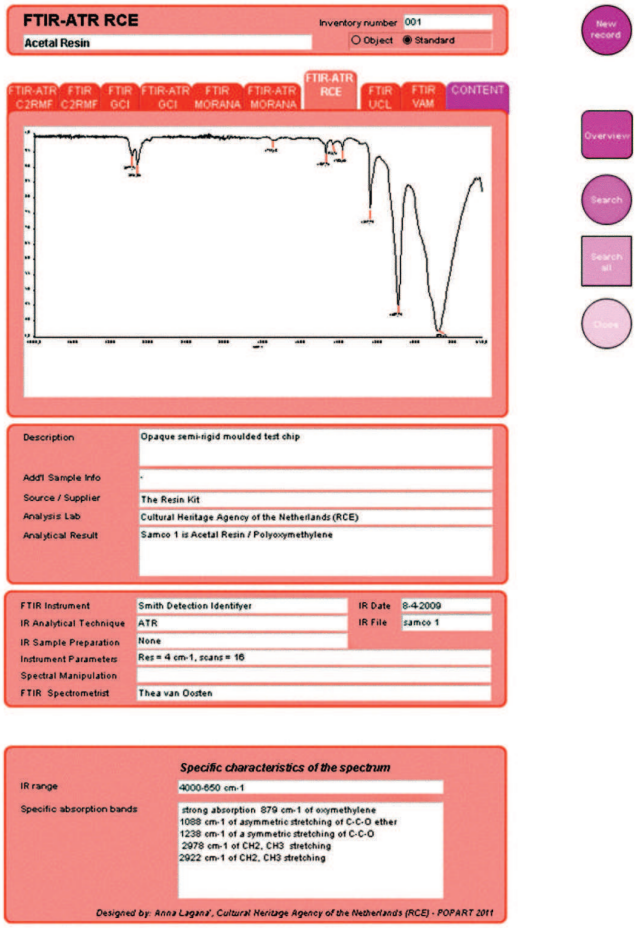

Figure 6. Database, FTIR spectrum

and data reproducibility. The results of the Round Robin test obtained from such a large reference collection as SamCo, showed clearly the capabilities, advantages, disadvantage and suitability of each analytical techniques in identification and characterisation of plastic materials.

Using a reference collection made not just with standard plastics but also with real objects with different compositions and conditions was demonstrated to be a useful tool and a great support for scientists when beginning the challenging task of plastic materials identification.

SamCo team

The team consisted of Anna Laganà and Thea van Oosten from Cultural Heritage Agency of the Netherlands (RCE), Brenda Keneghan from the Victoria and Albert Museum (V&A) and Yvonne Shashoua from the National Museum of Denmark (Natmus).

SamCo Database

Designed by Anna Laganà and Maarten van Bommel from Cultural Heritage Agency of the Netherlands (RCE).

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