PLASTICS IN PERIL

Focus on conservation of polymeric materials in cultural heritage

Leibniz Gemeinschaft
Museum für Naturkunde Berlin
Deutsches Museum
Supported using public funding by ARTS COUNCIL ENGLAND
University of Cambridge Museums & Botanic Garden

Plastics in Peril: Focus on conservation of polymeric materials in cultural heritage

Proceedings of a conference held on Zoom
16th–19th November 2020

Edited by Sophie Rowe

First published 2023 by University of Cambridge Museums

University of Cambridge Museums
c/o The Fitzwilliam Museum
Trumpington Street
Cambridge
CB2 1RB
www.museums.cam.ac.uk

Cover illustrations: Gromit suffering ATR: © Sophie Rowe
Deteriorating cellulose nitrate comb: © Christina Elsässer

Typeset in Myriad Pro by RefineCatch Ltd, Bungay, Suffolk.

Introduction

'Plastics in Peril' was originally planned by University of Cambridge Museums as an in-person conference to be held in March 2020 in Cambridge, UK. The global pandemic threw all plans out of the window and we found ourselves stuck at home in lockdown. The future of the meeting was very uncertain when the Leibniz Association of Research Museums in Germany contacted the Cambridge organisers to discuss their own plans for a conference on plastics conservation. In short, we decided to work together to host an online conference blending contributions from both meetings.

This was our first experience hosting an online conference on Zoom, and it surpassed all our hopes for a lively and collaborative gathering. Almost 1000 people registered to attend the meeting, from every continent on earth except Antarctica. The topics covered ranged from managing whole collections of plastic objects to treatment of very specific materials; from working with highly specialised scientific teams to making inventive use of limited resources; and from 'Smart' storage units to 'curating decay'. Videos of all the presentations are available to watch on YouTube here: https://bit.ly/Plastics-in-Peril.

This volume contains the papers selected for the original in-person Cambridge conference, and they reflect many of the themes that came out in the wider joint meeting.

The question of identification is a crucial one on plastics conservation, and not all museums have access to sophisticated analytical techniques to help with this. Van Aubel et al. describe the practical use of their Plastic Identification tool, which enables museums to identify many plastics without these aids, while Hendrickx et al. discuss how this same Tool was used to assess the needs of two Belgian collections.

The specific challenges of plastic in collections must be seen in their wider context, and the scale of the problem can be overwhelming. Cannon et al. have taken a highly strategic and clearsighted approach to this issue and discuss many options for managing difficult decisions about resources and priorities which are already used in different parts of the heritage sector. Sue Warren focusses on whole collection risk assessments and uses case studies from two large scale condition surveys to discuss how different approaches can highlight different information about the conservation needs of plastics in large collections.

A key focus for the meeting was to showcase practical treatments for a range of polymer materials, as this is still very much an emerging field. Costello et al. discuss treatments of polyvinyl chloride and regenerated cellulose sheets; Spring and Flexer reflect on their treatments of polyurethane soles on two iconic pairs of football boots; Mannina and Crowther explored treatments for degrading cellulose acetate mirrors which had to fulfil their original function in private homes; Joy Bloser tested several approaches to deteriorating plastic bags in art, including heat welding and encapsulation, while Sawitzki et al. came up with a combination of treatments for two early robots with multiple different plastic parts. Coughlin describes a promising low-tech method for identifying deteriorating PVC in

collections before it shows visible symptoms of decay. These papers offer plenty of ideas and inspiration for conservators facing similar challenges.

Another theme that emerged in the conference was around surface chemistry, how it can be modified and how gels can be used in cleaning. Costello et al. modified Mylar for one of their treatments, while Morrison and Nel explored gel cleaning of dirty PVC in depth. Their paper discusses their experiments and suggests some very useful approaches to this notorious conservation challenge.

Sometimes nothing can be done to stop the inevitable loss of objects. Gates Sofer et al. and Megan Creamer both discuss the practical long term management of deteriorating plastic artworks in very different contexts, including issues around replication and documentation.

A word about material names: the scientifically correct spelling of polymer names includes brackets (for example '(poly) vinyl chloride'), and this convention is used in scientific papers. However, many polymers are also known by a common name or group of initials (for example 'polyvinyl chloride', or 'PVC'). This volume is aimed at an audience of conservators as well as scientists, so in the spirit of supporting collaboration between them we have chosen to use more everyday terminology for plastic names, to minimise jargon and improve readability of the papers.

Time and time again, during the 'Plastics in Peril' conference and in these papers, the value of collaboration between scientists and conservators is highlighted. It is clear that a cross-disciplinary approach is essential for solving the challenges of plastics in collections, and working together is also highly rewarding and enlightening for all involved.

We hope you will enjoy reading these papers.

Sophie Rowe
March 2023

Acknowledgements

Many thanks are due to everyone involved in organising the 'Plastics in Peril' conference, in particular Marisa Pamplona, Peter Giere, Anna Micheluz, Katja Zelljadt, Simon Kunz, Anne Hering, Marieke Piepenburg, Eileen Westwig, Jenni Müller, Jürgen Müller, Julie Dawson, Kirstie French, Deborah Walton, Jo McPhee, Rich White, Jen Bull and Annie Bacon. We are particularly grateful for generous financial support from the Leibniz Association of Research Museums 'Aktionsplan'.

Grateful thanks are also due to Kirstie French, Jannicke Langfeldt, Fabiana Portoni, Paola Ricciardi, Nigel Strudwick, Will Gaby and Steve Flack for their help with publishing these proceedings, and particularly to all the contributors for their patience and understanding during the somewhat lengthy process of publication.

Contents

Plastification: the Plastic Identification Tool and workshop that helps to identify plastics in your collection

Carien van Aubel, Olivia van Rooijen, Suzan de Groot, Henk van Keulen and Lydia Beerkens

Unstable plastics are becoming a well-known phenomenon in contemporary art and design collections. To catalogue and care for the plastics in a collection, it is essential to know the types of plastic present. Therefore, the Foundation for the Conservation of Contemporary Art (SBMK) and the Cultural Heritage Agency of the Netherlands (RCE), launched Project Plastic in 2017, a project within the Netherlands Institute for Conservation, Art and Science (NICAS). During this project, which lasted two-and-a-half-years, a Plastic Identification Tool was developed along with a workshop that facilitates a learning environment for organisations caring for plastic artworks in their collection. The workshop was initially set up in Dutch, but due to international interest was translated into English.

The practical use of this tool is taught in a two-day workshop where participants learn to identify plastics by seeing, feeling, smelling and listening. A physical toolkit enables them to compare these characteristics. Following the workshop, participants have the opportunity to identify plastics in the collection of their own museum during a collection survey. Furthermore, the Plastic Identification Tool provides guidelines regarding the preventive conservation of the plastics.

The identification and the created awareness of plastics in the collection may lead to improved circumstances that can prolong the lifetime of the plastic objects in the collection. This article will outline the shape of the tool by using examples from the collection surveys performed during the project.

1. Introduction

Plastics are more and more often seen in our daily lives and the advantages and disadvantages are becoming clearer each day. This is creating a broad social debate on whether or not such quantitites of plastics are needed, how they can be used wisely and how it is possible to prevent waste plastics ending up in the environment. Parallel to this discussion, and less well-known, questions are arising in museums with artworks and design objects from the 20th century onwards. All these museums have plastics in their collection and depending on the type and amount, these plastics will deteriorate and this may result in problems, which in the worst-case scenario can lead to total loss of the artwork. Although in recent decades major steps have been made to explore this field, it is still relatively young and much is yet unknown.

What are we dealing with? The very first question that is necessary to improve this process is often difficult to answer. Project Plastics was founded in order to make this first step more accessible to all those responsible for the care of collections. It was a collaboration between the Foundation for the Conservation of Contemporary Art (SBMK) and the Cultural Heritage Agency of the Netherlands (RCE) (https://www.sbmk.nl/nl/projecten/plastics_projects)

Working with ten Dutch modern and contemporary art collections, an online freely accessible Plastic Identification Tool (https://plastic-en.tool.cultureelerfgoed.nl) was developed along with a physical toolkit (Plastic Identification Toolkit) and a workshop, which facilitates a learning environment for organisations that care for plastic artworks in their collection. The purpose of the Plastic Identification Tool is to help employees of museum collections and others involved in identifying what type of plastic they are dealing with. Once there is an insight into the plastic type that is present, they can undertake the next steps and investigate the best way to store and handle the object. In the article 'Project Plastics: Shaping the Plastic Identification Tool' in the post prints of Future Talks 019 (Van Aubel *et al.* 2020), there is a more detailed description of how to use the tool.

During the first year of Project Plastics, the global shape of the identification method was set up. Plastics were divided into four main categories, often easy to distinguish: foams, films, rigids and

elastomers. Plastic samples were gathered to compare characteristics, information regarding all types of plastics was collected and the format of the questions was discussed. In the second year the method was tested and refined during workshop visits to each of the ten participating collections, each planned for two full weeks. The first two days were allocated to the introduction and instruction course, so-called workshop days, where information about plastics was given and the identification method was taught. The following eight days focused on the identification of plastics in objects in the museum and in storage, consequently called the identification days. During the whole project we had access to FTIR analysis, either to investigate plastics with which we were not familiar, or for cases when the results from the identification tool were inconclusive. This paper will give an overview of those visits, useful insights and lessons learned.

2. Workshops and identification days

2.1 RCE Art collection

The first workshop was held at the Art Collection of the Cultural Heritage Agency of the Netherlands (Rijksdienst voor Cultureel Erfgoed (RCE)), which served as a trial. The RCE manages the art collection of the Dutch State and includes both visual and applied art. These objects can be found in museums, public buildings, ministries and Dutch embassies or in the depot in Rijswijk where the workshop was held.

During this workshop it became clear that in order to obtain knowledge during the identification days and ensure they are effective, it is necessary for the participants to follow the first two workshop days and learn the use of the tool. Participants who were not present during the workshop days had difficulty with identifying the different plastics during the identification days. The experts had to repeat the introduction and use of the tool and as a result there was less support for the other participants during the identification of the artworks. Another thing that was learned during this workshop was that the duration of the identification days, from 9am to 5pm in a depot without daylight, was quite exhausting. It was difficult to remain focussed and therefore it was decided to shorten the length of the identification days from 10am to 4pm. In this way the participants had some time to fulfil their other work commitments and still leave enough time and energy for the identification.

Complexities about the use of chemical names, product names and generic names were also discussed during this workshop. The majority of these are now included in the plastic type data sheets in the tool.

2.2 Stedelijk Museum Amsterdam

After the first trial workshop at the RCE Art collection, Stedelijk Museum Amsterdam was next. The Stedelijk Museum Amsterdam holds a collection of modern and contemporary visual art and design. The selected items for identification included the 'made by artist' group.

A considerable amount of the jewellery collection was part of the selection, and these objects were much harder to identify than expected. Due to the small size of these objects and the high-end finish, it was more difficult to identify plastic-specific characteristics. In less delicate, often bigger artworks it may often be possible to distinguish certain characteristics of the finish. Furthermore, due to the high quality of the jewellery, more expensive and less common plastics can be used. This creates more possibilities for the type of plastic present, and fewer visual characteristics that can be distinctive when using the tool, making the jewellery challenging to identify.

It should be borne in mind that the Plastic Identification Tool is a method that helps the user looking in close detail at objects, and identifying the plastics; however, it will not give the right answer in all cases. In some cases, the specific plastic cannot be identified and the possibilities can only be narrowed down. Sometimes certain plastics can be eliminated, sometimes certain groups (e.g. foams) can be eliminated, and sometimes there is still the possibility of three or four different plastics.

The installation *Papst* (2006) by the German artist Isa Genkzen is an excellent example of the large amount and variety of plastic that can be present in one single artwork. In total eight different plastics were identified, one of which had to be

Figure 1 The installation *Papst* (2006) by Isa Genzken investigated by Rebecca Timmermans and Suzan de Groot during the workshop at Stedelijk Museum Amsterdam. © Carien van Aubel.

verified with FTIR analysis, since the outcome with the tool was ambiguous. For example, the different coloured films used in this artwork were made of polyethylene (yellow), polyvinyl chloride (PVC) (blue and orange) and the decoration was made of polyethylene terephthalate (PET) (Figure 1).

2.3 Rabo Art Collection

Next in line was the Rabo Art Collection, the corporate collection of the Dutch Rabobank, which since 2021 has been stored at the Museum Boijmans van Beuningen Depot in Rotterdam. Because they have a close connection with some of the artists whose work they have in their collection, it is often known what techniques were used to make the artworks. However, curators noticed that sometimes the artist does not remember exactly what materials they used, for which the Plastic Identification Tool is very useful.

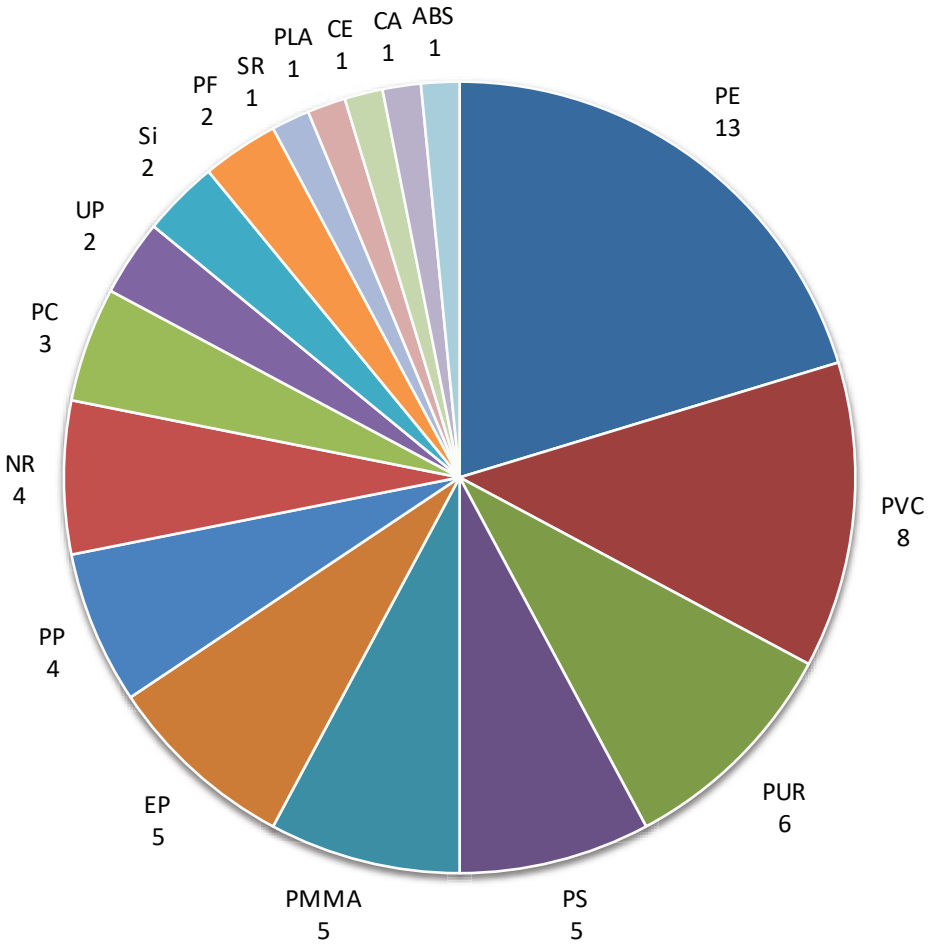
The collection is relatively small and young with plastics that could mainly be traced through the collections management database, using searches for materials description, including information provided by the artist, and/or supplied by the registrar when the work was acquired. This made possible the identification of almost all plastics within the available time, and some previously unknown production techniques were uncovered.

But there were also some challenging objects present, for example, artworks made by the artist and which are covered with a paint layer. Although the options for plastics are already narrowed down when the artist makes the artwork himself, it is difficult to distinguish between the remaining options when it is not possible to directly see and feel the plastic.

Because it was possible to identify all plastics present in the collection, this resulted in an overview of the different types and amounts of plastics present (Graph 1). In other, larger collections, only a selection of objects containing plastic were identified, which therefore gave just an indication of the overall distribution of plastics in the collection. It should be noted that each collection is different, which means ratios found here are not the same as in other collections, but they may still give an indication of the number and variety of plastic materials found in contemporary art collections.

2.4 Kunstmuseum Den Haag

The Kunstmuseum Den Haag is one of the largest modern and contemporary art collections of Europe and holds a collection focussing on fashion, applied and visual arts. The workshop at the Kunstmuseum Den Haag proved that thorough visual examination is perhaps the most important part of the identification workshop, because this may already reveal the type of plastic of which an object is made. The participants in the workshop and survey at each collection developed the ability to look thoroughly at the materials. In The Hague there was a wonderful example of how helpful this can be. The participants had difficulties with the identification of the plastic photo frames of the artwork *Soon (Inside) (Ground Zero)* (2008) by Isa Genzken. At that point they had not noticed that there was a recycling triangle visible with the type of plastic written above. After it was pointed out that they should investigate the reverse of the frames more carefully,



Graph 1 The plastics identified in the Rabo Art Collection.

the participants also noticed the recycling triangle with number 7 and the type of plastic written above, in this case polycarbonate (PC).

The Kunstmuseum collection also showed some 'beautiful' examples of degraded plastics. A spectacle frame showed a very clear sugar effect, a well-known phenomenon for degraded cellulose nitrate (CN), indicating a severe state of degradation (Figure 2.1). The material exhibits a squared crazing pattern that resembles sugar crystals, hence the name. Another example was the crazing pattern of polymethyl methacrylate (PMMA) in a lid of a jar, which was clearly visible since it was a coloured transparent plastic (Figure 2.2). These interesting examples were photographed and are included as visual clarification in the online tool.

Figure 2.1 A cellulose nitrate spectacle frame showing the sugar effect. From the collection of Kunstmuseum Den Haag. © Carien van Aubel.

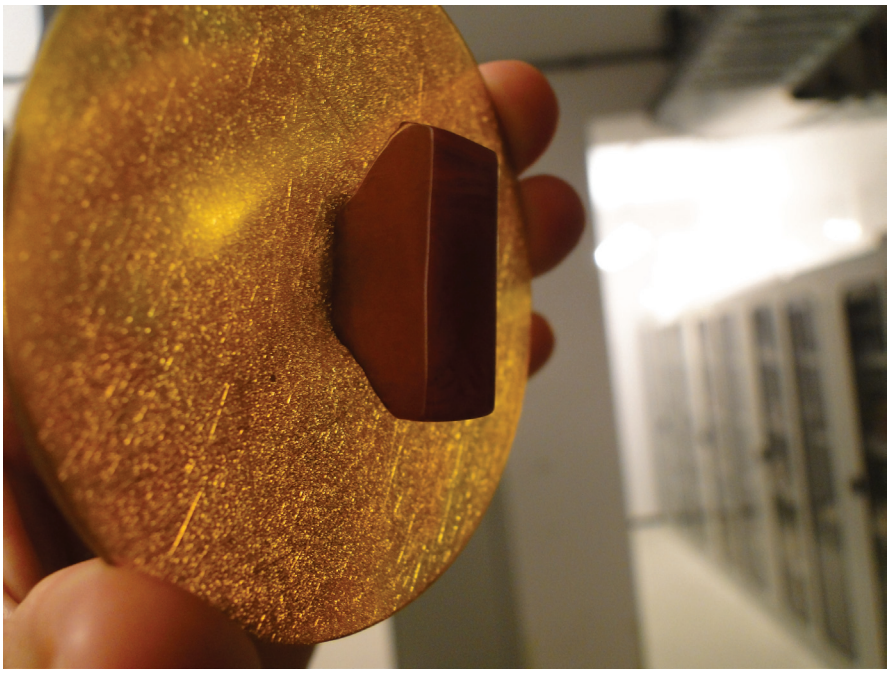


Figure 2.2 The PMMA lid of a jar showing a crazing pattern. From the collection of Kunstmuseum Den Haag. © Olivia van Rooijen.

2.5 Museum Boijmans van Beuningen

The Museum Boijmans van Beuningen in Rotterdam holds a collection of Western art from the Middle Ages until the present. During the survey various plastics could be identified by their distinctive odour. In the Plastic Identification Toolkit, nine different odours in individual jars are provided to help identify a specific polymer. It should be noted it is essential to be very careful when identifying odours. Odours can be overwhelming and therefore the best way of smelling is first wafting the air towards the nose, not inhaling deeply. When the odour is not very profound the object can be smelled more directly. Furthermore, odours can also be difficult to interpret and misleading. The origin of an odour is not always clear, and a less intense odour can cause misinterpretation. At the Museum Boijmans van Beuningen different odours were encountered. There was a polypropylene (PP) tube poured with unsaturated polyester resin. The resin was easily identified due to its odour that is described as styrene. Identifying the odour of a mat, belonging to the work *The Isle of Man* (1995) by Matthew Barney proved more difficult. It appeared to have an unknown, sweet odour and in addition museum employees verified the mat had changed shape over time. It was difficult to get a distinctive answer using the identification tool and the odour could not be attributed to a specific plastic. Due to the change in shape and it being a foamed plastic it was thought to be a synthetic rubber. The changes in appearance, showing the first signs of degradation, made identification a priority, therefore it was decided to analyse the plastic using FTIR Spectroscopy. The FTIR analysis proved the mat is composed of plasticized polyvinyl chloride (PVC), which fits characteristics of the sweet odour and deformation of the material.

This was particularly apposite for another artwork shaped like a nose, *Nose Sculpture Wall Sconce (Wasp II)* (2007) by Jim Shaw. Here a very distinct odour was noticed, and after several attempts it could be identified as polyester resin. When smelling, it is important to realise that the wooden boxes that are often used to store artworks may themselves have an acidic odour and therefore can interfere with other odours.

2.6 SCHUNCK

SCHUNCK in Heerlen covers many art forms such as visual arts, music, dance, literature and architecture. The collection shows parallels to the Rabo Art Collection, having only a small selection of plastic objects in their collection. It was thus also possible to identify all plastics in the collection within three survey days. The opportunity to survey all artworks in the depot meant that more plastics were found, resulting in finding small plastic parts on paintings and in objects where plastics were not expected (Figures 3.1, 3.2 and 3.3). This shows that in order to find all the plastics present in an art collection, it is necessary to search for them, also in works where they are not expected.

One artwork at SCHUNCK, *Photoshoot* (2004) by Thomas Raat, is made of self-adhesive plastic films and tapes. This artwork resulted in a discussion within the project team about tapes. Recognised as complex, due to the multi-layer structure, including adhesive layers, release- and colour coatings, tapes were felt to be too complex to include in the identification tool. However, with so many artworks in modern collections that have packing tape, desktop tape or duct tape, a section of questions on plastic tapes is included under the category of films. As most of these tapes can be immediately related to their function and use in daily life, the general product information of the tapes have served as answers in the identification questions. For example, the plastic carrier of brown packing tape is always made out of transparent polypropylene (PP) or polyvinyl chloride (PVC), with an adhesive layer of natural rubber (NR).

2.7 Kröller-Müller Museum

The Kröller-Müller Museum in Otterlo is known for its Van Gogh collection and outdoor sculpture garden. However, it also has a large number of modern and contemporary art objects that contain plastics. During the first two workshop days at the Kröller-Müller Museum the whole technical staff department was present. This made those days even more informative because people with a variety of backgrounds each have their own knowledge of materials and making processes. Therefore, all participants benefitted from these different views.

Figure 3.1 Pieces of PVC doll heads attached to a painting. From the collection of SCHUNCK, Heerlen. © Carien van Aubel.

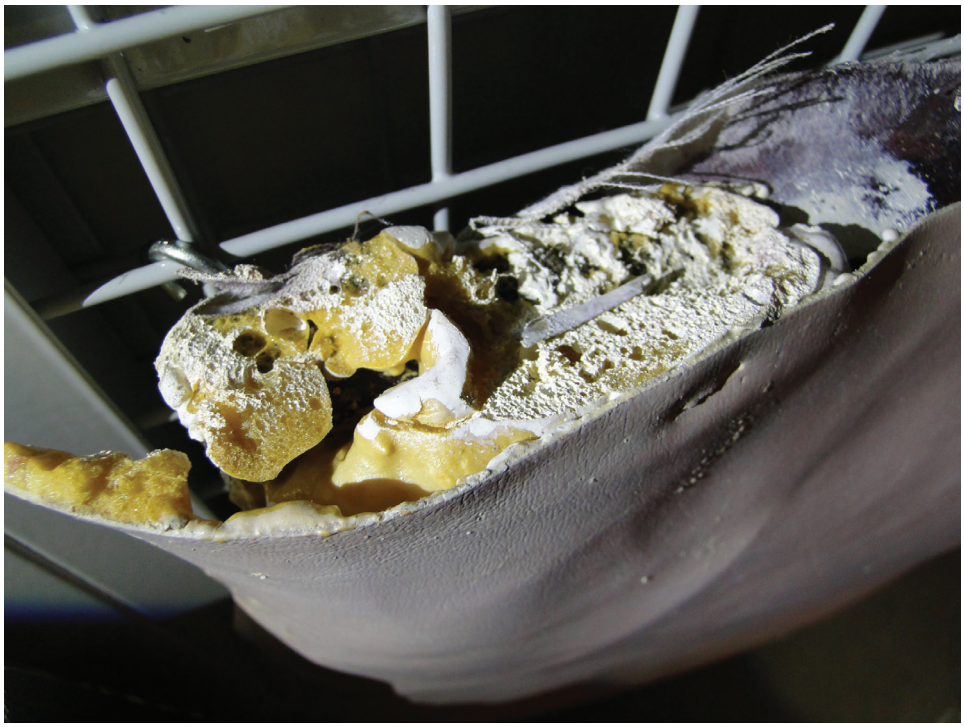


Figure 3.2 PUR foam that is used as a filling material for a painting. From the collection of SCHUNCK, Heerlen. © Carien van Aubel.

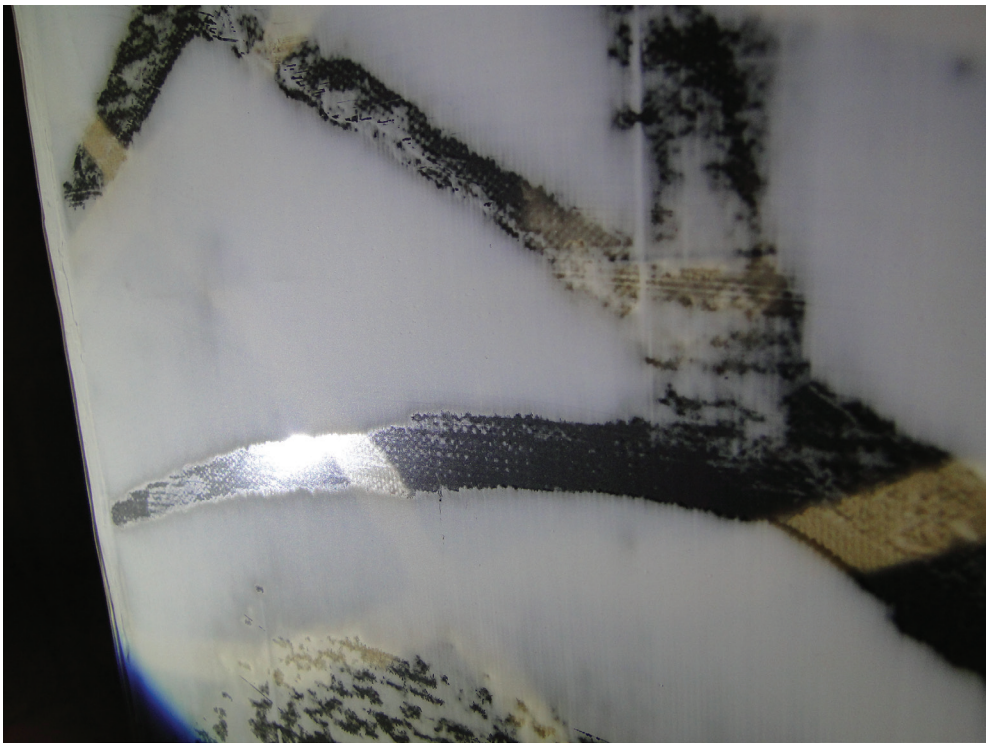


Figure 3.3 PE film used as a canvas on which paint was applied. From the collection of SCHUNCK, Heerlen. © Carien van Aubel.

Another important lesson learned at the Kröller-Müller Museum was that even the specialists could be wrong sometimes. The sculpture *Klik klak, experiment I*, (1976) by Panamarenko resulted in a long discussion. The transparent material used for the wings of the artwork showed a crazing pattern, which is very typical for polymethyl methacrylate (PMMA). When illuminated with UV light, the UV light passed through the material, and was not blocked, another indication that the material used was PMMA. During the project, several objects were analysed with FTIR Spectroscopy to verify the results and use of the tool. This was also the case for this object. A small sample from one of the wings was taken and surprisingly, the FTIR analysis showed that it was not made of PMMA, but polycarbonate (PC). Polycarbonate usually blocks UV light, and as a result some experts found it hard to believe even after the identification by FTIR. Further investigation by Henk van Keulen showed that polycarbonate that does not block UV light has a shorter chain length, (limited by tertiary butylphenol), compared to polycarbonate used in a spectacle lens that does block the UV light. This example resulted in changes in the online tool. Updating and tuning the online tool is an important feature; even after finishing the project, adjustments can be made. For example, plastics that are not yet found in artworks can be added in future. Continuing the organisation of workshops at different collections will help to keep the tool updated.

2.8 Bonnefantenmuseum

The collection of the Bonnefantenmuseum in Maastricht focuses on lesser-known artists who are less visible in art histories but whose work can include hidden gems. One such artwork is *Birnam Wood* (1985) by Tony Cragg, entirely made from tiny pieces of waste plastic (Figure 4). The question is, how to identify such an artwork? It is not possible to track down what the former use of the plastic was, since it was broken into small pieces, and it would be impractical to identify all the different pieces. Given the types of materials that are often used in (disposable) packaging materials, it was expected to find a lot of polyethylene (PE), polypropylene (PP), polystyrene (PS), and perhaps polyethylene terephthalate (PET). It is important to stay alert and reflect on your own knowledge. Look for more information in the data sheets or in other sources; do you perhaps know an answer yourself? When the work was acquired, a bag with spare

Figure 4 *Birnam wood* (1985) by Tony Cragg. From the collection of Bonnefanten, Maastricht. ©Tony Cragg, Birnam wood, 1985, c/o Pictoright Amsterdam 2020.

pieces was supplied in case some losses would occur. Some of those samples were analysed in situ with FTIR Spectroscopy and it appeared that most of them were made of polyvinyl chloride (PVC), also a much-produced material. Then another question arose, namely, even if it were possible, would it be useful to identify each individual piece? Would this information be relevant in deciding how to store a work like this? It was decided that the answer to those questions would most likely be no. It is not possible to physically separate all those plastics, and therefore, when stored, conditions have to be chosen that more or less fit most of the plastic parts. It would be more important to think about issues like loss of colour due to light damage and therefore give advice on light levels for display. The conclusion to be drawn from this case is that sometimes it might be worthwhile to consider whether it is indeed necessary to identify plastics in a certain work, as in some cases it may be impossible to do anything with the information that is derived.

2.9 Centraal Museum

The Centraal Museum in Utrecht is the oldest municipal museum in the Netherlands. The museum holds a varied collection of art, urban history, fashion and applied art. During the workshop in Utrecht there was an example of the urgent necessity for this project. During the survey, a case was opened that contained *Zachte vaas 'Urn'* (1993) by Hella Jongerius. When the work was examined a year before, the staff remembered the vase was in good condition in its case. However, the vase had now completely disintegrated, broken in several pieces (Figure 5). This caused some confusion and disbelief about whether or not it was the same vase. When mentioning this to Suzan de Groot, she explained she encountered the same problem with a similar vase by Jongerius from a private collection (now donated to the RCE) that she investigated with Thea van Oosten. The vase is made of polyurethane ester elastomer (PUR-ester), which is sensitive to hydrolysis and can disintegrate when stored under normal museum conditions. The maker of

Figure 5 *Zachte vaas 'Urn'* by Hella Jongerius, private collection. On the left side is the vase in 'good' condition, and on the right side the same vase as a total loss after storage in normal museum conditions. © Suzan de Groot.

the vases used materials from the fabricator Smooth-On®, who stated that the material only has a shelf life of 6 months. Studio Jongerius knew that the pieces would not be sustainable, and changed to using silicon for their next batches. This first batch of soft vases can therefore be seen as prototypes. But when it is known that an object contains polyurethane ester, measures can be taken. In the case of polyurethane ester, storage with a low humidity level would be ideal. This shows the importance of knowing what type of plastics are in your collection.

Other concerns brought up at the Centraal Museum were problematic plastics with strong odours. The odour of 'Kobus 900' (1968) made by Evert Enno van Gelder was noticeable from everywhere in the depot space. It was not known what caused the odour, but there were concerns that it could affect staff health and safety and/or affect other artworks nearby. Indeed, when entering the depot, it was immediately clear that this work was made of polyester resin, due to its 'styrene' odour. The health and safety issue of this work is an example of a question that arose during the project and will be investigated further during a follow-up project. This project investigates the odours and other volatile organic compounds that plastics are emitting.

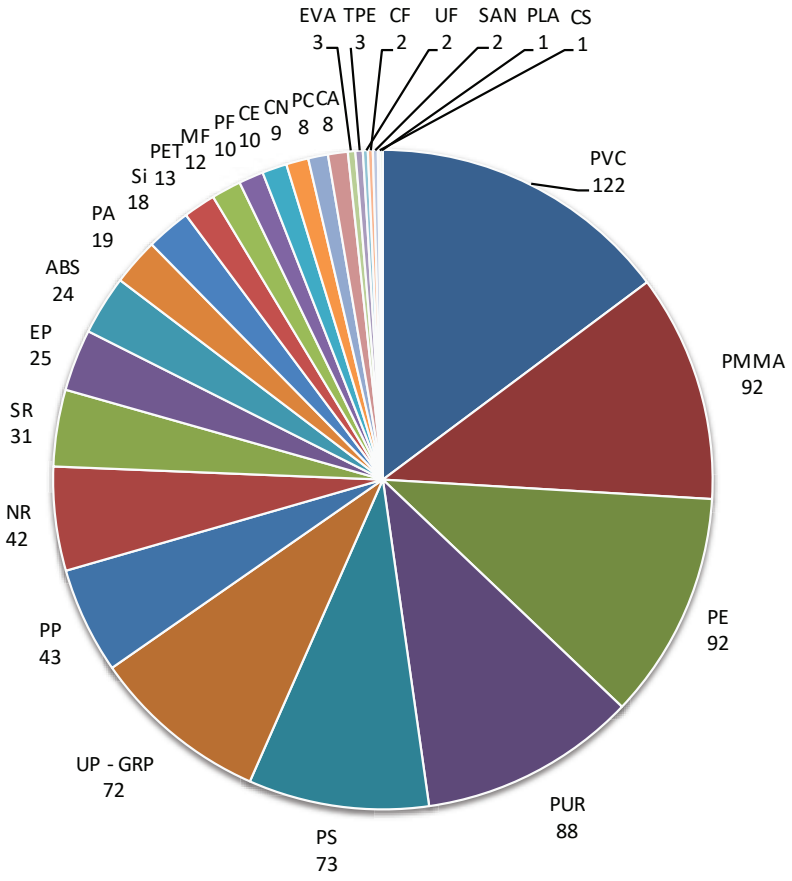
2.10 Van Abbe Museum

Last to be visited was the Van Abbe Museum in Eindhoven, a contemporary art collection focusing on international artists and the relationship between works of art and their surroundings. The collage of Hüseyin Bahri Alptekin, Self-Heterotopia – Catching Up with Self (1991–2007), made the complexity of storage evident. This artwork consists of over one hundred objects that contain metal, wood, plastic and numerous other materials. Certain types of materials can harm others, and for one material it might be better to store it in an anoxic environment, whereas another material might preferably be stored at a higher relative humidity. How to store an artwork like this? The first step is to know what types of materials are present, and for a collage of over hundred objects this is time-consuming. Once the material composition is known, it will be a challenge to decide on what the preferred conditions should be – should the conditions match with most of the plastics or should there be a focus on the most harmful or vulnerable plastic elements? All these factors must be considered and compound the difficulty of conserving an artwork like this. The museum made notes of our recommendations and aims to implement them in future storage modifications.

At the Van Abbe Museum there was an artwork by Marcel Broodthaers (*Téléphone* (1968)) that showed some similarities with another work by the same artist examined at the workshop at the Bonnefantenmuseum. It was thus thought to be interesting to see if the artworks were made of the same material. Results from using the tool were not conclusive and it was decided to perform FTIR analysis *in situ*. It was possible to do this without taking a sample. The material was indeed the same material, namely acrylonitrile styrene acrylate. This case shows that an overview of types of materials often used by particular artists, and which collections hold artworks from these artists, is very useful. Since additional participants from other museums can join the workshops and collections surveys, the knowledge that was shared among the different collections and backgrounds was an additional benefit of the workshops.

3. Results

During the project, plastics in ten different art collections were identified, a total of 825 plastic parts coming from 28 different types of plastic. The types of plastics found were dependent on the type of collection and also on the selected works (often difficult or problematic ones). From all those plastics, polyvinyl chloride (PVC), polymethyl methacrylate (PMMA), polyethylene (PE) and polyurethane (PUR) were found most often (Graph 2). Of course, it remains difficult to draw hard conclusions from this but interestingly PVC, polyethylene and polyurethane can all be present in different forms and are therefore very versatile. PVC can be produced as foam, film, sheet and in other industrial products. It can either be soft when it is plasticised (PVC-P) or hard when it is un-plasticised (PVC-U). Of the 122 plastic parts identified as PVC,



Graph 2 The total amount of plastics and different types found during the ten surveys of Project Plastics. PVC, PUR, NR, CN and CA are plastics that are known to possibly become sensitive.

38 are identified as PVC-P, five as PVC-U, three as a PVC copolymer with polyvinyl acetate (PVC/PVAc), and 76 are not specified further. Polyethylene can appear as foam (both as a hard and softer foam), as film, as sheet and in products made by industry. Polyurethane has even more manifestations, it can occur as foam (hard and soft), elastomer, or sheet produced by industry, but artists can also make it themselves. On top of that it also has different chemical forms; most importantly it can be divided in ester-forms and ether-forms. PMMA is unusual in that it is only found in rigid products. Nevertheless, PMMA is an appealing material for artists to work with, as it has very attractive optical qualities and it is widely available and easily formed.

Since it is important to identify those plastics that need special care, the most sensitive plastics need to be examined. It is known that PVC, polyurethane, natural rubber (NR), cellulose nitrate (CN) and cellulose acetate (CA) can become sensitive. In total 169 plastic types were found which have one of those materials in their composition, and together they make up 20% of the total number of objects identified. This is a significant number. It must of course be recognised that those responsible for the care of collections often selected objects for this project that pose questions or show degradation. It is also not the case that all of that 20% show problems and/or sensitivities, but although it might not be a representative number for the quantity of sensitive plastics present in each collection, it is definitely something that must be taken seriously.

From the workshops in ten quite different collections, lessons were learned, improvements implemented into the Plastic Identification Tool, and the setup of an instructional workshop for this tool was adjusted. Although each workshop was different, with different objects identified by different people, the general impression of the workshops was the same everywhere. All participants indicated that they learned a lot and that the workshop was very useful. Taking the time to look carefully and examine objects properly is in many cases very important and key in determining the identification. Although the identification tool does not always correspond to the right type of plastic, and in some cases it can be very hard to determine the type of plastic without analysis, the tool does always provide the user with a view and a direction. Furthermore, the website gives a good overview of different types of plastics, where they can be found, their history, their characteristics and their preventive conservation.

It was also observed that the result of the identification improved from one identification day to the next. Participants explained that after a few days the mass of plastics with difficult chemical names is reduced to a much clearer image of many types of plastics and their corresponding characteristics. The Plastic Identification Tool works much better in combination with attending a workshop. There are several factors that can influence the outcome, such as the information available for the artwork, the experience of the person doing the identification, the interpretation of several questions, and so on. Therefore, it can be useful to get a 'second opinion' from a colleague and when in doubt ask other staff what their thoughts are.

4. Conclusion

In summary, within Project Plastics ten collections have been visited, and during the workshops and surveys 111 people were trained. 825 plastics were identified of which 178 were verified with FTIR Spectroscopy. Furthermore, during the project seventeen presentations were given, of which eight were national and nine international, including Future Talks in 2017 and 2019 (de Groot et al. 2019; Van Aubel et al. 2020). Even though much is still unknown, Project Plastics and the developed Plastic Identification Tool is a next step in unravelling questions in the field of plastics in art and design collections.

Acknowledgments

This work could not have taken place without help from all the institutions that took part. Thank you to them and particularly to these people: Paulien 't Hoen (SBMK); Agnes Brokerhof (RCE); Tatja Scholte (RCE/SBMK); Thea van Oosten; Aafke Weller (EYE); Eline van der Velde; Arièn Boelens; Petra Dreiskamper.

Biographies

Carien van Aubel completed her postgraduate training in conservation at the University of Amsterdam, specialising in

Modern and Contemporary Art. In 'Project Plastics', a project by the Foundation for the Preservation of Contemporary Art (SBMK) and the Netherlands Institute for Conservation, Art and Science (NICAS), she developed an online identification tool resulting in workshops that enable those who take care of art collections to identify plastics in their collection themselves. Next to her work as a project-based conservator at Tate, she works freelance on a wide range of projects in both the Netherlands and the United Kingdom and has a London-based studio.

info@vanaubelvanrooijen.com

Olivia van Rooijen completed her MSc in Chemistry at the University of Amsterdam. Her final research project resulted in a publication in *Nature Communications*. After finishing her studies she joined Project Plastics, a project coordinated by the SBMK and NICAS, which focused on the identification of plastics in modern and contemporary artworks and design objects. She successfully combined her studies and the project with rowing at the highest international level.

Suzan de Groot studied analytical chemistry at the Hogeschool van Amsterdam and graduated in 1996. Since 1996 she has been employed by the Cultural Heritage Agency of the Netherlands (RCE). She specializes in identification and characterizing the degradation of organic materials using Fourier Transform Infrared Spectroscopy (FTIR) and Raman spectroscopy. Since 2012 the emphasis of her work has been on research into plastics in cultural heritage and in modern and contemporary art objects. Since 2014 she has been project manager of Project: Plastics at the RCE, within which the Plastic Identification Tool was developed. She is an affiliated researcher at the University of Amsterdam where she teaches about plastics in cultural heritage and is involved in projects for master's theses and post master's theses.

Henk van Keulen is a conservation scientist employed by the Cultural Heritage Agency of the Netherlands (RCE) since 1994. He is involved in Gas Chromatography Mass Spectrometry applied for the conservation/restoration research of works of art. He successfully started to use pyrolysis as a sample introduction technique (including thermally assisted hydrolysis and methylation using tetramethylammonium hydroxide (TMAH)) from 1996, and is the initiator for the use of Pyrolysis-GC-MS in conservation research.

He is currently engaged in the analyses of traditional and modern organic materials from different sources, such as paintings, furniture and modern art.

Lydia Beerkens is the Managing Director of SRAL The Conservation Institute, Maastricht, where she also works as Senior Conservator of Modern and Contemporary Art, employed since 1998. She developed specialised training programs in modern art conservation and works on modern paintings and sculptures. As a leading practitioner and researcher in modern art conservation, she publishes internationally on conservation case studies and on decision-making in modern art conservation, and has contributed to various Dutch research projects on modern art. Beerkens earned her PhD at the Radboud University Nijmegen in 2012. She currently combines conservation practice with her research focus on the artist, the artist's studio and on modern artmaking techniques.

References

de Groot, S., van Aubel, C., van Rooijen, O., van Keulen, H., and Beerkens, L. 2019. 'Identification of plastics outside the lab: developments of an identification tree', in: *Future Talks 017: Visions: innovations in technology and conservation of the modern*, ed Bechthold, T., Die Neue Sammlung: Munich.

Van Aubel, C., van Rooijen, O.. de Groot, S., van Keulen, H, and Beerkens, Lydia, 2020. 'Project Plastics: Shaping the Plastic Identification Tool', in: *Future Talks 019: Surfaces: lectures and workshops on technology and conservation of the modern*, ed. Bechtold, T., Die Neue Sammlung: Munich