2.1. In what condition are my artefacts? Case studies

As plastics objects can degrade quite suddenly and spectacularly in contrast to objects made from wood, stone, etc., it is advisable that plastic collections are at least examined if not surveyed quite regularly. An object made of a vulnerable plastic might degrade considerably within as short a time period as six months so regular inspection is advised. Previous surveys of collections at the Victoria and Albert Museum and elsewhere have indicated that there are at least five vulnerable plastic materials. These are: cellulose nitrate; cellulose acetate; poly(vinyl chloride) (PVC); polyurethane and rubber. It has been shown that these materials will degrade over time regardless of what form the object takes.

The surveys of plastic objects were carried out by three partners in different countries (Victoria and Albert Museum, UK (V&A), Rijksdienst voor Cultureel Erfgoed, Nederland (RCE) and Laboratoire du centre de recherche et de restauration des musées de France (LC2RMF)). Not every partner examined the same type of collection of objects although there was some overlap. Because of the disparity in collections and partner approaches various conclusions can be drawn from the surveys. The outcomes from the individual surveys are described in the following pages and a number of key findings were uncovered which are summarised at the end of this section.

2.1.1. Survey at the Victoria & Albert Museum

A survey of the plastic objects contained in the Furniture Collection in the V&A was undertaken. The objects surveyed date from the 1930's onwards. The collection includes small objects (boxes, ink stands, etc.) made from early plastics to modern furniture (chairs,

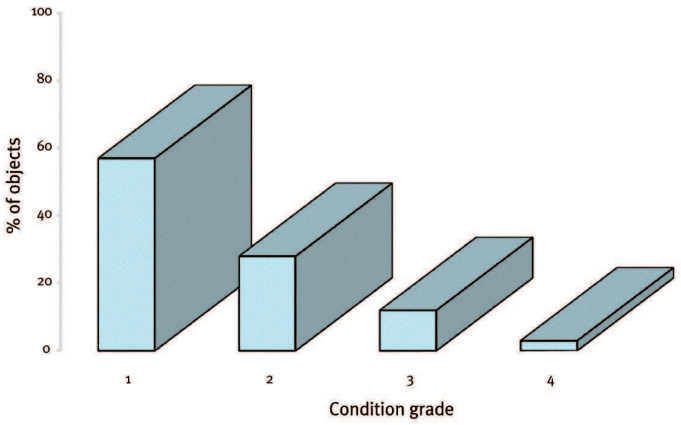


Figure 1. Condition grade of objects surveyed at Victoria & Albert Museum

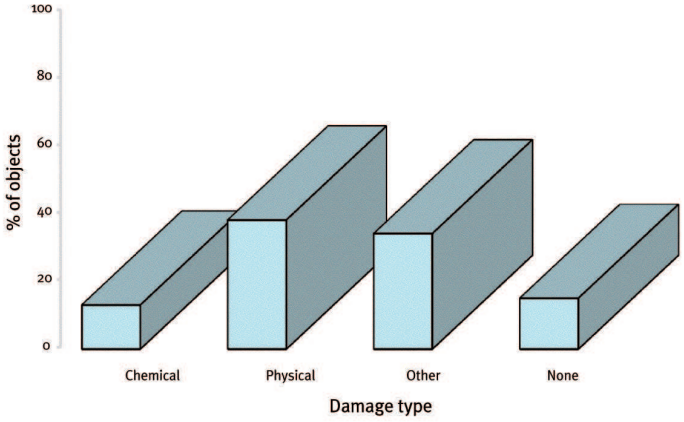


Figure 2. Damage type observed in objects surveyed at Victoria & Albert Museum

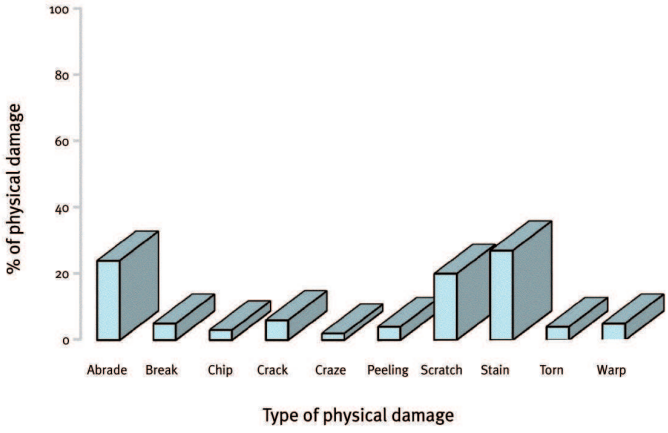


Figure 3. Types of physical damage observed in objects surveyed at Victoria & Albert Museum

etc.). The materials involved range from the semi-synthetic cellulose nitrate through phenol formaldehyde resins to contemporary plastics including recycled. No instrumental analysis was undertaken and identification of the particular plastics was based on documentation or visual examination. As many of the objects were large at least two people were required to undertake the survey.

Approximately 200 objects were surveyed. The objects were examined carefully and several photographs taken of each. The results were input electronically to a generic File Maker Pro survey database and described elsewhere in this book (modified to reflect each participating partners requirements). The main categories of data collected were:

- Descriptive of object
- Descriptive of storage
- Descriptive of damage
- Assessment of condition

The condition grades employed were as follows:

1. Good condition: the object is in good condition and stable. There may be minor physical damage such as staining or surface dirt but there is no chemical damage.

2. Fair: the object is in reasonable condition and is stable. There may be minor physical damage such as slight yellowing or discolouration may be evident.

3. Poor condition and there may be signs of physical damage. More serious chemical damage such as brittleness, blooming or sweating may also be evident.

4. Unacceptable, the object is in very poor condition and may also be chemically unstable. There may be a combination or major chemical damage.

Of the total number of objects surveyed the following condition grades were assigned:

- Condition grade 1 = 57%
- Condition grade 2 = 28%
- Condition grade 3 = 12%
- Condition grade 4 = 3%

The Figures 1 to 5 illustrate the results of the survey as descriptive of condition grade and different types of damage.

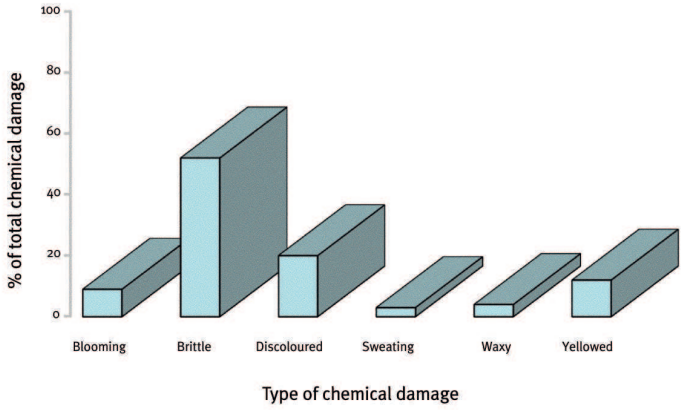


Figure 4. Types of chemical damage observed in objects surveyed at Victoria & Albert Museum

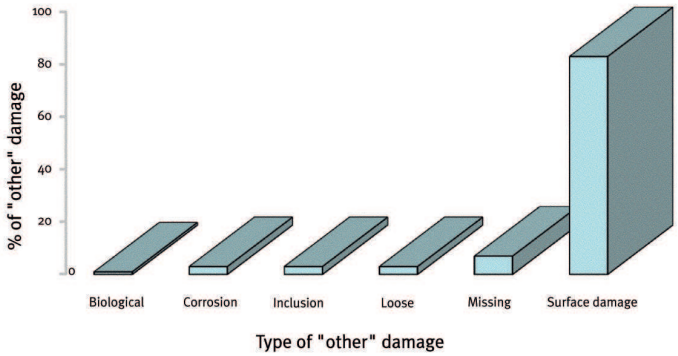


Figure 5. Types of "other" damage observed in objects surveyed at Victoria & Albert Museum

Figure 6. Pages 1, 2 and 3 of survey form used at Victoria & Albert Museum

Figure 6 shows an example of the used form.

The survey at the V&A has encompassed materials from the early 20th century such as cellulose nitrate boxes and phenol formaldehyde resin radios, to furniture made from recycled plastic packaging. Examples are shown below (Figures 7 to 10).

Although most of the objects surveyed are in good condition, there are some instances of damage which occur in more than one object. Crazing and delamination of polyurethane *faux leather* is one such problem.

Surface stickiness and darkening of plasticised PVC is also a problem as indicated by the changes in the Blow chair (Figure 11).

7.

8.

9.

Figure 7. Videosphere television made from acrylic (© Victoria and Albert Museum, London)
Figure 8. Vanity box made from cellulose nitrate (© Victoria and Albert Museum, London)
Figure 9. Radio made from cast phenolic resin (© Victoria and Albert Museum, London)

Figure 10. Chair made from recycled plastic packaging, Bär + Knell (© Victoria and Albert Museum, London)

Figure 11. Blow chair exhibiting stickiness and darkening (© Victoria and Albert Museum, London)

2.1.2. Survey at the Stedelijk Museum in Amsterdam

The Stedelijk Museum in Amsterdam (SMA) was founded in 1895, the same year as the first Biennale in Venice. Ever since the opening, the museum collected contemporary art paintings. In 1943, an Applied Arts Museum was founded which merged with the Stedelijk Museum. From that moment onwards and moreover after the Second World War, the Stedelijk Museum was collecting modern and contemporary works of art and applied arts and design. The museum consists of a huge collection and amongst them many objects made with plastics. The Stedelijk Museum is one of the modern and contemporary art museums that started collecting modern art works already in the forties, fifties and sixties of the 20th century and therefore now has many so called "icons" in its collection. Those icons are described and researched intensively, and this is obviously a huge advantage. The disadvantage is that popular "icons" are on loan more often that other works of art. Their service life is more intense end therefore they might have a shorter life span.

In 1995, then entitled ICN (now called RCE) carried out a survey into problems with plastics used in and for modern and contemporary works of art in the Stedelijk Museum in Amsterdam (Schleedoorn and van Oosten 1995). The outcome of this survey was presented to the conservation community through presentations at conferences all over the world. In Figures 12 to 14 the results are given.

Instead of performing a survey into problems with plastics in a museum collection, it seemed a good idea to revisit the collection of the Stedelijk Museum in Amsterdam and to redo the survey in order to establish the condition state of the works of art after fifteen years. In 1995, the museum collection was housed at four different locations with various climate conditions. In 2010 the whole collection was transported from the four locations to one, adapted to the latest requirements, storage location. All objects of the Stedelijk Museum Amsterdam are now stored together in one new well climate controlled building (temperature 20°C +/- 1.5°C and 50% +/- 5% rh in any 24 hours, ventilation is 5 $m^3.m^{-2}.hour^{-1}$, with a maximum velocity of 0.1 $m.s^{-1}$). All air is pre-filtered.

The survey in 1995 included 62 works of art and the plastics used for or in the works were described on the inventory cards of the museum. In Figures 12, 13 and 14 the various plastics and their amounts in objects are given. In some cases only the word unknown plastic or unknown rubber was used.

Plastic	Amount of objects	Condition good	Condition fair	Condition poor
Acrylic	1	1		
Formica	1	1		
PA	2	1		1
PMMA	20	2	8	1
Polyester resin (GRP)	11	2	4	
PS	3	3		
PUR	5		1	
PVAc	1			
PVC	3	1	1	
Silicone rubber	1			
Unknown plastic	18	4	5	
Unknown rubber	7	1	1	2

Figure 12. Various plastics and amounts at RCE: survey 1995

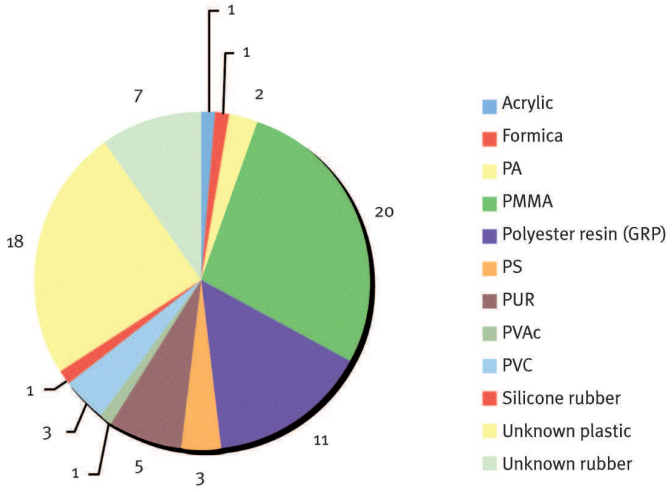


Figure 13. Outcome of condition of plastics at RCE: survey 1995

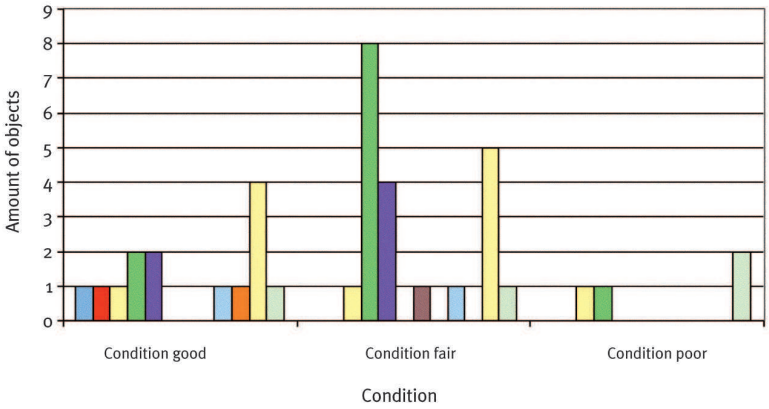


Figure 14. Condition of plastics at RCE: survey 1995

Therefore, the survey in 2010 (fifteen years after the 1995 survey) included also the identification of plastics used. Scientific examination using the portable FTIR (Smith detection identifier) was performed when necessary and possible. In some cases the nature of pristine surfaces means that sampling for analysis is not possible; therefore analytical examination of these artworks was not undertaken.

Not all of the 62 works of art of the 1995 survey could be examined; some objects were on loan and some of the objects were painted sculptures and/or paintings and they were inventoried in 1995 as plastic. During the 2010 survey therefore the paintings and objects that contained no plastics were excluded from the survey.

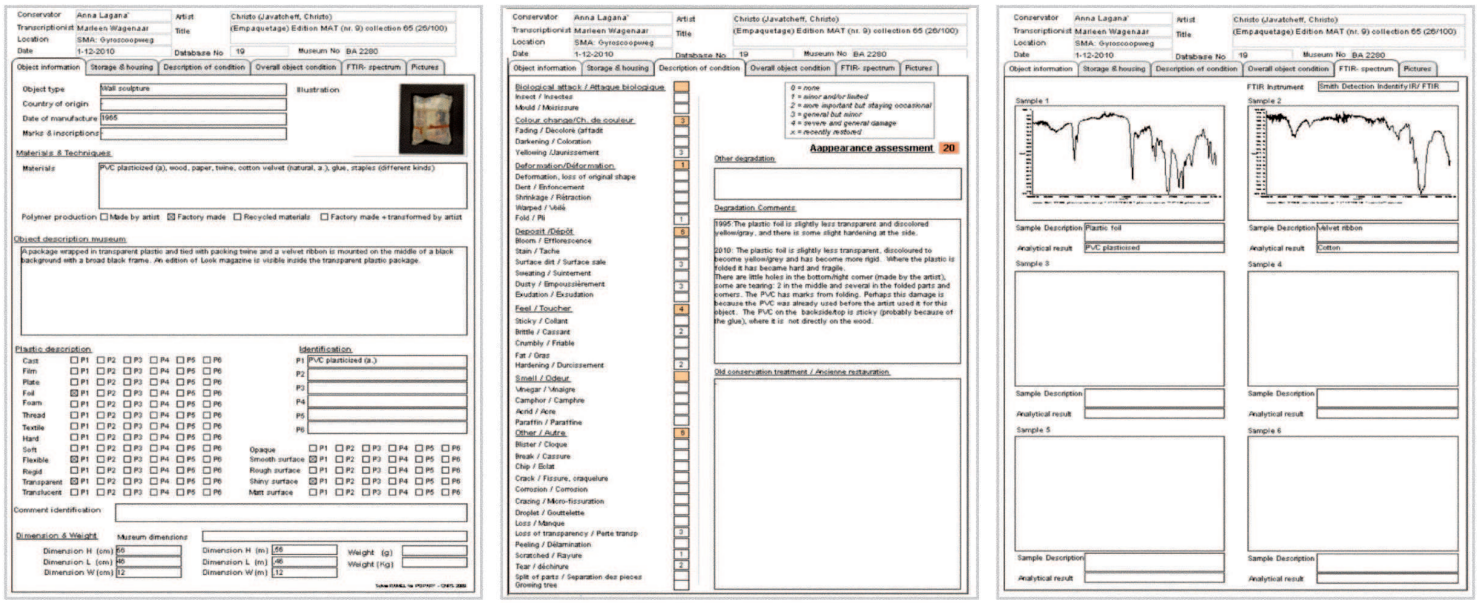


Figure 15. Example of the survey form used at RCE

Finally, 40 works of art were examined, photographed, sampled (when possible and necessary) and identified. All data from the 1995 and the 2010 surveys were filled in the File Maker Pro Survey database developed for this purpose. The database was modified to the need of RCE's requirements. New records to store analytical results and photos were designed by RCE and included in the survey database (Figure 15). The main categories of data collected were:

- Object information
- Storage and housing
- Description of condition
- Overall object condition
- FTIR analysis

The condition grades employed were as follows:

1. Good condition: the object is in good condition and stable. There may be minor physical damage such as staining or surface dirt but there is no chemical damage.

2. Fair: the object is in reasonable condition and is stable. There may be minor physical damage such as slight yellowing or discoloration may be evident.

3. Poor condition and there may be signs of physical damage. More serious chemical damage such as brittleness, blooming or sweating may also be evident.

4. Unacceptable, the object is in very poor condition and may also be chemically unstable.

Changes of the condition of the objects (damage phenomena) were recorded on the basis of a point system of damage. This point system was applied on the following topics: biological attack, colour change, deformation, deposit, feel, smell and other.

- 0= no damage
- 1= minor and limited damage
- 2= more important but staying occasional damage
- 3= general but minor damage
- 4= severe and general damage
- X= recently restored

To compare the results of the condition of the plastic works of art in 1995 with the condition of the plastics of the same works of art in 2010 easier, all data concerning the condition were filled in a Microsoft Excel spreadsheet file.

The final result, which is the change in condition of the surveyed objects after fifteen years of museum life, is represented in Figures 16 to 18. It has to be remarked that works of art can contain more than one type of plastic.

Of the objects surveyed in 2010, it can be concluded that;

- 21 remained in the same condition
- 13 objects containing PA, PUR, PVC, PP or natural rubber changed due to chemical and physical degradation while works of art containing either PMMA or PS changed due to mechanical damages and incorrect artist's technique (inappropriate adhesive) into a lesser condition
- 6 works of art (containing either PA or PMMA or both) changed into a better condition due to restoration or replacements

Overall, it can be concluded that in 2010 the condition of plastics in works of art of the Stedelijk Museum is that;

- 35% needs no intervention,
- 45% needs minor intervention meaning that the object is in reasonable condition and is stable but there might be minor physical damage such as slight yellowing or discoloration
- 12.5% needs restoration
- 7.5% is in an unacceptable state

The survey at the Stedelijk Museum in Amsterdam, the Netherlands has comprised plastics early dating from the 1930's until the newer plastics from the 1980's, some examples of which are reported below (Figures 19 to 22).

Plastic	Plastics in objects	Condition good	Condition fair	Condition poor	Condition unacceptable
Acrylic	0				
MF (Formica)	1	1			
PA	3	2	1		
PMMA	18	6	5	5	2
Polyester resin (GRP)	7	2	5		
PE	3	1		2	
PS	3	3			
PUR	3	2	1		
PVAC	2	2			
PVC	3	2	1		
Silicone rubber	1		1		
Not analysed plastics	2		2		
Natural rubber	4		2		2
PET	1	1			
PE elastomer	1	1			
CA (textile)	1		1		
PAN (textile)	1	1			

Figure 16. Plastics in works of art and condition (Stedelijk Museum, survey 2010)

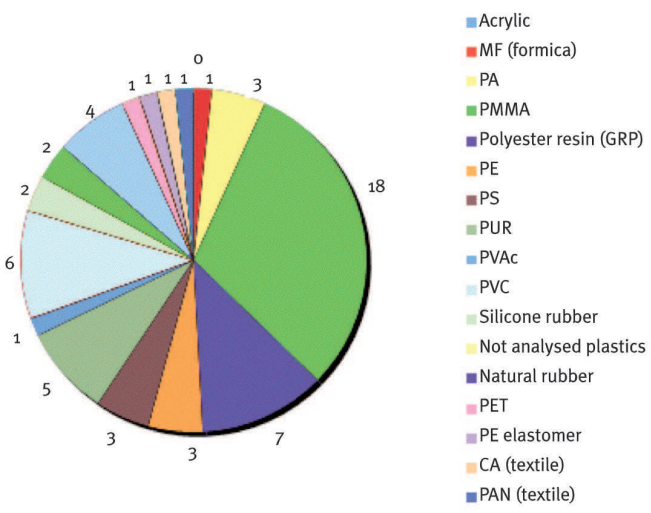


Figure 17. Various plastics and amounts (Stedelijk Museum, survey 2010)

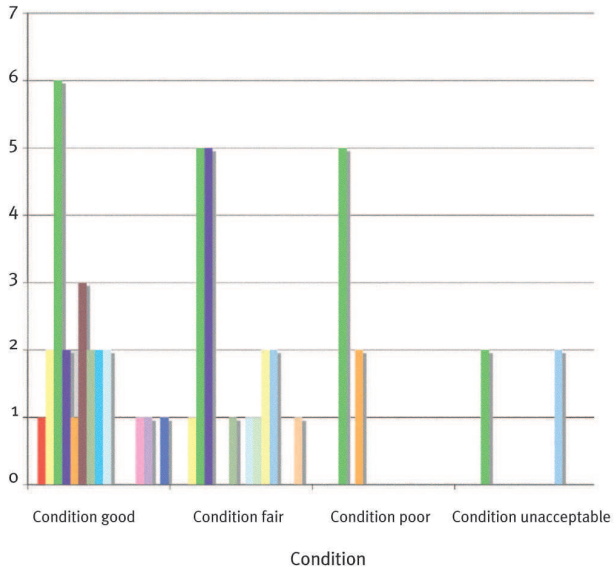
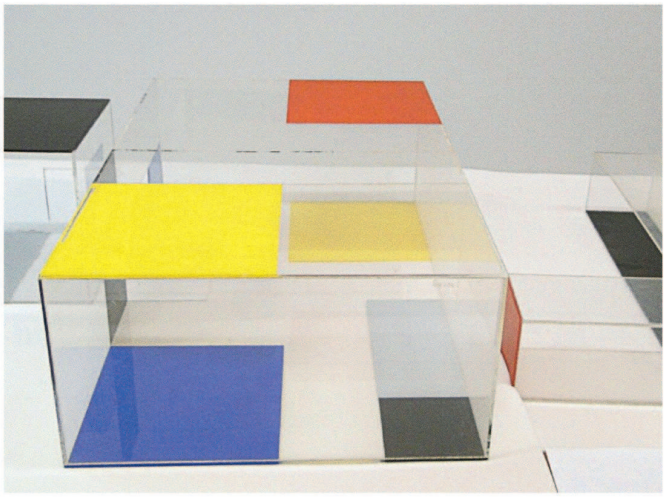


Figure 18. Condition of plastics (Stedelijk Museum, survey of 2010)



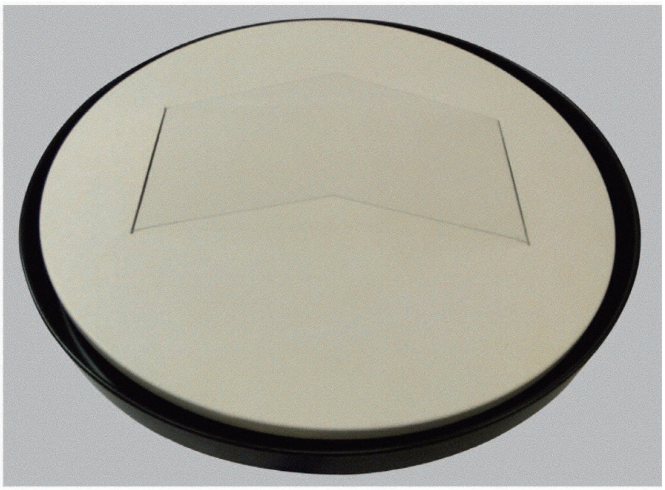


Figure 19. Josef Ongenae, "Ruimtelijk coloriet" , paint on PMMA transparent sheets, 1956 (© Collectie Stedelijk Museum Amsterdam, photo Anna Laganà)

Figure 20. Gabriele de Vecchi, "Deformazione assonometrica MAT" made from metal and polystyrene n.a. (n.a.= not analysed: in some cases, the nature of pristine surfaces means that sampling for analysis is not possible), 1966 (© Collectie Stedelijk Museum Amsterdam, photo Anna Laganà)

Figure 21. Nikki de Saint Phalle, "Tête blanche", Alkyd paint and GRP n.a., 1970 (© Collectie Stedelijk Museum Amsterdam, photo Anna Laganà)

Figure 22. Christo, "Wrapped Magazines" made from plasticised PVC, paper, velvet (cotton), rope, wood, 1965 (© Collectie Stedelijk Museum, Amsterdam, photo Anna Laganà)

Figure 23. Photo shoot on artefacts for the collection survey database, Museum Galliera, Paris (© C2RMF, photo Thomas Clot)

2.1.3. Survey at the MAMAC (Nice), the musée d'Art moderne (St-Etienne) and the musée Galliera (Paris)

Surveys have been carried out between 2009 and 2010 in three French public museums, owning a large range of plastics from the late 19th century to the year 2000 and covering various fields of cultural heritage. It is noticeable that all the museums enthusiastically accepted the request for access to their collections. All the curatorial staff were deeply aware of plastic conservation issues, but the lack of technical background and dedicated tools for documenting and monitoring plastic made objects hampers the development of an effective preservation and conservation policy for this material.

Like most French museums indeed, the musée d'Art moderne et d'art contemporain de Nice, the musée d'Art moderne de Saint-Etienne have no conservation scientist nor conservator in their permanent teams to facilitate collection management. The musée

de la Mode et du textile de la Ville de Paris employs several textile conservators to deal with the wide costume collection but has not specialist training or working with plastics. As a result, the identification of objects containing plastics through the use of existing museums databases is open to doubt when the entry is not supported and corroborated by prior chemical analysis.

Surveys have been undertaken without any sophisticated equipment, in order to work in museums everyday conditions and to assess limits and reliability of the objects mass identification and condition reporting without scientific equipment. Plastics hidden by other materials or by paint layers were not or hardly accessible, it is why the final count of some plastics may be under estimated in the final results. Another outcome is that plastic identification has been made at a general level only, by trying to identify the polymer family each plastic belongs to. Lastly, evidence of chemical degradation processes that do not cause visible or perceptible damage have not been detected and could not be taken in account in the final results.

Nonetheless, some micro-samples has been undertaken on selected objects, either when plastic identification was unsure by naked eye observation only or when degradation products visible on the surface require further analyses. Thanks to CRCC, a few environmental analyses have also been performed with SPME-GCMS in order to measure volatile organic compounds (VOCs) inside some wrappings and storerooms.

More than 230 objects have been examined in the museums storerooms by both conservators and scientists; the condition reports were completed in a dedicated database designed from the survey form. The overall result presents a snapshot of plastics distribution and condition inside the surveyed collections. In contrast, plastics condition or degradation monitoring has been hardly possible because museums files we referred to when preparing surveys, have little technical data on their plastic artefacts and often lack reference documentation like condition report to trace objects history and assess possible history. Significantly few documented conservation treatments have been noticed on the whole selection, except some limited water based cleaning which can be interpreted as a sign of caution or a sign of impotence or both.

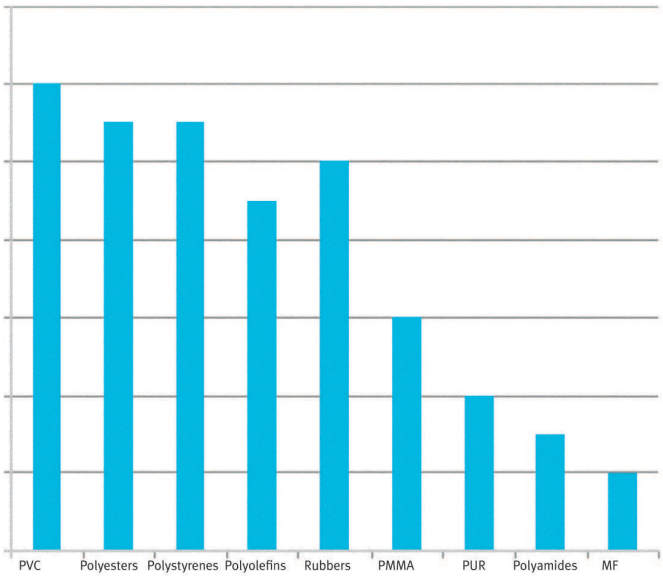


Figure 24. MAMAC Nice: identification of plastics

Musée d'Art moderne et d'art contemporain (MAMAC)

The MAMAC belongs to the *Ville de Nice* and was inaugurated in 1990. It presents significant collections of contemporary art, focusing on relationships between American Pop Art and French *Nouveau Réalisme* whose artists, like Yves Klein, Niki de Saint Phalle, Arman or Martial Raysse have been living and working around Nice during the 1960's. It is also interested in French and Italian contemporary art (http://www.mamac-nice.org/).

The collection comprises more than 1000 pieces and around 280 sculptures, installations or three dimensional objects of all types, which were firstly identified out by searching all terms related to plastics in museum notices accessible from "videomuseum", the French national database for modern and contemporary art (http://www.videomuseum.fr/spip.php?page=sommaireEn). The 100 objects matching the query have been pre-selected and surveys were performed on 54 pieces, according to works accessibility and time available for examinations. This large sampling gives a rather fair picture of the plastics collection state.

Like many other contemporary art museums, including the MAM St-Etienne presented herein, the rapid expansion of the collection causes general storage concerns that are not sympathetic to the implementation of prevention conservation plans. The MAMAC has neither specific packing policy nor storeroom dedicated to plastics. Anyway, it could be considered as a rather academic solution for the numerous mixed media where plastics are mixed with many other materials. Works made of/with plastics are spread over the different on site storerooms, depending on type and size. Small objects are kept unwrapped on shelves; flat pieces like reliefs are hung on racks while larger size pieces are stored in crates.

All types of plastics, available as commodities since the 1960's, have been found in the collection, with – in order of importance – plasticised poly(vinyl chloride) (PVC), used as sheets or moulded objects, polyesters casts, polyolefins polyethylene and polypropylene and polystyrene (PS) in the form of objects and plates, PMMA plates, and polyurethane foams and leather fakes (Figure 24).

However, the collection presents very specific issues linked to the large amount of "mixed media" and to the practices of artists who often used makeshift techniques in the making of some huge and complex assemblages, by gathering and mixing up all types of rubbish and used objects, as poetic records of everyday life. Taking exhaustive inventories with mapping of the making up objects in a detailed condition report is thus a methodological challenge that

Object overall condition	Plastic-made works overall condition		Plastic condition	
Good	11	20%	6	11%
Fair	23	43%	29	54%
Poor	18	33%	15	28%
Severe	2	4%	4	7%
total	54	100%	54	100%

Figure 25. Condition of plastics and objects at MAMAC

few permanent curatorial teams can undertake and which oversteps the mere plastics conservation issues (Barabant *et al.* 2003). Only easily visible and accessible plastics elements have been examined during the survey. It is noticeable that plastics found in these types of assemblages are the least and worse identified in museum files, and that available data (when existing) are often heterogeneous by confusing identification of materials and objects description, such as "bottle" or "head of mannequin". As a result, the proportion of unidentified plastics during the MAMAC survey is large.

In the same manner, obvious damage observed on these waste objects, like dirt, breaks or losses look misleading and are not to be considered always as artworks damage. As an ethical issue, some of them might be "original" degradation that do not necessarily need conservation treatments, even if the difference cannot be told clearly without relevant illustrated background information. The technical point is to detect any evidence of chemical degradation, to assess mechanical risks or to deem works which are to far removed from artist's original creation that would justify an active conservation treatment.

An important difference hence is to be made between a plastic object obvious condition and degradation within the meaning of any unacceptable or dangerous change since the creation, and condition of work as a whole.

Results of the MAMAC survey point out these differences, though general results hide more contrasted case studies. They generally showed a rather important degradation average for this category of objects (Figure 25).

Musée d'Art moderne de Saint-Etienne Métropole (MAM)

The musée d'Art moderne de Saint-Etienne is one the greatest and most significant French collection of modern and contemporary art outside Paris. The museum has been inaugurated in 1987 and belongs to the *Ville de Saint-Etienne*. It highlights artistic movements during the late 1960's and 1970's in France, with *Nouveau Réalisme*, *Support-Surface*, and *Figuration narrative*, and in the US, with some

MAM Collection	All kinds	Made of/with plastics	Plastic amount	Objects surveyed	Percentage
all "objects"	2188	665	30%	75	11%
furniture & design	1010	471	47%	48	10%
Art works	1178	194	18%	27	14%

* according to museum database (2008)

Figure 26. MAM St-Etienne : global data on the collection

important pieces of *Pop* and *Minimalist Art* (http://www.mam-st-etienne.fr/index.php?rubrique=65).

The museum has also built up an important section of contemporary furniture and design, which can be explained by the settlement of some national leading industries and mail order business plants in and around St-Etienne, up to the 1990's. Some of these pieces are also present in the Victoria & Albert Museum collection.

The museum owns more than 13,000 pieces in all, of which 2200 are listed as sculptures, installations, pieces of furniture or industrial design. Among them, 665 have been selected by searching all terms related to plastics with the same resources and procedure described for MAMAC survey. Surveys were conducted on more than ten percent of the "plastics" collections, according to objects accessibility and time available for examinations (Figure 26).

No specific storerooms or packing policy for plastic made objects have been yet planned by museum staff. Collections are split into the museum on site storerooms, mostly for small or flat works of art, and an offsite building where design and furniture are ordered on wooden or metallic shelves. Few plastic pieces are wrapped or packaged, except some most large works of art, which are generally kept and wedged in crates.

The collection contains all kinds of plastics since the 1950's, available as commodities or higher performance plastics related to industrial process for furniture manufacturing. The furniture catalogue entries are much more detailed and reliable than information available for art works of plastic. When considering that artworks have a higher value than household furniture pieces, the paradoxical situation may be explained by the high manufacturing numbers of industrial components used for mass production and marketing requires detailed information that is far easier to gather than for artists' unique pieces with non-normalised practices.

Important discrepancies between art collections and design collections are also to be noticed in the distribution of plastics within these types of collection, even if both series of artefacts are dated from the late 1950's to the 2000's. Fibreglass reinforced polyesters largely prevail as structural materials for pieces of furniture and are very little present in art pieces examined. In contrast, most plastics

MAM Saint-Etienne – plastics distribution			
	main material	secondary materials	
polyesters	18	3	21
PVC	10	13	23
PUR	9	6	15
polyolefins	9	3	12
PMMA	8	1	9
polystyrene	7	6	13
MF	3	0	3
rubbers	1	11	12
others	4	2	6
not identified	6	2	8
total	75	47	122

Figure 27. MAM St-Etienne: identification of plastics

	Plastic-made works overall condition		Plastics condition	
good	16	21%	11	15%
fair	38	51%	46	61%
poor	16	21%	15	20%
severe	5	7%	3	4%
total	75		75	100%

Figure 28. Condition of plastics and objects at MAM St-Etienne

found in the latter series are PMMA and polystyrene which are almost absent in the furniture sampling (Figure 27).

The overall objects and plastics condition average is better than in MAMAC. It mostly underlines that plastics condition is determined as much by physical or chemical criteria as by the kind of objects whose part they are (Figure 28).

Musée de la Mode et du textile de la Ville de Paris – Musée Galliera

The *musée de la Mode et du textile* is one of the thirteen museums owned by the city of Paris (*musées de la Ville de Paris*) and one of the most important French collections of applied arts, with all kinds of objects linked to clothing and fashion from early 18th century until now. Collections are exposed at the *Hôtel Galliera*, a small town house which makes extended display of collections hardly possible. Collections are progressively transferred into an off-site building located in *rue Servan*, in the centre of Paris, which comprises storerooms and studios for the permanent staff of curators, registrars and textile conservators (http://www.paris.fr/loisirs/musees-expos/musee-galliera/p5854).

The survey particularly focused on fashion accessories from the end of 19th century, which present a good opportunity for enlarging assessments to other types of pieces and to early plastics. We deliberately rejected synthetic fibre clothes which conservation issues are somehow different and would have required participation of a textile conservator in the team.

Inventory registration is still on-going for these parts of collections which include thousands of small artefacts that are generally poorly documented. At the same time, the museum staff are working on a re-packing long-term task, which involves inside and outside resources for preliminary works of documentation, identification of materials and techniques, condition assessment, etc.

Therefore, the objects selection has been made in the storerooms prior to survey with the help of the curatorial staff. The surveyed sampling includes one hundred fans, combs, brooches, belt buckles, glasses, bags, umbrellas, etc. as a few dolls. It contains seventy-three pieces of the late 19th and first half of the 20th century and 27 contemporary objects. Results are of lower statistical interest for a collection checking than other surveys insofar as it is neither possible to evaluate the proportion and distribution of plastics inside the whole collection nor to take stock of their condition.

Cellulose nitrates and acetates casts obviously predominate as "historic plastics" and constitute the larger part of the sampling material type. They are almost used as ivory, horn or tortoiseshell substitutes, sometimes in association with other elements, mostly copper and iron based metals.

Formaldehyde resins, such as phenol-formaldehydes (Bakelite), casein-formaldehydes, known in France as *Galalithe* ("milk-stone"), melamine and urea-formaldehydes are also well represented.

Though too small to draw any definitive conclusion, the recent plastics sampling is more versatile and includes mainly plasticised PVC used as casts, sheets or coatings, polyolefins, PMMA and polyesters.

As a result, the range of plastics families found in the collection is larger and more scattered than in the other museums (Figure 29).

All accessories are arranged in a vast and dedicated storeroom where they are still often kept in old wrapping materials. Most of the smallest surveyed objects were gathered by type, size and period in old cardboard packs. Natural material accessories and plastic accessories may be mixed up in the same boxes and sound plastics may be in close contact with damaged and off-gassing plastics. Some of them have also been enclosed during the 1980's in individual polyethylene zipped bags which impede ventilation.

Musée Galliera – plastics distribution			
	Main plastic	Secondary materials	Total
CN & CA	60	5	65
PVC	10	0	10
PF & Bakelite	7	2	9
CF	6	5	11
Rubbers	5	0	5
Polyolefins	2	2	4
MF	2	0	2
PMMA	1	1	2
UF	1	1	2
polyesters	0	2	2
PC	0	3	3
PUR	0	2	2
PA	0	1	1
not identified	6	7	13
total	100	31	131

Figure 29. Musée Gallliera, Paris: identification of plastics

	Objects overall condition	
Good	15	15%
Fair	49	49%
Poor	29	29%
Severe	7	7%
total	100	100%

Figure 30. Condition of plastics at musée Galliera

The way of selection may distort the condition results insofar as some damaged objects have been prioritised by museum team and as degradation has been used to discriminate between plastic and natural materials.

Raw degradation data are close to MAMAC results, with an amount of 35% of objects in poor or severe state but they differ in the higher proportion of objects that crumble away and may be considered as destroyed.

Considering that most objects are made of plastics only, difference between objects condition and plastics condition is not significant and is not taken in account in the final results (Figure 31).

General results

The amount of pieces made of/with plastic can be estimated at MAMAC and MAM only. According to the museum databases, it totals about 30% of the whole "objects" collections and the proportion is closely similar in both museums. Though far from sufficient to

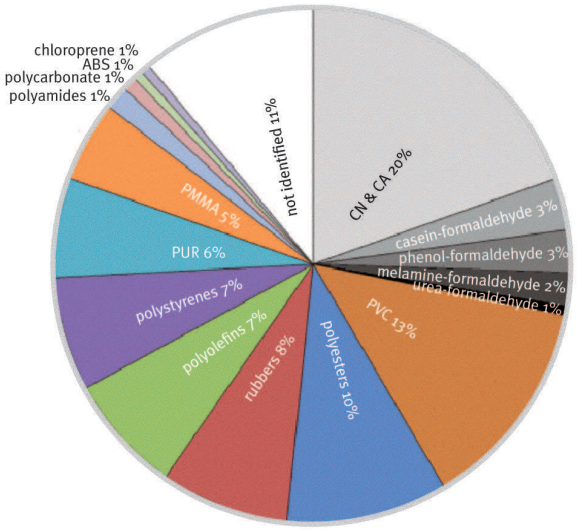


Figure 31. Distribution of plastics (three surveys)

infer any reliable estimation of plastics present in modern and contemporary art collections in general, the statistics gives an order of magnitude that points out that plastic numbers among the most widespread and common material and further inquiries would probably prove that this proportion is still increasing.

Composition and distribution of the overall surveyed sampling

The plot of the overall distribution of plastics ordered by family must be evaluated with the same general precaution (Figure 30).

- The early plastics sampling is mainly composed of fashion accessories made of cellulose nitrate (CN) and acetate (CA) at musée Galliera.
- Formaldehyde based resins like casein-, phenol- and urea-formaldehydes are also present as dominant materials for small and robust objects, like bulks or brooches.
- It appears as plasticised PVCs are the most common and versatile contemporary plastics found in all the surveyed collections. They are present in every type of collections, for all kinds of use and in various forms including sheets, coatings and mouldings. Hard PVCs were also found, but in a significantly lower amount.
- Polyesters of all types take the second rank in importance and distribution. They were found mostly in contemporary furniture collections in the form of fibreglass reinforced plastic (GRP) and as sheets or cast resins in the art collections.
- Polyolefins (polyethylene and polypropylene), polystyrenes (PS), polyurethanes (PURs) and PMMAs have pretty much the same scores. Polyolefins and PS were found in the form of sheets, plates or mouldings, PMMAs as plates only.
- The actual amount of polyurethanes (PURs) has been underestimated, due to the surveying conditions. PUR foams used as upholstery or structural material by contemporary sculptors were not accessible to observation and thus not included in the report.
- The amount of objects made of other plastics is too small for drawing any conclusion. Materials like ABS, polycarbonates and polyamides are not assessable from the survey outcomes and would need better targeted studies.

The ways of identification were actually based by cross-checking direct observation with museum data, historical knowledge on plastics and artists practices. Several observation criteria were used such as the aspect of the material, the object type, the plastic identification codes (SPI) and trademarks present, the compatibility between the date of the work and the date of the plastic onset, and lastly, by assessing degradations which might be characteristic of some plastics, for instance, the smell of vinegar that is are associated with cellulose acetate decay – the well-known "vinegar syndrome".

How far could surveyors identify the plastic they are examining? The experience usually shows that it is barely possible to go beyond the stage of identification by plastic family. Extra scientific analyses (FTIR and Py-GCMS) have been also undertaken when identification was too uncertain by normal means.

After surveys, 11% of the whole plastics set remain unidentified; it includes mostly plastics hidden by paint layers or inaccessible for examination, and also some plastics looking unusual or unfamiliar to surveyors that have not been characterised by analysis.

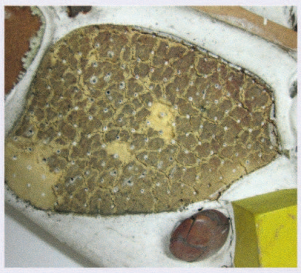
Seventy samples have been taken when possible and studied by the analytical tools applied on the SamCo. Interpretation has been achieved by comparing results with the SamCo and other commercial or institutional databases.

FTIR and Py-GCMS analyses carried out on the selected objects brought a few results that were unexpected by naked eye observation. Some wrong assumption made during the surveys point out the limits of simple observation only for identifying plastics.

Elastomers and some plastics looking like elastomers have been confused during visual examination. Rubbers, silicone, polyurethanes and plasticised PVCs, appeared thus as the most deceptive families of materials, either in the form of cast, foam or textile coating (Figure 32).

A belt buckle made of a perfectly transparent and rigid plastic with a design carved and painted on its back surveyed at musée Galliera presents another interesting example of identification issue due the "improbable" aspect of a material which puzzled the surveyors (Figure 33); no information was available for this object, neither dates of manufacture, nor indication present on the plastic. Three hypotheses have been offered for identification: polystyrene (PS), poly(methyl methacrylate) (PMMA), commonly known under the name of Plexiglas trademark or polycarbonate (PC), but all three plastics seemed at least barely compatible with the seemingly early dating of the object. Analysis by FTIR shows that the buckle is made of polyamide but this result needs further investigations (Figure 33).

Niki de Saint Phalle
Pas fini, 1959-60
(MAMAC 2001.13.4)
"Paint and objects on masonite"
Foam sole
Museum notice: unidentified
Hypothesis: PUR?



results of analysis: natural rubber

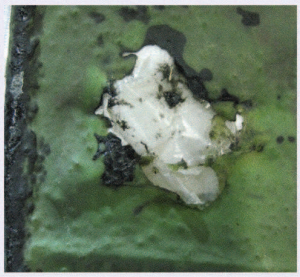
Niki de Saint Phalle
Gant de travail, 1960-61
(MAMAC 2001.13.8)
"Paint, plaster and objects on plywood"
Glove
Museum notice: rubber
Hypothesis: rubber?

results of analysis: PVC

Collective
La valise des nouveaux réalistes, 1973
(MAM 90.11.1)
"Objects in a suitcase"
Leather fake
Museum notice: unidentified
Hypothesis: PVC?

results of analysis: PUR

Gaetano Pesce
Lamp Airport, 1986
(MAM 2008.13.13)
"Urethane and bulbs on a lead base"
Museum notice: PUR
Hypothesis: silicone?



results of analysis: PUR

Figure 32. Examples of identification issues (© LC2RMF, photo Sylvie Ramel; LC2RMF, photo Gilles Barabant; CRCC, photo Agnès Lattuati-Derieux)

As a result, the naked eye observation is not always trustworthy for identifying plastics with an acceptable accuracy and reliability, even when led by trained conservators. Thus, scientific examination is the only way to bring appropriate answers. Because sampling of works materials may be delicate for both technical and ethical reasons, and does not meet the needs for mass-identification in museums, non-invasive portable analytical equipment must be preferred.

Plastic degradation

Observing and rating perceptible damages as objectively as possible is the first step of the diagnostic process but is not sufficient to undertake an identification of the plastic. In fact, perceptible degradations are not always easy to interpret without further research including historical data and analyses to find their root causes. However, it is possible to make a theoretical check list of the most common origins by discerning internal and external factors.

External causes of damage

- Second-hand and functioning objects showing damage originated before acquisition. Some of these alterations may be considered as original or even as genuine features and are thus acceptable to a certain extent but need to be identified, documented and assessed during the acquisition

Figure 33. Buckle (not dated): transparent plastic carved and painted on the back side. Musée Galliera, Paris (© C2RMF, photo Thomas Clot)

procedure. Many cases have been noticed during the three surveys either on furniture, on fashion accessories or on artworks incorporating used objects.

- Collection management and maintenance issues. They include all types of accidents occurring in museum related to inappropriate exhibition or storage conditions. A monitoring procedure is the only way to detect them and to improve measures for prevention.
- Inappropriate restoration treatment. Some evidence has been noted on the oldest pieces in musée Galliera, like undocumented attempts of solvent cleaning which have caused blurry marks, discolouration and changes in gloss.

Internal causes of damage

- Misconception of artefacts: such cases have been mostly observed on artworks. But they also exist with industrial objects, for instance lighting equipment type objects combining lamps and plastics with little resistance to heat and light, or objects combining cellulose acetates or cellulose nitrates with metallic elements that corrode in contact with acidic products emitted by plastics.

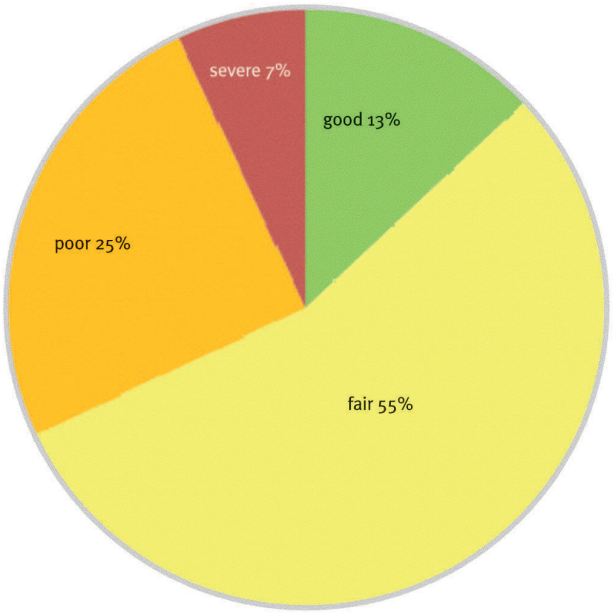


Figure 34. Condition grade of plastics (three surveys)

- Plastics own instability: all types of degradation intrinsic to plastics ageing, including both chemical processes and migration of plasticisers and other compounds.

Perceptible damage observed during surveys is not attributable to one or another cause so easily insofar as the history of objects may not be evident and as different factors often combine. For instance, decays due to a chemical instability may be generated or accelerated by poor exhibition or storage conditions. In contrast, deposits of dust are obviously related to external factors but a sticky surface due to the plastic formulation sweating will make dust particles adhere and accumulate on the surface. At last, some perceptible damages may originate either by internal or external causes. As a result, it has not been always possible to measure the respective part of each group in the surveys achievement at the risk of over-interpreting the results.

The distribution of plastics depending of their condition shows that 68% of materials are in a good or fair perceptible state, while 25% present more significant decay and 7% are severely damaged (Figure 34), four of which being destroyed.

As explained previously, the statistics need some comments to bring understanding to the raw data.

- Only perceptible degradation has been recorded. Chemical degradation processes at the induction step cannot be spotted by current means and are not evaluated in the survey.
- The overall condition was undertaken by assessing the objects state for exhibition and must not be considered as a summarisation of diagnostics or prognoses. Thus, results do not always make the difference between curable damages and decay due to dangerous active degrading processes that will progress.
- Results include all materials considered as plastics by museums, so that the sampling contains a significant amount of rubbers and elastomers, which are not studied by POPART but may be easily confused with some “real” plastics. Rubbers show dramatic degradation rates which amount to 70% and contribute to rise up the overall degradation average.

Classification of plastics by object overall condition average shows that contrast between “malignant” (CN, CA, PVC and PUR) and more stable materials is perceptible but is not so acute as expected. The percentage of polyesters, PMMA, polyolefins and polystyrenes

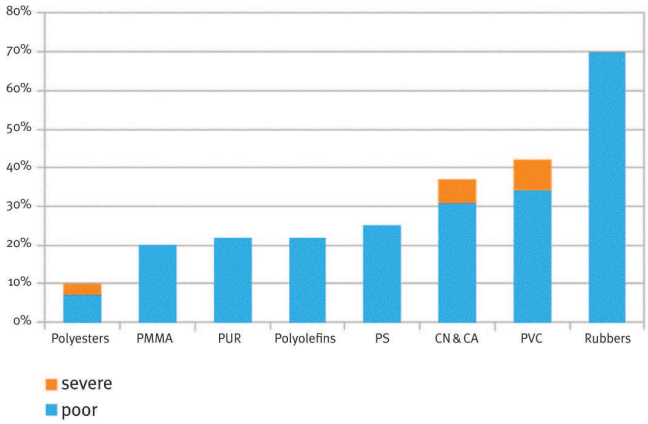


Figure 35. Degradation rate of plastics ("poor" and "severe" conditions only)

artefacts in poor condition represent less than 25%, with none or few objects severely degraded, whereas CA, CN and PVC artefacts it goes up to 40%, including about 10% of severe damaged objects.

The relatively low number of damaged PURs artefacts may be related to the high amount of textile coatings in the sample set which are less sensitive to environmental ageing factors than foams.

The analysis of data by damage category reveals that the type of degradation is more relevant than the damage amount to make the difference more visible (Figure 35).

The Figure 35 sums up the overall distribution of visible degradation, according to the vocabulary used in the survey form. In order to avoid any risk of misinterpretation during examination, visible degradation rated as "minor and/or limited" are not taken in account in the table.

Surface damage includes scratches, dusts and dirt of all types, such as fingerprints or deposits of adhesive tapes. This is the most frequent type of degradation in all the collections and totals more than 30% of the overall sample. Though unambiguously related to mechanical accidents or inappropriate care, they include marks of the objects useful life as well as alterations due to bad storage, exhibition or handling conditions in museum.

Some others may be also obviously related to maintenance problems like chips, stains when resulting of deposits migrated inside the material, or mould traces found on Niki de Saint Phalle's works which were stored for years in a damp shed before to be acquired. These kinds of degradation are not specific to plastics, but may have more serious and permanent consequence in so far as innocuous and effective treatments, when possible, are often still to be assessed.

Yellowing, shrinkage, blister, crazing, bloom, exudation or sweating can be considered as obvious markers of internal decay due to chemical or physical processes. They arise in about a quarter of the degradation total.

Other damage may originate from different causes or by combining internal process with external factors. For instance, breaks, tears or losses, generally caused to mechanical accidents, can also result from a structural weakening of a decaying material. But the causes are not detectable in global statistics and do not make the classification possible in one category or the other.

Other characteristics than visual, such as smell and feel have also been noticed systematically as markers for identification as well as for degradation, but are much more subjective and uneasy to describe with standard terminology. For these reasons, only small number of words made of unambiguous terms has been selected in

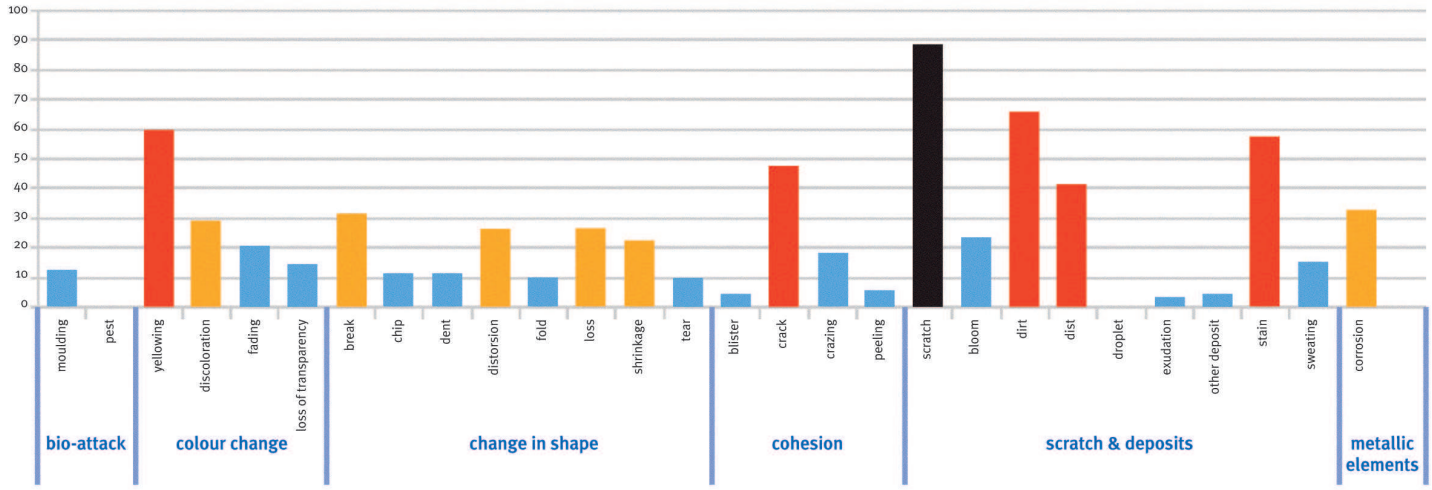


Figure 36. Kind and amount of degradations

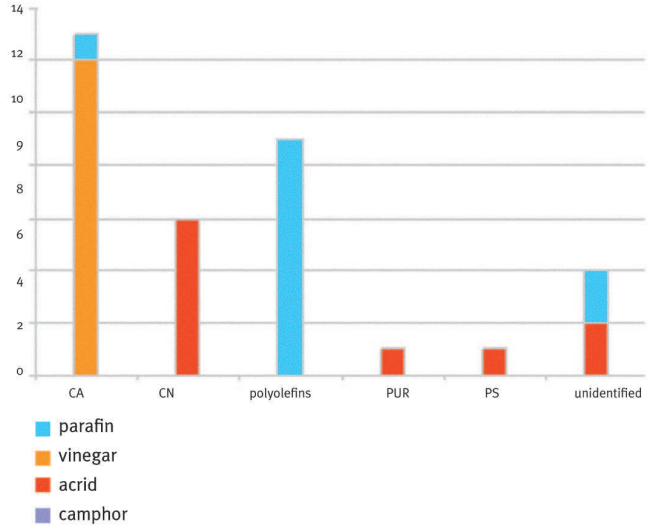


Figure 37. Other markers of damages

the form. Moreover, odour has been detected mostly when objects were kept in closed packing, but became much less perceptible in open environments. At last, unlike visual observation, odour cannot be quantified.

Though depending of the unpredictable experimental conditions during surveys, odour proved to be reliable and useful indicator for identifying some plastics from gas and VOCs (Figure 36) emitted during chemical or physical alteration process. It has been particularly effective in detecting degraded polyolefins from smells of paraffin and unsurprisingly degraded CA from ethanoic acid (acetic acid) odour.

Acrid odour has also been noticed on several degraded material and are generally but not exclusively associated to CN.

Contrary to what one expected, no smell of camphor has been noticed, though camphor, used as plasticiser for early CN, is currently associated (Figure 37).

2.1.4. Conclusion

The condition grading of the objects is dependent on the type and period of collection. For example, the modern art collections in the Netherlands (Stedelijk Museum) and France (MAMAC & St Etienne) have 20-30% objects in “Good” condition, whereas the collection surveyed in the V&A in the United Kingdom has a figure of 57% for “Good” condition. This reflects the type of objects. Artworks are

more likely to be transient and artists more prone to use materials inappropriately than furniture manufacturers.

Surveys of modern art collections in both the Netherlands and France revealed the most common materials used in their collections of contemporary artwork as polyesters and poly(methyl methacrylate) (PMMA). The two French collections of modern artworks also had a significant number of objects made from PVC. The collections at the V&A and musée Galliera in Paris have significant amounts of early semi-synthetic materials and early synthetics (e.g. Bakelite).

The identified materials which degraded most were PVC (France) and polyurethanes (France & UK). All three partners had some degrading materials which were not identified.

RCE in the Netherlands was the only institution which had access to a previous survey with which to compare results and thus show condition change over a period of 15 years. Their survey showed not only objects whose condition had deteriorated (35%) over this period, but also those whose condition had improved due to conservation (15%). The condition of art objects made from PMMA appeared to have benefitted most by conservation. Untreated objects made from PMMA had also deteriorated, with an increase in those categorised as in "poor" condition after 15 years.

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