About PRIMI, Plastics Research and Innovation for Museums and Industry

PRIMI brings together artists, conservation scientists, polymer scientists, industrial partners, and innovation specialists, to spot unknown needs, encourage new ideas, and – by cross-fertilization – uncover and disseminate the huge well of specific knowledge that this diverse group of experts have about plastics.

Much of the focus in the PRIMI project is based on the concept of 'extreme users', an extended definition of the 'lead-user' concept. The artists and designers participating in the project are extreme users, in the sense that they don't follow the manufacturers 'recommended use', product description. Instead they re-invent the way a product is used, either by using the raw plastic material in an unprecedented way, or by taking a plastic product and using it in ways not intended. Data sheets are suddenly non-applicable, as testing data is made irrelevant.

In PRIMI, we see the extreme use of plastics as holding innovative potential: can plastic manufacturers learn from the experimental and intentional use of plastics by artists? This potential is unleashed by applying the knowledge and experience held by the conservator and conservation scientist regarding the effects of real time aging in art and historical objects made of or containing plastics. The conservator and the conservation scientist observe how plastics subjected to extreme usage age and decay over time in museum and private collections. This knowledge is a potential source of new research areas and innovative product development, benefitting the manufacturer as well as the creator.

In this publication, the explorative nature of PRIMI is reflected in a collection of articles by the researchers in the project. Furthermore, a series of original art works and representations have been produced on plastic sheets (the plastic used to produce catheter bags for the medical industry) by designers Christian Flindt and Bodil Jerichau, and artists Claus Carstensen, and Bjørn Poulsen.

The PRIMI project took off in 2010 on the wings of a grant from the Center for Culture and Experience Economy, an experimental joint venture administered by the Ministry of Culture and the Ministry of Business, in Denmark.

Louise Cone, Statens Museum for Kunst (SMK)
Lars Lundbye, Blå Himmel

PRIMI

Plastics Research and Innovation for Museums and Industry

Extreme User Innovation

A research project by artists, industrial plastic developers, polymer scientists, and art conservators, 2011–13.

Designed by Lars Lundbye and Louise Cone

SMK CATS
Centre for Art Technological Studies and Conservation

Book
Editor: Lars Lundbye
Graphic Design: Åse Eg
Translation into English: Louise Cone
Photos: Statens Museum for Kunst-photo front and back cover, page 12, 14, 52, 53, 64-74, Ole Grøndahl Hansen page 5, 8, 9, Yvonne Shashoua page 37, 38
Printing: Narayana Press
Binding: Förlagshuset Nordens Grafiska AB
Print on plastic: Papyro-Tex A/S

Cover: Søren Dahlgaard and Lars Lundbye

ISBN 978-87-92023-23-0

PRIMI
Conceptual Design of PRIMI: Lars Lundbye & Louise Cone

Core members
Bjørn Poulsen, Artist
Bodil Jerichau, Textile Designer
Claus Carstensen, Artist
Christian Flindt, Industrial designer
Jørgen Wadum, Keeper of Conservation and Director of CATS, Statens Museum for Kunst
Karen-Marie Andersen, R&D manager, Papyro-Tex A/S
Lars Lundbye, Innovation consultant, Blå Himmel
Louise Cone, Art Conservator, Statens Museum for Kunst
Ole Grøndahl Hansen, General Manager, PVC Information Council Denmark
Søren Dahlgaard, Artist
Søren Hvilsted, Professor, DTU – Technical University of Denmark, Danish Polymer Center
Yvonne Shashoua, Senior Research Scientist, National Museum of Denmark

Partners
Statens Museum for Kunst
National Museum of Denmark
PVC Information Council Denmark
Plastics Europe
Papyro-Tex A/S
Technical University of Denmark

Sponsor
Center for Cultural and Experience Economy (CKO)
Papyro-Tex A/S

Thanks to the partner companies and organizations for providing creative and logistical support throughout the project.
Also thanks to SolVin–Solvay Plastics, Plasticarium, X-treme Creations, INEOS, Roskilde Festival

The Centre for Art Technological Studies and Conservation (CATS), was made possible by a substantial donation by the Villum Foundation and the Velux Foundation, and is a collaborative venture between Statens Museum for Kunst (SMK), the National Museum of Denmark and the School of Conservation at the Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation.

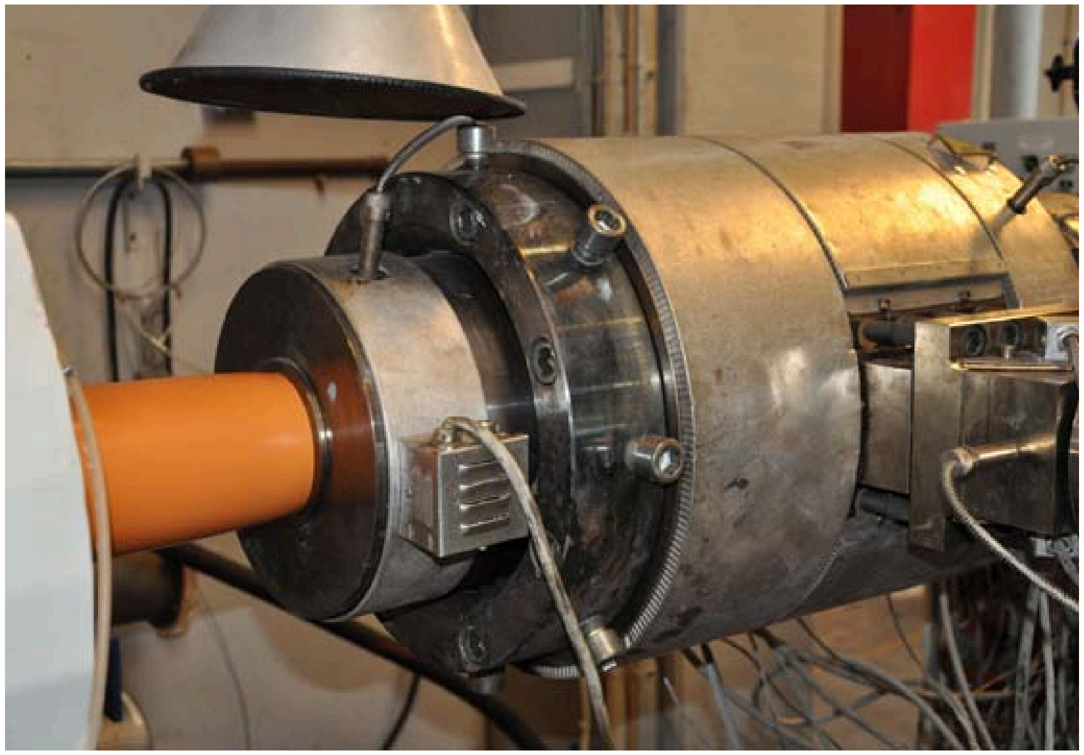
Content

Plastic

Roland Barthes, 12 November 1915-26 March 1980, was an influencial French literary theorist, critic, semiotician and philosopher.

Despite having names of Greek shepherds (Polystyrene, Polyvinyl, Polyethylene), plastic, the products of which have just been gathered in an exhibition, is in essence the stuff of alchemy. At the entrance of the stand, the public waits in a long queue in order to witness the accomplishment of the magical operation par excellence: the transmutation of matter. An ideally-shaped machine, tabulated and oblong (a shape well suited to suggest the secret of an itinerary) effortlessly draws, out of heap of greenish crystals, shiny and fluted dressing-room tidies. At one end, raw, telluric matter, at the other, the finished, human object: and between these two extremes, nothing: nothing but a transit, hardly watched over by an attendant in a cloth cap, half-god, half-robot.

So, more than a substance, plastic is the very idea of its infinite transformation; as its everyday name indicates, it is ubiquity made visible. And it is this, in fact, which makes it a miraculous substance: a miracle is always a sudden transformation of nature. Plastic remains impregnated throughout with this wonder: it is less a thing than the trace of a movement. And as the movement here is almost infinite, transforming the original crystals into a multitude of more and more startling objects, plastic is, all told, a spectacle of its end-products. At the sight of each terminal form (suitcase, brush, car-body, toy, fabric, tube, basin or paper), the mind does not cease from considering the original matter as an enigma. This is because the quick-change artistry of plastic is absolute: it can become buckets as well as jewels. Hence a perpetual amazement, the reverie of man at the sight of the proliferating forms of matter, and the connections he detects between the singular of the origin and the plural of the effects. And this amazement is a pleasurable one, since the scope of the transformations gives man the measure of his power, and since the very itinerary of plastic gives him the euphoria of prestigious free-wheeling through nature. But the price to be paid for this success is that plastic, sublimated as movement, hardly exists as substance. Its reality is a negative one: neither hard nor deep, it must be content with a 'substantial' attribute which is neutral in spite of its utilitarian advantages: resistance, a state which merely means an absence of yielding. In the hierarchy of the major poetic substances, it figures as a disgraced material, lost between the effusiveness of rubber and the flat hardness of metal; it embodies none of the genuine produce of the mineral world: foam, fibres, strata. It is a 'shaped' substance: whatever its final state, plastic keeps a flocculent appearance, something opaque, creamy and curdled, something powerless ever to achieve the triumphant smoothness of Nature. But what best reveals it for what it is is the sound it gives, at one hollow and flat; its noise is its undoing, as are its colours, for it seems capable of retaining only the most chemical-looking ones. Of yellow, red and green, it keeps only the aggressive quality, and uses them as mere names, being able to display only concepts of colour. The fashion for plastic highlights an evolution in the myth of 'imitation' materials. It is well known that their use is historically bourgeois in origin (the first vestimentary postiches date back to the rise of capitalism). But until now imitation materials have always indicated pretension, they belonged to the world of appearance, not to that of actual use; they aimed at reproducing cheaply the rarest substances, diamonds, silk, feathers, furs, silver, all the luxurious brilliance of the world. Plastic has climbed down, it is a household material. It is the first magical substance which consents to be prosaic. But it is precisely because this prosaic character is a triumphant reason for its existence: for the first time, artifice aims at something common, not rare. And as an immediate consequence, the age-old function of nature is modified: it is no longer the Idea, the pure Substance to be regained ot imitated: an artificial Matter, more bountiful than all the natural deposits, is about to replace her, and to determine the very invention of forms. A luxurious objects is still of this earth, it still recalls, albeit in a precious mode, its mineral or animal origin, the natural theme of which it is but one actualization. Plastic is wholly swallowed up in fact of being used: ultimately, objects will be invented for the sole pleasure of using them. The hierarchy of substance is abolished: a single one replaces them all: the whole world can be plasticized, and even life itself since, we are told, they are beginning to make plastic aortas.



Plastic making machine. Photo courtesy of Ole Grøndahl Hansen.

The Paradox Of Plastics

Ole Grøndahl Hansen, Director of the PVC Information Council, DK, argues the case for plastic and describes how the plastic industry clashes with society on environmental issues, raising the industrial consciousness and leading to new innovations.

In the French literary scholar Roland Barthes' famous short essay on plastics from 1957, in his book entitled *Mythologies*, he describes a typical phenomenon of the time, namely the plastic fairs that were being organized throughout the western world. I clearly recall this phenomenon in the early 1960's, where, being the son of a plastics entrepreneur, my parents dragged me, as a 7 year old, to Forum, the setting for trade fairs in Copenhagen at that time. People stood in long lines to see the process of processing plastic or, as Barthes describes it, the "magical operation". Exhaust systems were not used, as is required in plastic production today, and my memory of the smell emitted at these plastics fairs is especially poignant. Even for children, there was something pleasurable about these plastic fairs. We came home with piles of combs, balls, jump ropes and other plastic items, all in a rainbow of different colours.

Plastic fairs of the past could be seen as part of the experience economy of that time. Largely, it was the housewives of the 1960's who stood in line at the plastic processing machines to see the results of the miracles that ensued when the contents of bags filled with small pieces of plastic granules were poured into funnels and heated in a closed mechanical system, which transformed them into all sorts of household utensils. The result could be a washtub, a fork, a bowl or a hose, so the housewife could get back home with a useful souvenir. Yes, Barthes actually goes so far as to call the wonder the visitors were experiencing at the plastic fairs at the time as revelrous. Revelrous, he says, because transformation and change is how man measures his power. Now, these plastic fairs have fundamentally changed. Today, they have little to do with the experience economy. They are purely business-to-business events, and there are no longer either housewives or children in line to experience the magic of plastic production. Plastic industrial production has moved very far away from the consumer who benefits from the products in their everyday lives.

Today, the production of a plastic product is an extremely complex system in which specialized companies operate within a common value set. There are very few who realize that a catheter bag, used daily by millions in hospitals around the globe, is the result of a long chain of specialized business expertise and industrial activity.

A catheter bag is typically made of the plastic material polyvinyl chloride, PVC. First, the raw PVC material, a resin, has to be produced. This takes place at major chemical companies around the world. The starting point for production is salt and oil, which companies process into the resin. However, the resin is not in itself sufficient to produce a plastic product. Just as bread does not consist solely of flour, the resin must be endowed with a variety of additives and undergo several chemical and technical processes before it can move forward in the value chain.

In the so-called compounding companies, the resin is mixed to a compound. In the case of the catheter bag, the resin will be blended with stabilizers to ensure that the raw material can be processed in the machines used in plastics production. Also in the case of the catheter bag, a plasticizer must be added. The plasticizer is a prerequisite for making the bag soft, transparent, and flexible. Plasticizers and stabilizers are also produced at chemical plants. After compounding, the chemical company has performed their part of the process, and the mixture is now ready to move forward to the next process. Typically, the chemical compounding company sells its product to various plastics processing companies. A company may, for example, have specialized in producing the film, later used to make the bag, while other companies specialize in manufacturing the tubing attached to the bag. It is not until the next link in the chain that medical device companies come into the picture. Typically, a medical device company buys tubing from one company, and film from another. Medical device companies manufacture the bag, and attach the tubing, leading to the next step in the chain: the distributor, who ensures that the urine bag gets to the hospitals. As well as that, you have machine manufacturers supplying machines to all parts of the value chain. So before the nurse can attach the catheter bag to the hospital bed and guide the patient's urine from the body to the bag, a long and complex production process, involving many industrial partners, has already taken place.

Although plastic in principle can be categorized into a number of basic types, such as polyethylene, polyvinyl chloride, polypropylene, polystyrene, and a few others, it will actually be more illustrative to say that today there are thousands of different types of plastics, each with their own distinctive composition and characteristics.

The plastics industry is extensive. There are, in Europe, around 50,000 companies, which together employ more than a 1.5 million people. Where the raw material for making plastics is produced in large chemical companies, the processing of the raw material into various plastic products is typically done in small and medium sized enterprises. It is estimated that the European plastics industry has an annual turnover exceeding 280 billion Euros.

Although few people today disagree that plastic products are essential for living the modern life, plastic was, and still is, subject to massive criticism. Extreme reactions to the critique of plastics can be seen in different places in Europe, where there are examples of well-meaning families trying to live a life without plastic! But is it a reasonable effort to live without plastic? Should we all strive for a plastic free life?

I think it is often forgotten to what extent plastics have contributed to modern day life. It is often forgotten that the use of plastic led to a revolution in healthcare, when the multiple use of medical devices made from glass, metal and rubber for single use was replaced by devices made of plastic. The change resulted in a decisive decrease in cross-infection between patients. Or what about the importance of food packaging in plastic? Plastic plays a large role in the extended shelf life of food, a fact that is not always on the consumers mind while at the meat department in the supermarket. The prominence of plastic will typically become apparent when irritation over the amount of plastic in the piles of household garbage becomes visible. What about the use of plastics in construction? Who considers that plastics – besides improving the working environment for construction workers because of their lightweight – provides clean drinking water and diverts our wastewater? Moreover, what about the energy savings found in the transport sector, after plastics were introduced? Cars, planes, and trains are made considerably lighter through the use of plastics. What about the importance of

The production of raw plastic material is done by huge global chemical companies. INEOS' plant is based in Sweden's petrochemical center in Stenungsund north of Göteborg. Photo: Ole Grøndahl Hansen.

plastic windows that do not require the maintenance a wooden window does? No, it is the negative aspects of the use of plastics, which dominate the media. The negative aspects of the use of plastics are sometimes justified, sometimes absolutely not. However, when they are justified, they can work to positively influence significant environmental improvements.

The story about PVC is a good example of how fierce criticism of a plastic material has led to change, prompting a large industrial sector to take significant steps towards sustainability. PVC-evolution is also interesting from a Danish perspective, as Denmark was influential in directing focus onto the negative aspects of PVC. Denmark was the prime mover in the EU in terms of getting the plastics industry to put solutions on the agenda.

In the late 1990s, the environmental discussions about PVC were at its peak in Denmark. A powerful political environmental triumvirate was formed, consisting of Svend Auken, the former Social Democratic Minister of Environment, Sten Gade, the Chairman of the Parliamentary Environmental Committee, together with an advocate for Greenpeace, Jacob Hartmann, who together placed PVC on the media's agenda, giving it growing importance. This threesome was later strengthened as Social Democrat Ritt Bjerregaard was designated as the EU's Environmental Commissioner, reiterating Danish PVC political thoughts to the EU.

It is thus partly to Denmark's credit, that the European PVC industry has, during the last 10 years, handled the issues that arose from the Danish initiative. They continue to do so today. PVC – of which 6 million tons are produced each year in Europe – was criticized as containing environmentally harmful additives such as heavy metals and harmful plasticizers such as phthalates. The material was subject to criticism, because the collection and recycling of waste products was nearly nonexistent. The Danish critique of PVC gained more and more responsiveness

PVC is primarily used to produce products for the building industry, such as these pipes from Nordic Wavin's stock in Hammel. Photo: Ole Grøndahl Hansen.

in the EU, which enhanced the attention paid to the environmental impacts of PVC material caused throughout its life cycle.

Such a massive resistance could not be ignored by the PVC industry. In 2000, Vinyl 2010 was formed, an extensive voluntary environmental program, which was characterized by the fact that the entire value chain of PVC-related businesses, as described above, joined forces and set up ambitious targets for how criticism of PVC material could be counteracted positively. Ten years after starting, Vinyl 2010 had completed all the goals it had set for itself. After Vinyl 2010-targets were met, it was decided by the European PVC industry's value chain to continue the environmental work, thus founding Vinyl Plus: a new environmental program that includes new objectives to be met by 2020. This new, comprehensive environmental program is also formulated in collaboration with an environmental organization, so a new era was heralded.

Another area that illustrates the negative effects of the use of plastics in society, and which has gained, in recent years, a prominent place in the criticism of plastic, is the sheer volume of plastic waste floating in the oceans. The term used to describe this phenomenon is *marine litter*, and it is not specific to one type of plastic material. *Marine litter* is defined as man-made objects that, after being used, either intentionally or accidentally, end up as ocean waste. It is estimated that about 90% of these poorly degradable waste fragments derive from discarded plastic products. The problem is compounded by a lack of problem solving initiatives, in contrast to the challenges presented in recycling PVC, where the industry is working towards finding a solution to the problem by investing in environmental protection and in finding substitutions for the environmentally harmful additives. The *marine litter* phenomenon is much more extensive, more complex and its solution will involve far, far more people. The global plastics industry is aware of the problem of plastic waste in the oceans and is going to be a part of the solution. For the plastics industry, it is evident that plastics do not belong in the oceans as waste. When a plastic becomes waste, it must be collected and recycled. The plastics industry will have a significant role to play in advising on the collection, sorting and recycling of plastics, so that the phenomenon of *marine litter* will be restricted in the future.

Some will argue that the problems related to the use of plastics, for example the *marine litter* phenomenon, is so invincible that the only solution lies in restricting consumption. The thinking is also based on the notion that because the plastic core is made of a non-renewable resource, namely oil, we might as well prepare ourselves to be phased out. On the other hand, I would argue that since oil is becoming scarcer, one of the only sane things to use it for – is making plastic!

And why is that? Well, in 2011 the EU Commission published a report outlining its long-term vision for how the world's resources should be used in the future. It states that in 2050 we will be 9 billion people. If we continue to use our resources at the same rate, it will require at least one additional planet to sustain us. The report states unequivocally that we cannot continue as before. One of the Commission's solutions to the challenges we face is to promote the consumption of durable materials, materials that do not require much maintenance and materials that can be recycled. So who knows, maybe the 90s most maligned plastic, PVC – which exactly meets the requirements that the Commission's report demanded – will have its renaissance in tomorrow's sustainable society!

The road towards a future where plastic is considered a fascinating, magical, civic, and sustainable material can seem long. To achieve this goal, I think we must start creating closer ties between the consumer and the production process. I'm not saying that we must go back to the plastics fairs of the sixties, but some experience economy related initiatives from the plastics industry would probably not be the worst place to start.

Conservation and Innovation

Statens Museum for Kunst's (SMK) Keeper of Conservation and Director of CATS, Jorgen Wadum, met with innovation expert Lars Lundbye in the new contemporary art wing of the museum, to discuss the PRIMI project and how the conservation department and the Centre for Art Technological Studies and Conservation (CATS) can spread its knowledge out to external stakeholders.

Lundbye: We have just gone through the conservation department's workshops. For the ordinary museum visitor it is an invisible and closed part of the building. It is part of the apparatus to maintain the artworks in the museum so they can be presented and well groomed. But why is such an important part of the museum experience not more visible?

Wadum: The closed museum is a tradition from the past, from the time when the museum was a mausoleum of cultural heritage, where the audience devoutly walked around among the treasures. But a modern museum is a different dynamic entity with many activities and many 'shop windows'. Not only directed towards museum guests, but also by way of digital media where we can be seen and heard worldwide 24/7, communicating the knowledge that permeates the museum. Behind the walls of the exhibition space, conservators are building up new knowledge about the artworks.

A good example is our material knowledge: conservators are trained in materials science in regards to both active and preventive conservation. We need to prevent air pollution, improper humidity and temperature changes, from damaging the individual works. To accurately preserve and restore a work of art, one must nevertheless be able to analyze its components on a molecular level. In collaboration with the School of Conservation and the National Museum, the conservation department established, in 2011, a research center, *Centre for Art Technological Studies and Conservation* (CATS). This centre has a number of scientists affiliated who, in collaboration with the conservators, are capable of using advanced techniques to analyze the types of molecular changes that are taking place inside the artwork: changes that will alter the expression of the work, and thus the experience of the viewer. It can be dramatic color changes, or smooth surfaces that suddenly become sticky. Changes in the molecular structure therefore will influence how we can maintain the surfaces. Are we still able to clean them, can we dust them, can we can rid them of impurities? If we can, without damage, our research has succeeded. The knowledge we generate includes several material groups: from lapis lazuli (natural ultramarine blue, ed.) deriving from 15th century Afghanistan, to works made of plastic the day before yesterday.

The museum houses a constantly evolving knowledge resource. We have to be good at activating this knowledge, which often cuts across disciplinary boundaries to artists, the audience, industry, and anyone else who can use it. It's an exciting challenge to make the hidden knowledge of material culture visible and to invite society to use it.

Lundbye: When we talk about art and society, we walk straight into a fierce controversy that pops up oc-

Conservation innovation seems like an oxymoron, but the potential in the hidden weird knowledge amassed by art conservators, make the museum's conservation department a potential treasure box of new insights for material industries. Photo: Statens Museum for Kunst.

casionally: can and will art – and the museum – play a role other than simply supplying works that can be experienced by the audience? When the avant-garde movement emerged in the last century, it articulated the idea of bringing art and society closer in dialogue. But the actual experience is that modernist artworks and art appreciation became limited, and that art became an introverted project with its own little universe of knowledge, directed inwards. Some of what I see, as being very inspiring in working with the field of art conservation, is that it is easy to circumvent this controversy by focusing on the materials.

Wadum: In the PRIMI project we build on the belief that dialogue between the artist, conservator and industry can create new values. Our point of departure now is that where the experience of viewing art is not solely limited to just viewing the object – and being a headache for the conservator – it has become an exciting and definable collection of unique materials through which advanced research can evolve to be a resource for new knowledge about the aging of materials and combinations of materials.

We acquire works such as Tomás Saraceno's floating transparent globes, *Biospheres,* some of which are inhabited by living plants. The moment they arrive at the museum, they are protected by the Danish Act on Museums (Museumsloven, ed.), which obliges the museum to preserve the things we acquire in order to show art from today and from the past well into the future. We have 700 years of art here at SMK, and if the older works weren't still here, we couldn't see the works of today in their proper historical context. The new works in plastic will also one day be older art. So we have a problem, because we need to know how to take care of ephemeral contemporary art. We need to generate knowledge about how materials degrade and try to answer the question as to whether we can stop or at least slow down the aging process.

When we ask questions about newer works, made of materials that surround us in everyday life, we step out of the museum and into a, for example, industrial context. In newer artworks, it is not always the case that the artist has considered the longevity of the materials. Many art schools purposefully avoid teaching about material knowledge. For many years, we have had the perception that artists should not have to worry about materials and their durability. It would only hinder them in their freedom of expression; SMKs international seminar *Permanence in Contemporary Art – Checking Reality,* held in 2008, which laid the foundation for the PRIMI project, also addressed this issue. (The contributions here can still be experienced digitally at SMKs website, ed.)

Lundbye: You are suggesting that we have a world of material knowledge that the new generations of artists and, indeed, museums and their audiences, have been isolated from. The focus has until now been on the concept and the cognitive in the work. It is only when the work ends up in the conservation workshop that one discovers that it has a lot of built in material-based information – and challenges.

Wadum: Yes, there are examples of artists whose work we have acquired, where the colors have subsequently changed, the material is degrading or even pulverized, as foam does over a relatively short number of years. It is painful to experience, because the artist has created an important work, which has been acquired by the museum and has become a part of the nation's cultural heritage. Now it suddenly falls apart, and instead of having its original significance, the material becomes slightly inarticulate to the viewer. The exciting thing is, that in that instant, there arises some unforeseen new opportunities. Through scientific research, the life of a work of art, and its changes, become a part of the conservator's new knowledge about material properties over time. Now, the work can be included in an alternative dialogue with society, for example with material research at DTU (Technical University of Denmark, ed.), or with innovative researchers from the plastics industry, such as we did in PRIMI.

Lundbye: The institution will not make demands on art, just as you mention that art schools lack educating artists about materials. Art has the role of practitioner of a free practice. Within its own logic, it has its own world and recognition. The result can be a work of art that will hang protected here at the museum. We must only look, not touch. So we look somewhat reverently upon the artworks, hoping to redeem the value that the museum promises: one or another form of recognition, some kind of aesthetic, emotional or intellectual context. Suddenly you are pointing to a completely different value set, which requires that we touch, feel, and analyze the material. Is there a whole other dimension that is not about the work as a work, but about the practice of the artist through the material and the challenge that lies in that? That the artist enters and challenges the materials that ultimately end up with the conservator? Where subsequently the conservator's work releases a lot of knowledge about materiality and the materials and their fate over time? Does this give us grounds to think about something in relation to the eternal debate surrounding art institutions and societies, about art and the creation of values in society?

Wadum: It is about finding the surprising angle. Art has many values in society. It both tells stories and asks questions, it satisfies and provokes, and it touches our emotions and our sense of aesthetics. When the conservator goes in and desiccates an artwork, and almost literally splits it down into

To keep Tomas Saraceno's *Biospheres* in plasticized PVC inflated, conservator Louise Cone experiments with a number of patching and repair techniques after analyzing the material properties.
Photo: Statens Museum for Kunst.

atoms, a completely new and different knowledge about the genesis of the artwork is generated – as well as knowledge about how the inherent and unavoidable processes of decomposition affect the work. With increased knowledge, we discover the work's newly found hidden value: a new value that in the first instance can be used to preserve the work and others within the same material constellation. We can also channel this knowledge into society and our new partners in the industrial sector. The artworks come, so to speak, to provide community service through the results of our scientific studies, which could be beneficial to a myriad of producers, for example to help produce more durable plastic products for bottled water and the hospital industry, which has different requirements for the material than, say, the manufacturer of plastics used for coat hangers.

Lundbye: Within the field of innovation, you work with the concept of *lead users*, which was launched by Professor Eric von Hippel from MIT (Massachusetts Institute of Technology, ed.). He has demonstrated how most medical equipment is not in fact developed by industry but by the doctors. When a surgeon makes an incision, an obvious need for a particular type of technology arises. The surgeon cannot wait for this to happen, so he gets it fixed one way or another. Other doctors may have the same needs and go on to develop some gadgets based on the surgeon's solution that can be commercialized and benefit others.

What we are experiencing with artists and preservation, I think, is a radicalization of that practice. A lead-user is a super-user, who, from a special need innovates on top of an existing technology. I can see that artists and conservators use materials in ways that were never intended. It was never meant to use plastic, aluminum,or whatever it is that would be used, in the sense that the artist uses it. Plastic was never intended for eternity. Plastic is used for purchase-and-throw-away products. And suddenly we have a user who does something completely unexpected. For example, Claus Carstensen, who mixes waste products together with various plastic materials, urinates on it, puts lubricating grease on it, etc.: in his case, with a deliberate strategy in mind, in that decomposition is actually a key point in the work.

There, we get a type of user, which we can call an *extreme user*: a user who is using technology and materials outside of their intended use -going decidedly outside the framework for which the application was developed. I see a lot of possibilities in the world of art conservation for art conservators to engage themselves with this extreme usage. It may lead to a new type of user-driven innovation: generated by the knowledge generated by *extreme users*.

I think the experiment with PRIMI is reminiscent of some of the projects from the 70's, which took place in the United States. For instance, Xerox Park and Bell Labs' 'Experiments in Art and Technology' (EAT, ed.), where artists such as Robert Rauschenberg, John Cage, Öyvind Fahlström and Robert Whitman worked closely with engineers Billy Klüver and Fred Waldhauer. It unfolds now in, for example, Interactive Institute in Sweden, ARS Electronica Futurelab in Austria and V2 lab in Holland, where the participants are also a kind of *extreme user*.

Wadum: Artists are, and have probably always been, *extreme users*. In the transition from painting with temperas to painting with oils, the need arose to develop other material properties in order to bring the illusion of the painted surface closer to a representation of reality. They wanted the transparency of the color and thin glazes to create new and hitherto unknown depth in the works. The innovation happened in the artist's studio, where they mixed new materials together. The same has happened, and is happening, with contemporary art. For many contemporary artists the materials used are not necessarily art materials. It is something that occurs by the artist experimenting, making demands, and mixing components together, thereby creating a new reaction. Despite the material's lack of compatibility a work is created, providing experiences and knowledge, which the museum will preserve and disseminate onto the next generation.

To create new knowledge, it is important to seek out these *extreme users*, put them together with conservators, scientists and those producing new products. Besides studying the artwork, our profession has developed a worldwide network of conservators, who are interviewing artists about their creative process and artistic intent, as well as about the importance of material selection. Some of these interviews can be found in the recently published *The Artist Interview. For Conservation and Presentation of Contemporary Art. Guidelines and Practice* (Jap Sam Books) and via INCCA (*International Network for the Conservation of Contemporary Art*).

We are very aware that our museum users are particularly interested in material culture, so we plan material-oriented exhibitions at SMK, as well as conveying our knowledge via our website. The direct dialogue with the artists and the plastics industry is, with PRIMI, still in its infancy. However, it is the beginning of something that can become much larger and have far greater reaching implications for the way we look at the materials of the future. Conservators and conservation scientists can extract new knowledge from the works of art. Moreover, together with the right stakeholders, the museum can become a dynamic catalyst for innovation in society in an entirely different way than we had ever imagined. In the future, we can envisage experiencing the creation of one or another object, which has been developed based on CATS' research into the ephemeral nature of contemporary art materials.

A Trojan Horse

Interview with artist Claus Carstensen, a former professor at the Royal Danish Academy of Fine Arts, by Jakob Fibiger Andreasen, Head of Press, Statens Museum for Kunst.

The picture was painted outside in a backyard in Frederiksberg, and the frame had to be cut and folded over to make it fit into the Charlottenborg exhibition space, where, in 1986, it was exhibited for the first time as part of a larger, three-part installation at the exhibition entitled *Limelight*. The painting consists of sewn linen canvas clamped onto a large wooden frame. In 1982, I had bought a lot of dispersion paints, heavily pigmented acrylics, which I had laying around in the studio. They were poured onto the canvas as grounding, and then I pissed on it. The motif is painted with enamel paint, asphalt, oil paint, and grease. Then foam pieces were stapled onto the surface. As a self-referential element, the cloth that I used to dry the brushes with was attached to the right side of the painting.

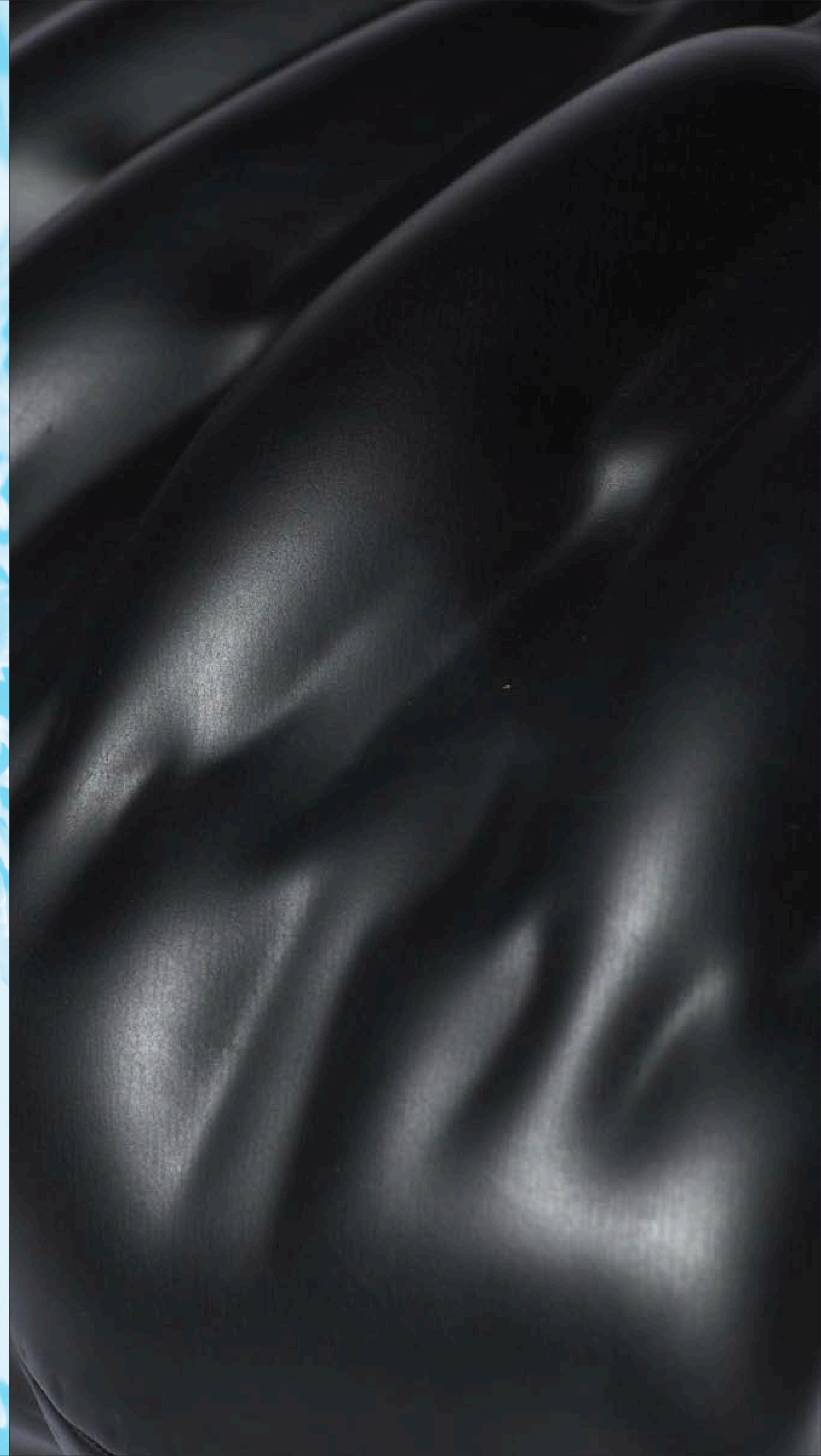
The title refers to the occult theory about the astral body, which comes out of the body as an ethereal duplicate of the physical body. According to esotericism, the astral body emits energy and creates and aura around it. In parapsychology, there exists something similar in the idea of ectoplasm. In the painting there are two figurative elements that can be hard to spot: at the top is the head of an African painted in strong, contrasting shadow. A little further down on the right, there is a goat with a candle in its forehead. The goat is a symbol that allegedly was used by some Masonic orders, but which also appears in pagan rituals as "the evil goat". *Ethereal body* is a comment to this esoteric field, but also a paradox in itself. There is an upwards movement in the image, which originally hung up against the ceiling while on installation at Charlottenborg. There is also an opposite movement in the painting: the foam rubber pieces hang down, just like the grease starts to run down when it gets warm. So while it is a work reaching upwards throughout its reference to the astral and ethereal, it is also a work that insists on its own physicality and heaviness.

Physical transience plays a crucial role. There is a deliberately built in process of decomposition in the work: the foam rapidly begins to discolour, becoming porous when exposed to the ultraviolet rays of the sun. The work was originally conceived as an implosive institutional critic, a kind of Trojan horse, beginning to decompose after the museum had acquired it. It was never intended to be hanging in the museum today. However, I am in a paradoxical situation: the museum has classified the work as an 'ENB' work (a work of *unique cultural significance*, ed.) But I have also come to realize that there is no man-made culture without symbolic and political representation. The painting represents a type of implosive iconoclasm, that was part of the baggage of the 1980s and it should be seen within this context.

The period of 80's art from which I derive, shared in many ways the iconoclastic vision of the institutional critique from the 60's, just inverted. Art in the 60's consisted of monochromatic surfaces, anonymous boxes, etc., that neither spoke of nor represented anything, while art in the 80's was about overbidding and producing images that constantly referred to each other, so that the very reference disappeared. Where the institutional critique of the 60's was explosive and non-representative, we practiced implosion and a massive overflow of representation.

Ethereal body is for me the beginning of the end of these quickly produced and overloaded images. The work is in line with the French thinker Georges Bataille's ideas. Marx has, during his critique of the political economy in *The Capital,* an example of twenty pieces of fabric that turns into coats illustrating how those who own the means of production, exploit labour for profit. Bataille turned this productive, profit-oriented logic up side down and wondered what would happen if one burned the coats instead of selling them. It is this type of extravagance that is also present in the painting, which of course was not originally tied to anything other than its own termination.

Claus Carstensen in front of *Ethereal Body*, 1986. Dispersion paint, oil paint, asphalt, enamel paint, urine, foam rubber, grease, and fabric on canvas, 400×300 cm. Photo: Statens Museum for Kunst.


00:00 min


00:25 min


00:28 min


00:35 min


00:47 min


01:12 min


01:41 min


02:17 min


02:38 min


03:10 min

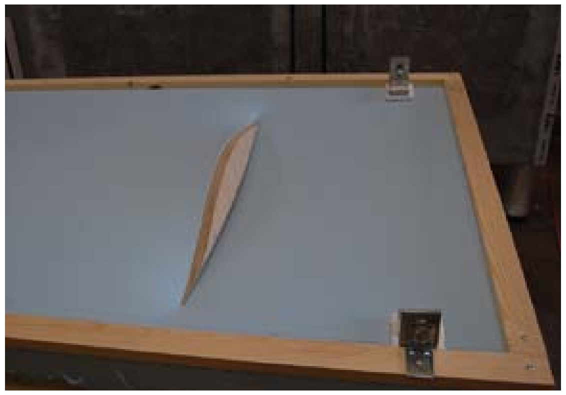
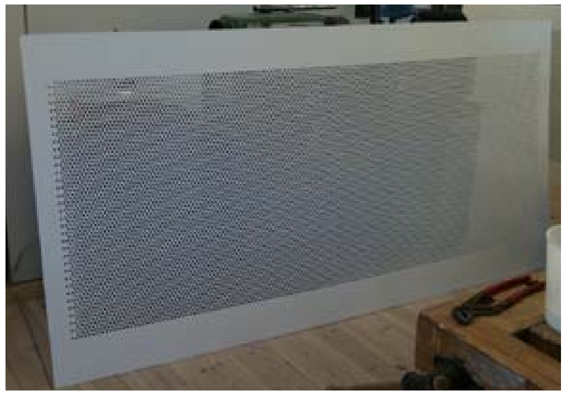
FLINDT / JERICHAU

Foamy

Process
The form is made of knitted rope
The upholstery is filled with expanding foam
The form leaves an imprint on the upholstery

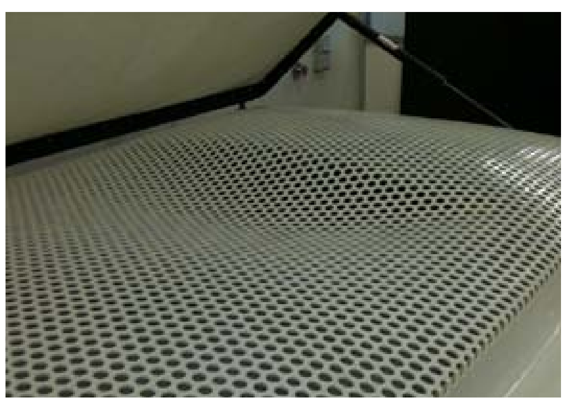
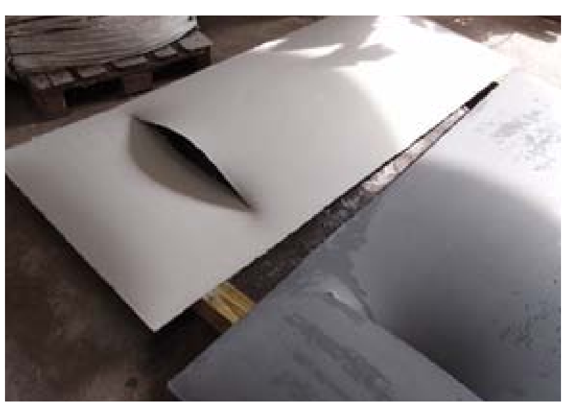
Product
Foamy is a large floor puff
The project is a reinvention of upholstered furniture

Materials
PUR foam and Neoprene





Panels

Process

Spray casting of the concrete facade elements into a textile form
Perforated plastic panels are vacuum formed over the concrete facade elements
Plastic panels are mounted with foam and textile

Product

Facade elements in high-strength fiber concrete with integrated lighting
Sound-absorbing panels with integrated lighting

Materials

High-strength fiber concrete, perforated ABS plastic, foam, *Kvadrat* textile
Chicago

Tracking Plastic

Carsten Thau, professor at the School of Architecture in Copenhagen, speaking in June 2010 with the artist Claus Carstensen. The conversation is about plastic in the light of history, and based on Roland Barthes' essay 'Plastic' from 1957, where Barthes discusses plastic and plasticity. The essay is also reprinted in this publication. The following is an excerpt from the interview between Thau and Carstensen. It can be found in it's entirety under Statens Museum for Kunst's website.

Carsten Thau: With regards to creating a form, it seems as though plastic is fundamentally without any resistance. It can take any shape and is totally malleable. All conceivable metamorphoses can take place without friction. An object's authority has previously been closely associated with certain characteristics: wood was used like this, or steel, which had other characteristics, could be made so and so thin. A given construction of the object should reflect the characteristics of the material, and combining the materials would further expose the beauty and texture of each of them. This disappears to a certain extent when you make casts with synthetic materials.

It precipitates the situation of young people today, who are using computers to build their models. They no longer experience any resistance in the material. Think of what it was like before, when you had to work with stone, plane wood, cast in iron or bronze, etc. What a tremendous opposition and process-like toil was met *en route* to the object. For the designer and the architect, that resistance has now largely disappeared.

The material and the technique offer less resistance. The docility of the material is in my opinion, heralded by plastics. Plastic anticipates, in a way, this semi unreal lack of resistance in the material, which today is experienced virtually. Plastic is therefore associated, in a way, with a set of conditions which can be exploited far greater in minimal art, namely, where subjective expressivity and markings are removed in favor of the abstract industrial formula in the chosen material, underlining the impersonality of the material. Mass-produced steel plates were used, plywood was used, in some cases clean varnished surfaces, but only in rare cases, plastic – (which may have been perceived as being too feminine). But plastic heralds, in a way, the peculiar impersonality of industrial objects in a way that reaches further. It reflects the pure industrial formula. It no longer reflects the expressive communication of work done by hand or traces of work done by hand.

Plastic can do something new. It has a certain hardness. Faced with new products made from synthetic materials, people think that it is probably a new chemical formula we have identified. In this way, we have a double view of plastic objects. On the one hand, it is some thing we can understand; have in the world that has substance and permanence. On the other hand, it is also something you look at as a synthetic code.

Plastic is, for all intents and purposes, a part of 'the unbearable lightness of being'. It was of course already a part of this by way of the cultural criticism that, at the time, was introduced in relation to America, which came with all these wonderful plastic things. There was a wide spread slang expression in the fifties: plastic fantastic! An expression aimed at superficial seduction, a body without mass, and a phantom that half belonged to the domain of the fantastic and was the tense subject-related parallel to the frictionless fuck. Plastic was in some ways a precursor to fast food and other things that were easy and 'light', in an Americanized sense of mass culture. But today, I would say that the lightness is embodied in the way people look upon many of these new plastics – synthetic materials – as something which is the result of a chemical formula – an industrial code.

Previously you thought: this object consists of objects existing in the world. Today you will be able to construe this from the objects chemical formula: different formulas for different purposes. It has thus become more intangible and it is quite abstract, this is what is fantastic about this material. The code is what is characterizing these substances. You need a material that can withstand this and that, high temperatures and many other things. Then you try to work on formulas that can solve it.

Previously it was a question of how one could work with a given material, which is already in the world, and can be formed into a useful object. Today we think: How can I develop a synthetic material that has certain properties. Thereby moving attention away from the material processing to the more intangible laboratory conception, at the same time that the things in plastic – from toys to bathroom equipment – seem partially like replacement gizmos. Synthesis means exactly that it is not "real".

Claus Carstensen: For instance, plastic is not bound to time, at least not in the commonly viewed perception of it. It can be replaced because it is no longer structurally dependent upon, as you mention, the traditional principles for constructing form. Plastic can be molded and can, in principle, be industrially reproduced ad infinitum. Thereby becoming timeless. Until it begins to show wear. Wear is traces of time and is, among other things, what we have discussed in connection with the preservation of plastic, which of course, is one of the main reasons why we are in the PRIMI project in the first place. I think one problem is that plastic is seemingly objective and timeless, the fact that it, in principle, can be produced over and over. But time leaves traces and establishes marks in this seemingly objective and timeless material in the form of scratches, cracks, etc.

Carsten Thau: Many sculpted materials have the ability to acquire a patina. They can hold and record time. This is something that has been celebrated in the European tradition. Not the Romans in ancient times, they had no interest in the patina. But since the 1700s and possibly already since the Renaissance, there has been an interest in – for example – the oxidation of bronze: the way that bronze objects acquire a special green glow. Just as one has appreciated that marble statues could also record time. Acquiring a patina gives them the sublime effect of carrying this enormous amount of time within themselves. The question is whether or not plastic simply becomes shabby, without ever obtaining the noble attributes of time that are so esteemed in parts of culture and art history.

Plastic was the preferred material in the fifties because it was 'shiny', versatile, it revolutionized the lives of housewives, and it was the image of America, the American civilization. It comes to Europe to replace enamel tubs and 117 things. It arrives together with other images from the U.S.: double carports, cars with tail fins, ultra green lawns, housewives bearing the 'new look', having Tupperware parties. Plastic is connected, at the same time, to the Europeans' ambivalent relationship to this element of modernity. It is abstract and a bit alien, an eternal future, timeless.

The language of the hands disappears with plastic because it is an emanation of the pure mass industrial formula and at the same time, a picture on this new, gloriously weightless modernity. Plastic objects belong to all and none. Plastic is something that truly fascinates, a sparkling expression of color and celebration that fades quickly. But today, I think that plastic has moved from having this type of status to becoming a new kind of alternative nature. It is so to speak, everywhere, this new nature in our culture. Where in the fifties it was a spearhead of the modernization of everyday life, it is now simply present without signal character. Nothing within the world of plastics and composite materials can surprise anyone or awaken anyone's special attention.

Conservation of plastics is of course particularly delicate in art because of its high call to claims of authenticity. It involves, among other things, whether the artwork will be able to transfer it's meaning if one tries to make a copy. I do believe that making a copy of a plastic artwork is apparently, in some cases, technically very difficult. And there is the question and criteria of authenticity. Earlier you saw the artwork as a kind of cult object or something that holds a very special religious force. Later it was thought that if the artist has signed the work, then something of his original, spiritual genius was present in the work. Nevertheless, I believe a copy should be made or parts renewed, where you are faced with degradation in works made of plastic.

Refurbished works do not always loose their magic. Take the stock exchange building in Copenhagen. There is not one single stone left dating back to the time of Christian the 4th. Not one single stone in the whole of the building's exterior. But people nonetheless perceive the exchange building as if it conveys a genuine aura from the time of Christian the 4th. An artist like Marcel Duchamp was also theoretical and reflective in his work on the subject for the same reason. His original *Fountain* from 1917 no longer exists, but the copies that exist have not lost anything of the aura there must have been in the original.

Claus Carstensen: I have worked a lot with soft foam plastics, which I have tacked onto a series of images such as *Ethereal Body* from 1986, which pulls in the opposite direction, of, for example, Tomas Saraceno's *Biospheres*, which to me represents the weightless, 'inflatable', industrialized version of the cult of eternity.

Ethereal Body was conceived and created as an evaporating, self-destructive work that would slowly dissolve as a result of the impact of time, UV light and humidity. With regard to the preservation of *Ethereal Body* I have landed in an institutional dilemma. The work has recently become a part of a group of works classified as being of 'unique cultural significance' (ENB, ed.), for the Danish cultural heritage, which implies that all means should be used to assure its preservation. Strangely enough it is no more than a few years ago that the former Director of the museum (SMK, ed.), Allis Helleland, was ready to destroy the work exactly because of the difficulties presented in preserving it. This would have been the case if the museums conservators had not taken action. In just a few years the work has gone from being 'disposable' to becoming a landmark work of art, which means that I now have to find a pragmatic solution to the problem of degradation, since part of the intention of the work was that the foam would acquire a patina and eventually decay.

I knew that this would happen. That the light blue and white foam would slowly disintegrate. But as I said, I think that you have to proceed pragmatically and, eventually, when the time is right, replace all the foam at once. I think it might keep for fifteen or twenty more years, after which a decision will have to be made. Viewed from a pragmatic point of view, I would not mind if all the foam was changed out at once.

The picture was exhibited for the first time at Charlottenborg, in connection with the exhibition, *Limelight*. The foam was, at this time, completely new. At the time I did not realize that the work would go on to become a part of the Danish cultural canon. Strictly speaking, the picture represented a kind of implosive or reversed institution criticism – as opposed to the 60s and 70s inclusive or expansive institutional critique, which sought to abolish art institutions by involving all forms of reality and life practices. My thoughts were more about the way institutions were resisting resolution, its boundaries impermeable to the surrounding society, forcing the criticism to be implosive, meaning that you are able to install decomposing, Trojan works within it. It was an extension of the punk 'do-it-yourself' conceptions, postmodern theory and the discussions they had generated in relation to the concepts of implosion, etc. Paradoxically, this agenda has now been lifted, and another is dictated in the form of a preservation strategy.

Photo courtesy of Solvay/SolVin

Making and Breaking Plastics

Plastics expert Yvonne Shashoua, PhD. Senior Researcher, Department of Conservation, National Museum of Denmark, introduces us to some of the chemical properties of plastics and their degradation.

Making plastics

Polymers are used as the base material to make plastics. Polymers are large molecules often described as chains comprising repeated chemical units. The repeat unit is usually a small molecule known as a monomer. Typically there are between 1000 and 10,000 monomers in a polymer chain. Monomers may contain carbon, hydrogen, oxygen, nitrogen, silicon, chlorine, fluorine, phosphorous and sulphur. The chemical process of joining the monomers into a polymer is called polymerization.

Polymers are named after the monomer rather than after the repeating unit in the structure. For example polyethylene, prepared from the monomer ethylene, consists of a long chain of repeating methylene -(CH_2)- groups. Polymers prepared from more than one species of monomer are called copolymers eg butadiene-styrene polymers.

The first polymers were developed in 1862, known as semi-synthetics and were the bridge, technologically speaking, between natural and fully synthetic polymers. Natural polymers include materials from trees, plants and insects such as paper, rubber and shellac. Semi-synthetic plastics were made by treating a natural material chemically to modify its properties, usually with the aim of producing something mouldable. In 1909, the first fully synthetic polymer was produced by reacting two chemicals (monomers) together. It was known as Bakelite after its inventor.

Cellulose plastics, particularly cellulose nitrate and acetates were the most commercially important semi-synthetics and have been used to prepare photographic films, textile fibres and lacquers. To prepare cellulose nitrate, cellulose is treated with concentrated nitric and sulphuric acids. Sulphuric acid catalyses the reaction, so it can occur without heating and under ambient conditions. The product is washed with water to remove residual acids.

New cellulose nitrate is a colourless polymer which is brittle and tough, but flexible when plasticized and cast as thin films and sheets. The high flammability of cellulose nitrate was a highly undesirable property in its applications as coating, doping (tightening and windproofing) treatment for the canvas-covered wings of aircraft used in World War I, and in cinematographic films. Its flammability resulted in the development of cellulose acetate at the start of the 20th century. Cellulose acetate involves reaction between cellulose and acetic acid.

Preparation of synthetic polymers

The polymerization process (chemical joining of monomers) generally occurs either by adding monomers together just like adding one Lego brick to another or by condensation polymerization where bonds are broken and remade to form complex, network structures.

Polymers formed by addition polymerization include polyethylene, polypropylene, poly(methyl methacrylate), polystyrene and poly (vinyl chloride) (PVC). For addition polymerization to take place, the monomer must contain at least one double bond. Double bonds are broken to make a free bond to join with. A catalyst may initiate or speed the process. In the second stage, monomers continue to add together, forming increasingly longer chains. During the final stage, known as termination, all the monomer molecules have reacted and the reaction ceases.

$$nCH_2 = CHCl \quad (\text{-}CH_2 - CHCl\text{-})n$$

vinyl chloride *poly (vinyl chloride)*

The degree of polymerization or number of repeat units in the molecular chain, n, ranges between 500 and 1500. This corresponds to a theoretical molecular weight average of 100,000-200,000. In practice, all batches contain molecules with a range of chain length.

PVC like all addition polymers, is thermoplastic, so it softens on warming. The glass transition temperature of commercial grade PVC is approximately 80-84°C and the melting point around 212°C. Maximum usage temperature for commercial compounds is between 65°C and 80°C. The polarity introduced by the presence of chlorine means that PVC is soluble in polar solvents eg. tetrahydrofuran and cyclohexanone. The high concentration of chlorine in the polymer (56.8% by weight) imparts flame retardant properties, a property which has been utilised in electrical insulation cables and housings.

During polymerization by the condensation technique, a reactive chemical group on one monomer reacts randomly with another group on a second monomer molecule, with the formation of a small molecule as the monomers join together to form a chain. The small molecule is usually water or alcohol which splits off during polymerization. Polymers formed by condensation polymerization include polyesters, nylons, and formaldehyde polymers.

Most polymerization reactions do not progress to completion, resulting in the residues of starting materials in the resulting plastic. Approximately 1-3% of residual monomer is found in acrylics, poly (vinyl chloride), polystyrene, polycarbonates, polyesters, polyurethanes and formaldehyde polymers immediately after production and is often detectable by smell.

Additives

The chemical and physical properties of polymers can be changed considerably by incorporating additives soon after manufacture. The type and quantity of additives allow many different products to be produced from the same polymer. For example, raw PVC polymer is a brittle, inflexible material with rather limited commercial possibilities. Attempts to process PVC using heat and pressure result in severe degradation of the polymer. Compounding PVC involves incorporating sufficient additives to the raw polymer to produce a homogeneous mixture suitable for processing and with the required final properties for the lowest possible price. PVC can be used to produce rigid guttering, plastic grass, soft toys, electric cable insulation, photograph pockets, and shoe soles simply by varying the amount of plasticizer in the formulations between 16 and 50% by weight.

During processing, PVC is milled together with liquid plasticizer, so that the latter physically attaches itself to the surfaces of the polymer particles, separating them from each other and allowing them to flow over each other, increasing flexibility on a macro-scale. Of the one million tonnes of plasticizer used annually in Europe, approximately 90% comprise phthalate esters frequently di (2-ethylhexyl) phthalate (DEHP). The effects on health of

DEHP, particularly that of children, has been of concern since the 1980s and toys and accessories intended for children younger than 3 years are not allowed to be sold in Europe.

In addition to plasticizers, the major additives are fillers which bulk and opacify plastics, anti-ageing additives which minimise or eliminate degrading effects of heat, light or oxygen on polymers and colourants which impart protection from light and cosmetic effects.

Breaking plastics

In general, deterioration of plastics objects in museums is visible within 5-25 years of collection. However, it should be remembered that most museum objects have been used or displayed before they are collected. Their past contributes greatly to the rate and type of deterioration. Instability of the earliest plastics, cellulose nitrate and acetate is expected due to their poorly stabilized formulations and because they are the oldest man-made plastics in museums. However, PVC was first developed in 1926 and is still in use, so its deterioration is rather unexpected.

Causes of deterioration of plastics may be broadly divided into physical and chemical.

Physical causes include:

• *Stress, fatigue and mechanical damage.*
These are a result of use of the plastics object and could comprise frequent bending of a PVC soft toy leading to its failure or abrasion to the surface of a vinyl record as it is repeatedly pulled out of its sleeve to play, resulting in its inability to produce perfect sound.

• *Migration or loss of additives.*
These are consequences of the properties of additives used to formulate plastics; their selection is related to the function, expected lifetime and price of the final product. Camphor, one of the earliest commercial plasticizers, sublimes at ambient temperatures and so was lost rapidly from cellulose nitrate formulations. The result of plasticizer loss is shrinkage and brittleness.

• *Absorption of liquids or vapours.*
Polyethylene is especially vulnerable to absorption of liquids. Tupperware food containers often develop tacky internal surfaces after long-term use due to the absorption of oily materials from contact with foods.

• *Excessive exposure to high or low temperatures or rapid change in temperature.*
Thermal shock causes polymer chains to pack together and this manifests as cracking.

Chemical causes include:

• *Oxidation.*
Most degradation reaction paths for plastics involve oxygen, either by direct reaction of polymers or additives with oxygen or by the formation of another reactive material from oxygen. Highly unstable ozone (O_3) is the product of the reaction between oxygen and ultraviolet light. It readily adds across carbon double bonds present in synthetic rubbers.

• *Metal ions.*
Copper ions act as catalysts to accelerate deterioration reactions of many polymers, particularly synthetic rubbers. Spectacle frames constructed from cellulose nitrate, are often more degraded in the area around copper-containing screws and around the wires in the arms, than in the rest of the frame.

Breaking semi-synthetics

The major causes of instability of cellulose nitrate are due to reaction with water known as hydrolysis. Degradation of the polymer is autocatalytic, that is, the products of breakdown tend to catalyse a faster and more extensive degradation reaction than the primary processes if allowed to remain in contact with degraded cellulose nitrate.

One of the first products of deterioration is the highly reactive, highly toxic oxidising agent nitrogen dioxide (NO_2), identified by its yellow vapour and distinctive odour. Nitrogen dioxide reacts with moisture in air to form nitric acid, known for its ability to corrode metals on contact.

Degradation can be divided into three stages. The first stage involves the evaporation or migration of plasticizer manifested by shrinkage of the object; the remaining material is highly flammable and burns at a temperature up to 15 times higher than that achieved by burning paper. As degradation continues, internal cracks or crazes develop and cellulose nitrate yellows as shown in [Figure 1]. In the final stage, crazing known as crizzling is so extensive that cellulose nitrate disintegrates. At this point, its flammability is the same as that of paper.

Some metals, notably copper, accelerate the rate of degradation of cellulose nitrate. Copper screws and arm wires of cellulose nitrate spectacle frames from the 1930s accelerate degradation of surrounding cellulose nitrate and are, in turn, corroded by the nitric acid formed from the its degradation product.

The major degradation reaction of cellulose acetate is similar to that of cellulose nitrate, reaction with water is known as deacetylation. Deacetylation results in the formation of acetic acid


Degraded Cellulose nitrate spectacle frames from 1940s. Photo: the National Museum of Denmark.

Plasticized PVC baby bath book has lost plasticizer manifested by shrinkage and curling.
Photo: the National Museum of Denmark.

(CH_3COOH) which gives a distinct vinegary odour to degrading materials, the process is also known as the 'vinegar syndrome'.

Degradation does not follow a linear rate, but is slow during the initial, induction period and more rapid after onset. Shrinkage, tackiness and increased brittleness due to the migration and subsequent evaporation of plasticizer from between the cellulose acetate chains is also a frequent symptom of degradation.

Breaking synthetics

In many international museum collections, degradation of plasticized PVC materials, in the form of clothing and footwear, furniture, electrical insulation, medical equipment, housewares, vinyl records and cassette tapes, toys and packaging materials used to store objects, has been detected as early as 5 years after acquisition.

Degradation of plasticized PVC materials in museums is frequently observed as migration of the plasticizer from the bulk phase to surfaces. From there, plasticizer evaporates at a rate dependant on its vapour pressure. This process may be detected as tackiness, increasing brittleness and discolouration of the PVC polymer itself. The mechanism by which degradation of PVC takes place is complex. In general, it comprises the evolution of hydrogen chloride (dehyrochlorination process). In addition, cross-linking and chain scission reactions affect the physical properties of the degraded PVC. Cross-linking results in high molecular weight, stiff polymers, while chain scission reduces the molecular weight, thereby increasing solubility.

As degradation progresses, the polymer begins to absorb radiation in the ultraviolet part of the spectrum. The rate of degradation can be followed using colour changes from white to yellow to orange to red, brown and, ultimately black.

The rate and extent of deterioration of plasticized PVC and the migration and loss of plasticizer, particularly phthalates are related. Di (2-ethylhexyl) phthalate (DEHP) inhibits the degradation of the PVC polymer, therefore when it either migrates to surfaces or is absorbed by other materials, PVC materials discoloured, became tacky to the touch and embrittled. Other plastics such as low density polyethylene is an effective absorber of oily materials, including plasticizers as demonstrated by a polyethylene fishing box used to store plasticized PVC lures in Figure 2.

Polyurethane-ethers degrade by oxidation, resulting in discolouration and a loss of mechanical properties. Since oxygen comprises 21% of air, it is difficult to prevent its contact with objects. Polyurethane foams degrade more rapidly than films or fibres since their many cells offer a greater surface area to volume ratio over which oxygen can have contact with the polymer. Degradation results in chain scission, in which energy breaks polymer chain bonds to create a polymer with two or more shorter chains, manifested as crumbling of foams. Such crumbling often starts at surface skins of foams and, when the surfaces crumble and fall way from the object, fresh, undegraded foam is exposed to light and oxygen, perpetuating degradation to the point of complete failure.

Extreme User Innovation

The PRIMI project is an attempt to implement a new productive form of user innovation realizing the artist's and designer's potential as "Extreme User" – a radical type of lead-user defined by using a product or a technology in a way that's radically different from it's intended use. Innovation expert Lars Lundbye explores the potential of implementing Extreme User innovation.

We only see what is already on the map

America was discovered when Christopher Columbus literally sailed outside the chart! Despite all the contemporary knowledge about sea routes, and despite the warnings of his captains and his crew's violent resistance, he sailed west beyond the sea maps – and found the new world. Similarly, Ferdinand Magellan's expedition to the Pacific Ocean would not have happened if he had listened to his competent navigators and their maps. Two analogies to why the competent technocracy of corporations and institutions seem to systematically evade the radical innovations all yearn for. Any skilled analyst will aim to provide "the right answer": to map the world and put it on charts. And subsequently to steer the company accordingly. The problem arises when the world's complexity cannot be handled by a map - when the world cannot be contained in the "correct analysis". The challenges of ever faster change with raging globalization, environmental problems, digitization of everything, urbanization, changing consumer attitudes, customization, etc., puts enormous demands on companies' listening capabilities, constant creative interpretations, and the ability to change – demands, that run contrary to professional management skills. The better we get, the more educated our management and employees are, the more we run the risk that we stay inside the chart. The ships and nautical charts are controlled today by well-trained MBAérs, which in turn are employed in a system where headhunters' CV databases and templates for the correct profile ensure that managers speak the same language of management standardization. A technocracy of very competent and talented – and similar – managers and technocrats whom know all about the competitors, know all about the location of customers in the market, know everything about the business supply chain, etc., and are thus increasingly controlling and more and more precise in their navigational charts.

Unfortunately there seems to be a reciprocal relationship between being good at drawing charts and the ability to detect the new. The Harvard professor and innovation guru Clayton Christensen has shown how the best companies systematically destroy their own ability to innovate by simply being too clever! Very few large companies survive the long run, and Christensen demonstrates how companies' increasing perfection and understanding of the business world they operate in, causes them to turn inward, preventing them from seeing the new developments and radical measures that may be going on right in front of their noses, but outside of their maps and thus their understanding of the world.

Very much in line with this, other innovation research has consistently shown that innovation does not happen as a result of a particular analysis, but iteratively and in a complex interplay between actors and contexts. From Michael Porter's "cluster" theories to Henry Chesbrough's "open innovation" models, there is a red thread through the last 40 years of research into innovation, showing how innovation happens in open systems and requires input from many sides. Innovation happens in interaction with the outside world.

The Lead User innovation revolution

In the past decade, MIT professor Eric von Hippel's work on the so-called "lead user" concept has gained considerable attention, not least in Denmark, where the Ministry of Economy and Business has supported a number of initiatives within user-driven innovation.[1]

User-driven innovation is one of the easiest ways to circumvent the company-centric technocracy trap. By radically involving, listening to – and even giving influence to users and customers, a company will automatically go somewhat outside the chart. The perspective changes from mapping the world to listening to the needs, conscious or unconscious, that users actually have and are experiencing.

"Lead users" are a special type of user distinguished by having a very clear need or problem, while being at the same time able to formulate or even work on a solution. If the problem is great enough, inventions will appear to solve it, as Plato (or Frank Zappa depending on who you listen to) noted: Necessity is the mother of invention. Lead Users are characterized by having a greater awareness of their needs than mass market – and therefore businesses can benefit from working with them to identify future solutions to needs that later become apparent among the masses. A few by now classic cases are von Hippel's demonstration of how a large percentage of the innovations made in medical equipment come from front-end doctors' work or LEGO's work with lead users in the development of its Mindstorm products.

The next level: Extreme user innovation

The PRIMI-project takes this a step further with the concept of the **Extreme User**[2].

As also discussed by Wadum and Lundbye in the article "Conservation and Innovation", published earlier in this book, an Extreme User is a radical type of lead-user defined as a user, that uses the product/technology in a way that's radically different from it's intended use. It is an unconventional user-type placed squarely outside the map, and beyond the industry's traditional usage of products, technologies or services. As with lead users, the Extreme User must have a strong need and a creative impulse to do something about it, but as an innovator he/she will be changing the rules of the game, forcing the innovation process outside the map. Extreme users articulate needs and solutions outside products and their uses.

The molecular gastronomic revolution spearheaded by the Catalan restaurant El Bulli, is an example of extreme user innovation. By combining advanced chemistry with the culinary arts, produce, meat and spices was subjected to uses never intended, and chemical processes were used in contexts never thought to be within chemistry, providing the world with new extraordinary tastes and experiences.

Involving the arts, a number of inspired and inspirational initiatives have been experimenting with the artist as an extreme user. In the 1960's Bell Lab initiated what was to be know as E.A.T. (Experiments in Art and Technology), started by engineer Billy Klüver together with artists Robert Rauchenberg and Robert Whitman involving artists in new technology development. The concept was expanded at Xeros PARC where an artist-in-residence program in the 1990s teamed artists with software developers. And

Claus Carstensen
Membran, 2012

in the last 20 years several experiments have engaged these radical approaches. V2_lab, a aRt & D (aRtistic research & Development) lab in the Netherlands, experiments with bringing artists into interdisciplinary technological innovation and realization. The Interactive Institute is a Swedish experimental IT research institute that combines expertise in art, design and technology to conduct applied research and innovation, product development and spin-off companies. At ARS Electronica Futurelab, (Austria) artists and researchers work on joint 'shared creativity' projects and commissioned assignments involving clients worldwide. And Futurelab brings together computer artists, computer scientists, physicists, media and product designers, architects, game developers, telematics engineers, sociologists, art historians and scholars.

The PRIMI-project is a prime example of this way of thinking. The project is an attempt with a new productive form of user-innovation based on casting the artist and designer in a role as radical lead users or as "Extreme Users" in a collaboration with art conservators. Art conservators articulate the extreme use of the artist by gaining and formulating unique knowledge about the life of the material and it's properties as they deal with the unintended consequences of artists' extreme usage of materials and processes. Museum law actually demands that conservators must deal with this, as part of a museum's public financing. This unique blend of extreme use and the scientific analysis and knowledge embedded in the conservator, gives the project it's unique value to both the plastic industry and the museums.

The key to success is the combination of the artistic extreme usage of materials and the applied material research. It is thus very different from traditional "art and business" attempts of transporting artistic processes into companies. By focusing strictly on plastics and on the material knowledge embedded in the art conservation research, the project demonstrates how art can bring insights and value – not as the abstract art insights traditionally promoted by the art institutions, but on a very real and practical level. PRIMI's extreme usage value chain of plastics researchers, plastic producers, application producers, artists and designers, museums and art conservators, is a value chain never realized in the industry due to it's weird and marginal practice. But focusing on exactly these weird relations brings out new perspectives, new collaborations, and new insights.

Creativity and co-creation needed to counter business-as-usual.

The financial crisis has made it very clear how unpredictable and complex the global interconnected system is. Managers all over the world are facing ever-increasing pressures caused by rapid changes in technologies, consumer attitudes, and globalization. Being able to navigate in the sea of change requires whole new competencies and attitudes to management.

Tomorrow's leaders are asked to be innovative and creative; they must display integrity and courage, be able to make the right decisions and stand up for them; and they must be open and sharing, able to co-create with the world around them. In a recent research project, IBM's intelligence unit interviewed 700 global HR-directors and found the above competencies to be the most wanting in managers.[3]

Balancing the everyday pressure to control, plan and map with this new urgent and outspoken need for innovation, companies must look for new ways to innovate.

Extreme User innovation provides a pathway to weird knowledge and opens up new perspectives. Identifying and bringing together marginal or hidden value chains of extreme users may be the antidote to business-as-usual.

Notes

1 www.ebst.dk/brugerdreveninnovation.dk

2 First introduced by the author in his key note speech at the conference "Permanence in Contemporary Art – Checking Reality" at The Royal Danish Academy of Fine Arts, in 2008.

3 IBM Institute for Business Value, Cultivating organizational creativity in an age of complexity, 2011

Photo courtesy of Solvay/SolVin

Claus Carstensen
Membran, 2012

Breathing Plastic

Contemporary art conservator Louise Cone, Department of Conservation, Statens Museum for Kunst, explores the nexus of the PRIMI project: the specific challenges related to the preservation of the plastic artworks investigated by the project team.

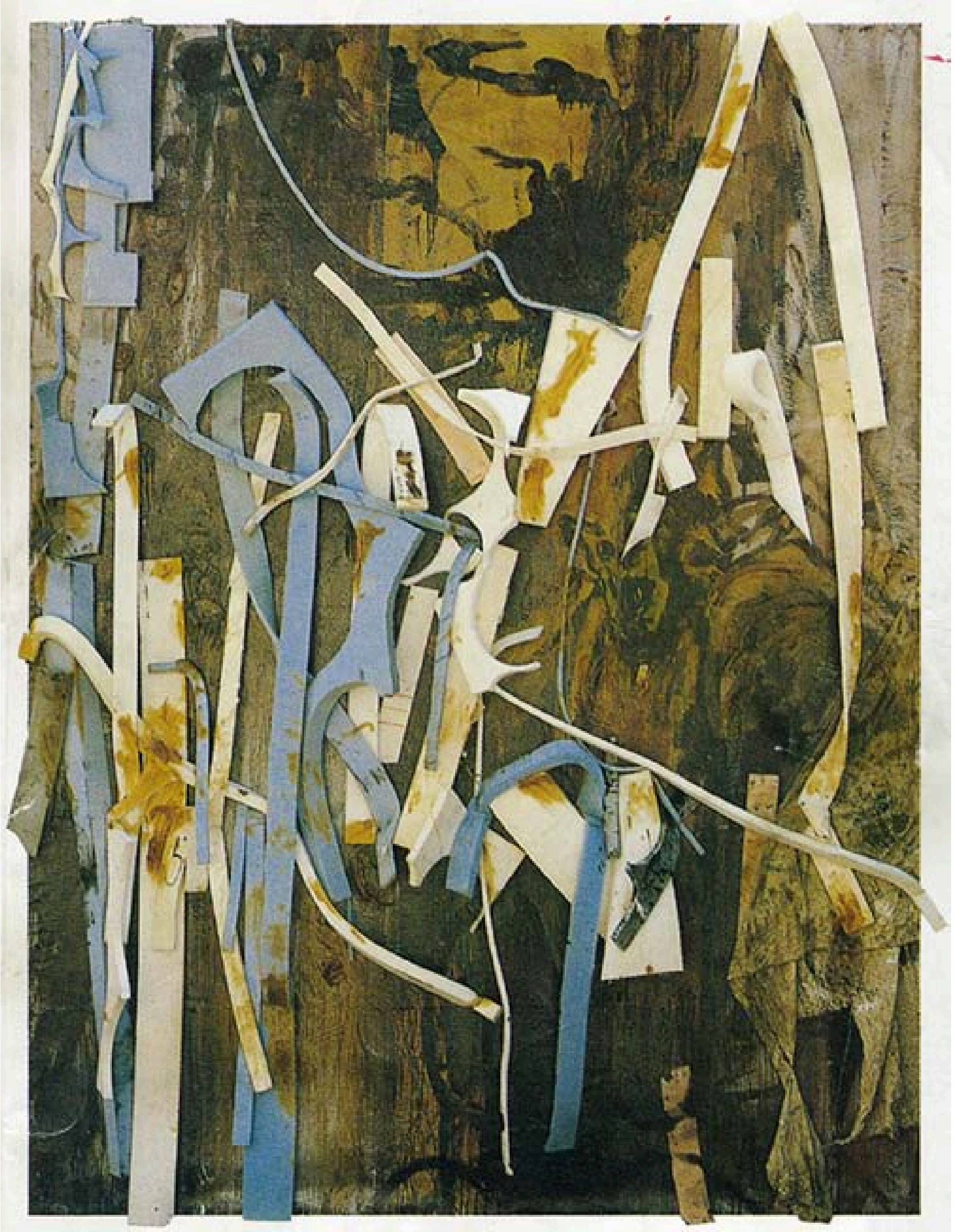
In 1986 Claus Carstensen (b.1959, Denmark) created what would later become a vital work in the contemporary collection at Statens Museum for Kunst. The work *Ethereal body* is a composite work consisting of soft polyurethane foam, grease, paint and urine on canvas, and was never intended to last. The artist states in a recent interview at the museum about this work:

'...The work was originally conceived as a kind of implosive institution criticism; a kind of Trojan horse is acquired by an art museum or another public cultural institution and subsequently begins to decompose. It was not the intention that it should hang in a museum today...'

The work not only hangs in the museum today, but is categorized as a work imbibing 'unique cultural significance', a status shared with works in the older part of the collection such as Andrea Mantegna's impressive *Christ as the Suffering Redeemer*, ca. 1495-1500, or the Golden Age painter C.W. Eckersberg's *View of the Garden of the Villa Borghese in Rome*, 1814.

Ethereal body is, though, starting to live up to its name: the foam pieces hanging on the work have changed colour, from blue and white, to green and yellow. Some of the surfaces of the polyurethane foam are also starting to crumble. Today, 26 years on, the foam pieces in this work are reaching their life expectancy.

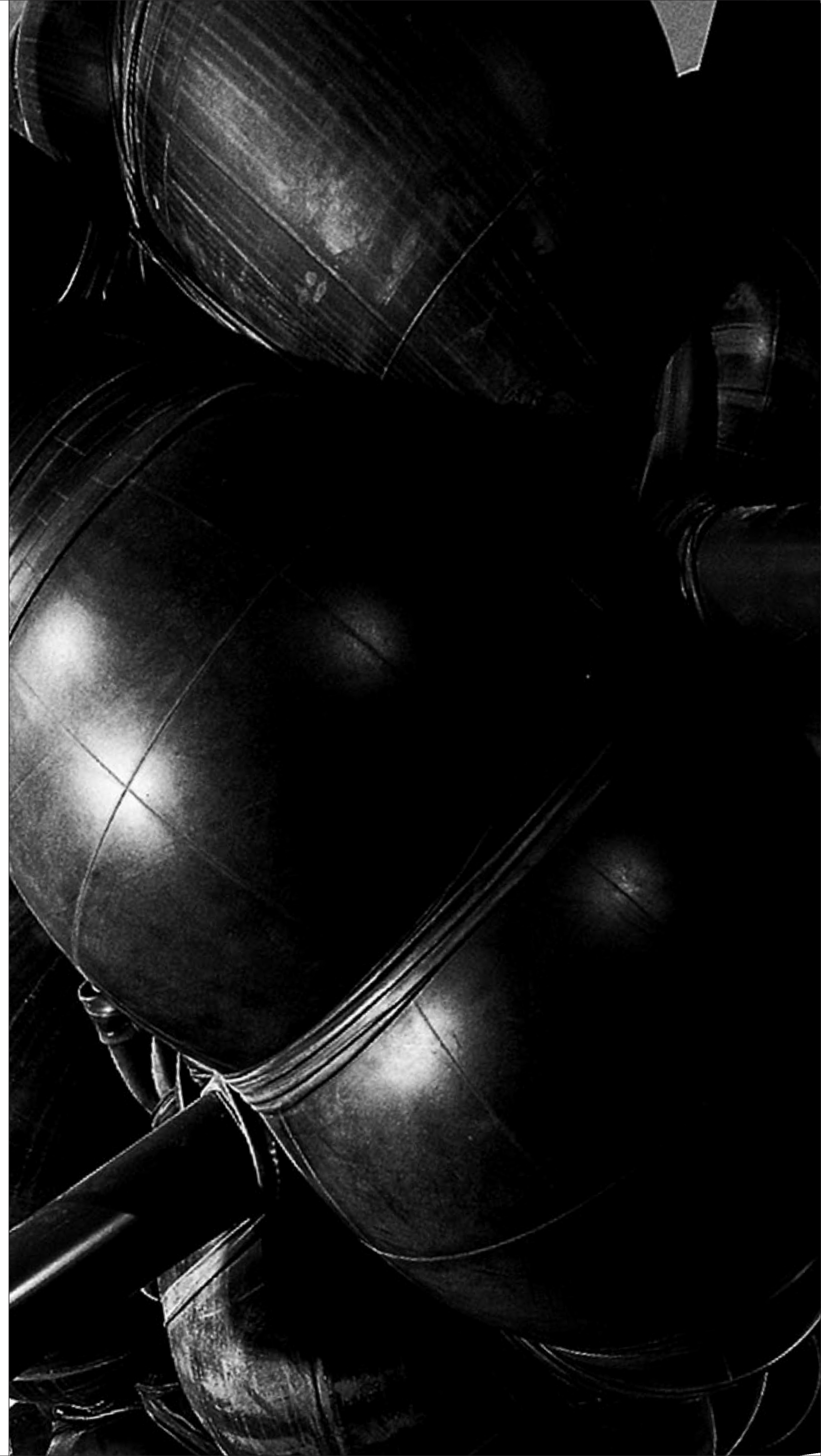
Ethereal body has been a central object to the PRIMI project. Not so much for the conservation work it has received (or not received, read on), but for the discussions it has spurned regarding the implications material degradation or damage can have for the appearance of the work, its impact on the viewer, and for its future existence. Questions



Claus Carstensen *Ethereal body*, as seen in 1986.
Photo: Statens Museum for Kunst.

Ethereal body, 2012.
Photo: Statens Museum for Kunst.

Bjørn Poulsen
Longing for Space Travel



have been raised as to why colour changes of plastics are not regarded as 'patina', but as signs of decay, and how this subsequently impacts on the interpretation of the work regarding its meaning as well as its status. The following quote from Carstensen is taken from an interview with the artist about his postion regarding conservation of the foam pieces:

'…The physical transience plays a crucial role. A, quite deliberately, built in decomposition process in the work, in that the foam rapidly begins to discolor and become porous when exposed to sunlight's ultraviolet rays… What I would suggest is that you – as long as I can be consulted – preserve the work sensitively and mechanically (bring fallen foam pieces back in place, dusting it, etc.). When the work is in such bad condition that the restorer's hand can no longer even make do with gentle and mechanical preservation, I suggest that, in consultation with me, we make a complete replacement of the foam elements, which are the most fragile and porous parts of the work. This is relatively easy to make, as there were photographs taken of the work the same day it was made. Under no circumstance should you start experimenting with protective coatings in the form of paint, spray, etc., as it probably will only prolong the inevitable – a complete replacement of the foam elements. Concerning preservation of the other parts of the work, I would suggest the conservator comes with a suggestion, which I am then consulted about.'

Conservation, in the case of *Ethereal body*, and contemporary art in general, will always be dependent on the views of the artist and how they view the consequences and impact of the physical changes affecting their works. In this case, Carstensen's decision not to make use of techniques available to prolong the life of the foam forces us to witness its transformation and ultimate disintegration. If a total reconstruction of the foam pieces is undertaken, we have the chance to treat the new foam before we attach it, an interventive conservation treatment that would certainly prolong its life expectancy.

Carstensen does not want the foam to be given a protective coating to delay degradation, even though one such treatment for polyurethane (PUR) foams has been developed by conservators together with senior conservation scientist Thea van Oosten, at the Netherlands Cultural Heritage Agency (RCE) in Holland. The polyurethane (ether foam) is misted with a consolidant which fills the brittle cells of the polyurethane, bridging them together. The consolidant is a polyether dispersion of aliphatic isocyanate (Impranil® DLV) in isopropanol and water, with Tinuvin®[1] added as an antioxidant.[2] Consolidants have been proven effective in the fight against the degradation of polyurethane foam, even though you are only prolonging the inevitable. We can expend the life expectancy of the foam, which, in this case, means less interference and changes to the work as a whole over time.

Generating valuable knowledge

Within the scope of the PRIMI project the work done at the RCE is a prime example of how, through the need to prolong the life of art objects, innovative techniques are being developed by conservation scientists together with conservators, which have potential applications outside the field of art. Can conservators use their knowledge and observations regarding the degradation of plastic to incite and feed the work of both artists and researchers/developers in large plastic manufacturing plants? Similarly, can conservators gain useful information and incorporate working methods used by the artists and manufacturers in their work with conserving plastics?

During the course of the PRIMI project, focus has been placed upon the exchange of knowledge between artists, conservators, polymer researchers, plastic manufacturers, and representatives of the huge branch organisations representing plastics in Europe.

The question is whether this interaction can lead to a real exchange of valuable information – making the conservation department an active player possessing knowledge about, for example, the real-time aging of plastics, techniques for repairing them, and ways to protect them from premature aging. Valuable information in a time where more focus is being placed on sustainability, and control of limited natural resources.

Fighting the idea of planned obsolescence

Back in the 1930's when nylon was invented as a substitute for pricey silk stockings, the original quality was so excellent that the nylons never ran, thus halting sales. The engineers were ordered to make the nylons less durable, so that they wouldn't last. The *made to break culture* was thus born and has dominated the way many items are produced today. Many manufacturers produce items – purposefully – in a lesser quality, and we don't expect certain products to last. Planned obsolescence has dominated the western world's way of thinking and doing business and our relationship to objects. In attempting to conserve artworks made of plastics, we need to understand the consequences that planned obsolescence has for the artworks in our care. We need to challenge the underlying presumption that works of art made of plastic are diametrically opposed to conservation, even though some of the plastics used to make the artworks have a prescribed lifespan. The average artificial ageing test done by plastic manufacturers is geared for a 5 year period. The museum world has a much longer time perspective when it comes to preserving their collections, where 100 years is not unusual.

Artists have been using both hard and soft plastics for quite sometime now, for designers even longer. In the art world maybe the best known early use of plastic was the constructivist artist Naum Gabo's sculptures from the 1920's and 30's, made of styrene and later Plexiglas. By the 60's the use of plastic was widespread among artists. Artists such as the sculptor Claes Oldenburg were experimenting with the use of plastic, and designers such as Verner Panton were making trendy objects for everyday use.

A trip to IKEA

A trip to IKEA for the artist Bjørn Poulsen (b. 1959, Denmark) is a different experience than it is for most. The artist finds many of his materials in the everyday mass produced items sold there. He groups them into colours and uses them in his art. The artist works mostly with rigid plastics such as poly methyl methacrylate (PMMA) as well as melamine (melamine-formaldehyde) (MF), or rigid poly vinyl chloride (PVC). His monumental work entitled *Univers* is an example of such a collage of plastics, consisting of parts of everyday plastic household objects. The artist says about this work:

'… it is composed of fragments of various bowls, gutters, toys, buckets, etc., which are all screwed together. The middle of the sculpture is covered with a layer of clear blue acrylic, resulting in a bubble-like structure…most of the plastics are made of hard PVC, which has a long lifespan. I don't expect it will last forever, but at least 20-30 years as things look today. This work was made before my involvement with PRIMI, so when I made it, I had no idea that problems could occur with this work within my lifetime. As long as I am alive, parts

Bjørn Poulsen
Longing for Space Travel

Poulsen
ging for Space Travel

The relief, entitled *Univers,*2009, is 13 meters long, and is installed at the DNC canteen in Aarhus, Denmark. Photo: Bjørn Poulsen.

can be changed without trouble. It is highly unlikely that we could make a identical recreation, but only a form of re-interpretation, depending on what type of plastic I will be able to get at the time. It would be difficult for a conservator to recreate it without my presence, but everything is, in the end, a question about resources...'

Bjørn Poulsen in action with his axe, cleaving some *Margrethe* bowls over. You can see the sculpture *Navigator* in progress in the background. Photo: Bjørn Poulsen.

Bjørn Poulsen's expectations for a 20-30 year survival rate are more than likely. As he suggests, hard plastics have a longer lifespan than, for example, soft plastics. But they are susceptible to other types of problems such as stress cracking where the plastic is bolted together, crazing on the surface from interaction with improper cleaning fluids, and of course graffiti, scratches, or other types of damage including vandalism. With plastics, as with many types of materials, it is not always about chemically induced degradation and damage, but also about mechanical damage. In a work such as this with so many different types of plastics, there may be some plastics showing signs of mechanical damage, such as stress cracking, and others showing signs of chemical changes, such as colour changes, before others.

The Danish 'Margrethe skål', a bowl designed in 1954 and named after the present Queen of Denmark, is commonly used by Poulsen. The bowl is made of melamine (melamine-formaldehyde) (MF), which the artist cleaves into pieces. The artist then rivets or screws the plastic pieces together to form large sculptural works. The artist talks about why and how he uses melamine:

'In many modern works of art, there is an element of destruction; existence is not just a walk in the park. Destruction is an important element in the sculptures I have created out of Margrethe bowls. These expensive designer objects become destroyed by being cleaved over by and axe. However, it's not only about the destruction. Out of the ruins many fragments are created, which I can use to screw the sculpture together with. I can, by the way I place my cut, determine rather precisely which part of the bowl will become visible. Melamine is, in this instance, very well suited, in contrast to acrylic, which splinters uncontrollably...'

Many hard plastics, like melamine, are typically thermosets and have no added plasticizer. Damage is characterised by breakage, scratches and crazing, but are, as mentioned above, generally more stable than plastics with added plasticizer. Plexiglas®, poly (methyl methacrylate) (PMMA), better known as acrylic, and rigid poly (vinyl chloride) (PVC), melamine-formaldehyde (MF), polystyrene (PS), polyester (PE) and acrylonitrile butadiene styrene (ABS) are just some of the hard plastic types available, which are being used by artists today.

The soft stuff and inflatables

Some flexible plastics get soft and pliable through the introduction of plasticizers, and poly (vinyl chloride) (PVC) is the polymer that needs it the most.[3] By contrast, polyethylene Tupperware containers require no plasticizer to be soft. Plasticized PVC can consist of up to 50% plasticizer. The plasticizer used most often to soften PVC is a phthalate but there are other plasticizers on the market today[4] (such as Danisco's vegetable-oil based Grindsted® Soft-N-Safe).

Nonetheless flexible PVC is widely used by many artists and designers today. Another plastic, the polyurethane foams, (PUR), (as seen in Carstensens *Ethereal body)*, ethers and esters, are also used extensively by artists, both in their flexible and rigid forms.

Tomas Saraceno (b.1973, Argentina) presented, in 2010, a large-scale

Tomas Saraceno *Biospheres*, plasticized PVC, acrylic,rope, pumps, plants, water.
Installation view from 2010, Statens Museum for Kunst. Photo: Statens Museum for Kunst.

installation of works made of flexible PVC and acrylic at Statens Museum for Kunst entitled *Biospheres*. *Biospheres* is an attempt to create alternative inflatable living spaces, suspended in the air with systems installed for watering and airflow. Saraceno's inflatables are especially challenging: some being extremely large, or filled with water and/or plants. Questions about how to repair holes, decrease the rate of diffusion, keep the plastic from discoloring and keep algae from forming have all been addressed in the PRIMI project, and are relevant not only to specific artworks such as Saraceno's *Biospheres*, but to many artists and designers who use flexible PVC to create inflatable objects. Finding methods to preserve, store, repair, and keep inflatables functioning and looking good, are all growing challenges in the art and design world. The question of functionality and inflatables is not exclusive to newer works. In the 1960's the concept of pneumatic art gained in popularity.

1960's-1970's

Historicity plays an important part in the work of the conservator and conservation scientist and there are many ageing artworks made of plastic in art museums, design museums, and museums of cultural history, which can allow us to observe the effects of real-time ageing on objects. The effects of ageing or degradation vary and can be influenced by the type of plastic, the use of the object, and the environmental conditions it has been subjected to. The Danish artist, Willy Ørskov, (1920-1990, Denmark) created, during the late 1960's and early 1970's, a large series of pneumatic sculptures. These works were made of nylon lined with rubber, a material typically used, at the time, for making life vests. The works are inflated by way of a valve glued onto the sculpture. Statens Museum for Kunst owns a series of these works entitled *Bøjninger* (*Bendings*), which now, after 40 years, are failing. The rubber lining inside the inflatable sculptures has unfortunately deteriorated, separating from the nylon and making it impossible for the sculptures to hold air. Many ideas have been suggested as to how to solve this difficult problem, and it was agreed to attempt to create an inner bag lining, which would imitate the function of the work, while at the same time preserving the works authenticity. A coated polyester barrier film was used to create airtight inflatable inner linings for the works. This is still a work in progress, and the questions which have been raised while working on these sculptures, have turned out to be extremely relevant for artists and technicians working on inflatables, including tests to discover which plastics work best as oxygen barriers while at the same time being flexible and easy to weld.

In 1969, the Danish artist Peter Louis-Jensen (1941-1999, Denmark) made a series of works in flexible PVC entitled *Flag*. These works were, upon creation, hung in an exhibition at 'Den Frie', ex-

Detail of inner balloon lining with valve, for one of Willy Ørskov's, *Bendings* (foreground). Photo: Statens Museum for Kunst.

Willy Ørskov, *Three Large Pneumatic Sculptures Bent at an Angle*, 1970, from the series *Bendings*. Photo: Statens Museum for Kunst.

Detail, *Flag*, Peter Louis Jensen, 1969, damaged, brittle, and cracked PVC before conservation. Photo: Statens Museum for Kunst.

hibition space in Copenhagen. *Flag* was a part of a political manifest and was closely tied, as was the artist, to the 'experimental school' (eks-skolen, ed.).

Statens Museum for Kunst acquired two of the *Flag* works, both made of plasticized PVC and from 1969. In one of the works (both entitled *Flag*), the clear PVC is sewn together to form a pouch and a piece of burlap, the size of the bag, is placed inside the PVC pouch. *Flag* has horizontal and vertical pouches sewn into the plastic, which contain sand.

The condition of the work upon acquisition in 2001 was far from good. The plastic was brittle and cracked, causing most of the sand to escape. The handsewn edges had, in many places, become undone. The plastic was analysed by Fourier transform infrared spectroscopy (FTIR) which confirmed that it was indeed PVC with a phthalate plasticizer. The brittleness, and slight yellowing, is due to the plasticizer migrating out of the plastic and oxidation. *Flag* has been restored during the course of the PRIMI project. To restore this work it was necessary to patch the plastic, re-sew some of the seams, replace the missing sand and create a new hanging system that supported the weight of the work, which is now on display.

Breathing Plastic

The artist Søren Dahlgaard (b. 1973, Denmark) participated in the PRIMI project with his works *Breathing Room* and *Hedge*. *Breathing room* is flexible PVC film extended over adjacent wooden frames to form a large semi-closed space. A compressor behind the wall blows air into the plastic, making it distend and converse, as If it was breathing. The artist says this about his work:

'When I develop a new art project, the big picture comes first. After that, in the research phase, I have to find the best way to execute the work, which includes identifying the material (s) which have the best qualities in relation to the works construction, aesthetics, sound, colour, texture, longevity, flexibility, price, weight, etc. In many of my sculptures, paintings and installations, I have used PVC or other types of plastic because of their mate-

Flag after conservation, 2012. Photo: Statens Museum for Kunst.

Søren Dahlgaard, *Breathing Room*, concave. Photo: Søren Dahlgaard.

Søren Dahlgaard, *Breathing Room*, convex. Photo: Søren Dahlgaard.

rial qualities. *The Breathing Room*, is an example of a work, where I had to find a material which looked like a normal white painted plaster wall in texture, but in reality should be a thin membrane which could move from a convex form to a concave form with the help of air. After testing a number of different materials, I found that the PVC film, which normally is used as a film screen, worked best to realize this idea. '

Plastic film, be it PVC or another type of plastic, is used by a number of artists in their work. Plastic films or sheets are susceptible to wrinkling, creasing, holes and rips. In the case of *Breathing Room*, as well as in other works by Dahlgaard done on plastic film, he is challenging the normal applications of PVC sheeting, as well as exploiting its characteristic flexibility and relatively low rate of diffusion. The artist has been addressing how to keep the PVC from becoming deformed when packed away for storage, a problem far greater than it sounds, as the plasticizer in PVC will move causing the plastic to take on the shape of any bump, fold or object it is pressed against. This problem has been seen in numerous other artworks on plastic sheeting, many which the artists have also painted upon, and attempts to re-smooth the surface have been partially successful with the use of heat, pressure or suction, moving the plasticizer back in place. Fixing holes and rips is equally challenging, and patching a smooth blemish free surface is the equivalent of retouching a monochrome painting – extremely challenging. One of the industrial partners in the PRIMI project, Papyro-Tex, a large manufacturer of PVC sheeting, was helpful in suggesting ways to solve these particular problems, something they had not addressed before.

Painting on plastic surfaces

The closed surface structure of plastics is generally not seen as a suitable painting ground, but is, nevertheless, being used by many artists today who are using plastic sheeting as their 'canvas'. The example presented below is not exactly paint on flat sheeting, but the problems the artists encounter with adherence are very similar. Dahlgaard paints a plastic polyethylene privet hedge with acrylic paint and sprays it with numerous layers of cellulose nitrate car paint. The paint comes off in flakes when the hedge is touched. When the flakes fall off, the top layer of the polyethylene leaf is also removed. If the paint falls off both sides of the leaf, it appears nearly transparent.

The artists about his work *Hedge*:

'For this 3-dimensional landscape painting, I had to find a plastic hedge, which resembled a privet hedge. After much research, I found it in China. The problem was to find out what kind of paint would bind to the surface of the hedge, because plastic has the type of surface, which repels most types of paint. The Senior Research Scientist at National Museum, Yvonne Shashoua, identified the type of plastic the hedge was made of as well as its properties. She also could tell me what types of paint would bind to the plastic hedge.'

The hedge was analyzed using FTIR. Senior Research scientist Yvonne Shashoua says about this work:

'Analysis suggested that Søren's hedge is made from polyethylene, the same plastic as Tupperware containers, which has a chemical structure similar to wax. As a result, paint does not adhere well to it. The acrylic paint he has used is water based and less flexible than polyethylene when dry. It therefore flakes and peels off when the leaves are handled. When it peels, the upper surface plastic layers and colour of the leaves are also removed. To improve adherence of paint to polyethylene, the waxy surface should be abraded just prior to painting to give a key to the paint. Polyethylene is not soluble in solvents used in paints and therefore cannot be partially dissolved to improve adhesion as other plastics can e.g. polystyrene.

Søren can either order plastic hedge in the desired colour instead of painting it, he can abrade the leaves prior to painting to improve adhesion, or he can use hedge produced from another type of plastic.'

This kind of knowledge is incredibly valuable for the artist. Here, he is

Søren Dahlgaard in action painting one of his landscape painting s entitled *Hedge* from 2008, at the park at Louisiana Museum of Modern Art. The artist is dressed as 'The Dough Warrior'. Polyethylene, acrylic, cellulose nitrate paint, and bread. Photo: Søren Dahlgaard.

Housepaint adhered poorly to the waxy surfaces of polyethylene hedge leaves and flaked on contact. Photo: The National Museum of Denmark.

given some real information about the material he is using, as well as what he needs to do to make it work in the way he has envisioned. The PRIMI project was all about this type of interdisciplinary exchange. However, the questions being asked were not just answered to satisfy the artists' curiosity about materials, they were addressed to a larger audience: what can our industrial partners learn from this type of material experimentation, problem solving, and analytical rebuttal? Instead of looking at this product as a fixed 'product', with defined usages, the manufacturers could be looking at the potential for innovating their product, both in terms of product development and in terms of marketing.

Design

Finally, what would the design world do without plastic? Tupperware, computers, telephones, toys, lamps, utensils, furniture; an endless line of products all made of different kinds of plastics with different properties. Unlike most art, design products are mass-produced, and mass distributed. Designers Christian Flindt (b. 1972, Denmark) and Bodil Jerichau (b. 1957, Denmark) were both involved in the PRIMI project. As designers, product development involves finding the right products to realize their design ideas. As opposed to the previously mentioned *made to break* product design, the designers of high end products are looking for products with lasting value. They are also looking for inventive ways to exploit existing products and enter into collaborations with manufacturers. The PRIMI group held an idea exchange workshop with a large European plastics manufacturer, Solvay[5], with some interesting results. Flindt and Jerichau state:

'Along with the PRIMI group we visited SolVin/Solvay in Brussels. They have developed some fiber reinforced PVC sandwich panels, which are lightweight, strong and are thermoplastics (reversible process – can be heated and reformed, ed.). Ordinary glass fiber consists of glass fibers and a thermoset (irreversible process, ed.), thus having a fixed form. However, when the glass fiber strands are mixed into PVC, you get a product, which on subsequent heating can be thermo-formed (thermoplastic, ed.). SolVin is in the process of developing this product – in the form of sheets in varying thicknesses. They make it as a sandwich construction out of 2 layers of fiber plastic plates with a third, slightly thicker plate with a honeycomb form. This gives a very light and strong construction which can still be thermoformed. Since we are in the process of developing sound absorbing panels in organic forms, we thought it was an interesting product to try and work with. Product development takes time, but participation in PRIMI has revealed a new material to us, and a new market for SolVin...'

The experiences of Flindt and Jerichau point to a potential product development brought on by the cross-fertilization of ideas. Using a thermoplastic polymer to make lightweight, ther-

Back side of the sound absorbing light panels designed by Flindt and Jerichau, showing the honeycomb PVC sandwich panel. Photo: Flindt / Jerichau.

mally formable honeycomb panels, is definitely an innovation on the part of SolVin – a new product called *Nidacell®*. The designers see –immediately- other usages for these panels than what SolVin has already considered (transport carriers, insulation, shock absorbtion, etc.). This information can be used by the company to market their product to a whole other set of customers, while the designers are now able to create their sound absorbing light panels in a much easier and cost effective way.

This article is a short summary of just some of the case-based challenges we have been working with in the PRIMI project. The author would like to thank all the artists, designers, scientists, conservators, and industrial partners involved in the project for their insightful comments and inspirational thoughts.

Notes

1 Tinuvin® is a UV light filter and stabilizer.

2 Van Oosten, Thea. 'PUR facts: Conservation of Polyurethane Foam in Art and Design', University of Chicago Press Books, 2011.

3 Shashoua, Yvonne. 'Conservation of Plastics: materials science, degradation and preservation', Elsevier Ltd, 2008, pp. 59-89.

4 Phthalates are esters of phthalic acid and are mainly used as plasticizers (substances added to plastics to increase their flexibility, transparency, durability, and longevity). They are used primarily to soften polyvinyl chloride (PVC). Phthalates are being fazed out of many products in the United States, Canada, and European Union over health concerns.

5 SolVin / Solvay, situated in Brussels, Belgium, is a leading global producer of PVC and specialty plastics, and the leading European producer of PVC.

Who's Who

Bodil Jerichau
Bodil Jerichau is a textile designer from Copenhagen, Denmark. Bodil works as a freelance textile designer of interior textiles in both woven and other textile techniques. She works together with numerous designers, architects, and companies on developing lightning, furniture and other interior objects, as well as advising designers and companies on the use of textile materials.

Jørgen Wadum
Prof. Dr. Jørgen Wadum works in the field of conservation & restoration and technical art history. Wadum is Keeper of Conservation at SMK and Director of the Centre for Art Technological Studies and Conservation (CATS), a research consortium between Statens Museum for Kunst, The National Museum of Denmark, and the School of Conservation at KADK, Copenhagen, and he is chairman of the Department of Conservation & Restoration at the Faculty of Humanities at the University of Amsterdam and has published and lectured extensively internationally on a multitude of subjects related to technical art history and other issues of importance for the understanding and keeping of our cultural heritage. Wadum holds positions in several international organisations and committees.

Ole Grøndahl Hansen
Ole Grøndahl Hansen is Master of Arts in literature from Copenhagen University. Since 1995 General Manager of PVC Information Council Denmark - a knowledge center for the widespread plastic material PVC financed by industry. In dialogue with different stakeholders, the council seeks to communicate about the role of PVC in modern society and deal with the challenges the material has in respect to sustainability. Ole Grøndahl Hansen is project manager of PVCMed – an alliance of international companies which seeks dialogue with stakeholders about the use of PVC in health care. He is a member of VinylPlus Communication Commiteee, the advisory board of European Medical Device Technology and board member of the Danish PVC recycling association WUPPI.

Claus Carstensen
Claus Carstensen is an artist, writer, and curator based in Copenhagen. He studied Comparative Literature at The University of Copenhagen and art at the Royal Danish Academy of Fine Arts, where he also taught as a professor from 1993 to 2002. From 1981 to 1983 he paticipated in The Psycho-Semiotic Circle of Copenhagen. In 2004 he taught as a guest teacher at Otis College of Art and Design in Los Angeles. He has exhibited at the biennales of Sydney, Sao Paulo and Venice and is represented in a number of large museum collections, both in Denmark and abroad, among others Universalmuseum Joanneum, Graz, Kunstmuseum Liechtenstein, Vaduz, Statens Museum for Kunst, Copenhagen and ARoS, Aarhus.

Louise Cone
Louise Cone is a fine arts conservator. She has been working at The National Gallery of Denmark since 2005, specializing in the field of contemporary art conservation as well as being in charge of the museums sculpture collection. Louise holds a degree in Fine Arts from The School of Visual Arts in NYC, as well as a Masters degree in Conservation from the Royal Danish Academy of Fine Arts, School of Conservation. She was project leader for the PRIMI project.

Yvonne Shashoua
Yvonne Shashoua is a Senior Researcher at the National Museum of Denmark specializing in modern materials and investigating the degradation and conservation of plastics.

After graduating in industrial chemistry, she worked as a paint technologist for Berger Paints in England. She joined the British Museum as a conservation scientist in 1988, where she worked for 10 years. Yvonne holds a PhD in polymer chemistry, and is the author of numerous scientific publications about the conservation of plastics, including a monograph 'Conservation of Plastics-materials science, degradation, and preservation' published by Elsevier in 2008.

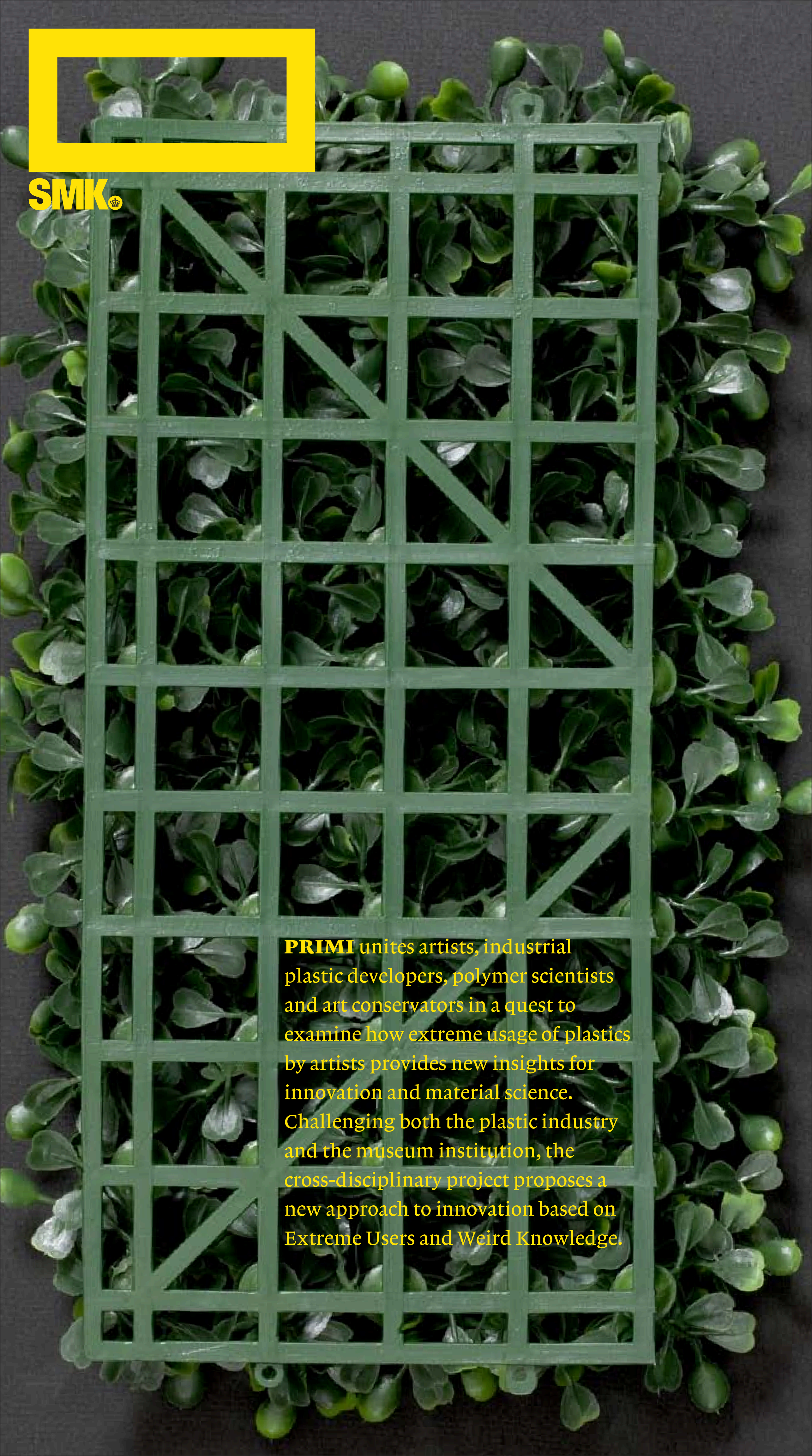
Lars Lundbye
Lars has extensive experience in both business, leading several companies, and in the arts as a former curator. With an executive MBA and a Masters in Literature, Lars excels in crossing borders between technology, business development, and experience design. He is an expert in innovation and advises global companies and organizations on innovation, experience economy, and sustainability. Lars was the idea generator behind the PRIMI project, and drove the innovation processes.

Christian Flindt
Christian Flindt is an industrial designer based in Copenhagen who studied architecture at the School of Architecture in Aarhus, Denmark. Christian has won a number of prestigious design prizes and competitions. His design objects are exhibited and sold globally.

Bjørn Poulsen
Bjørn Poulsen is an artist based in Copenhagen. Bjørn studied sculpture at The Royal Danish Academy of Fine Arts. He has received many grants and awards for his work, among them from the Danish Ministry of Culture. Bjørn is represented in museum and private collections, such as Kunsten in Ålborg, Carlsbergfondet and Statens Kunstfond. He has exhibited extensively and is represented by Gallery Møller Witt.

Søren Dahlgaard
Danish artist Søren Dahlgaard currently lives in Copenhagen. He graduated from the Slade School of Art London in 2002 and since then has been developing a body of work that stems from 1960s practices, such as Conceptualism and Land Art. Dahlgaard has shown at The National Art Gallery in Copenhagen, MoMA/PS1 in New York, Singapore Biennal, Vancouver Biennial, Louisiana Museum of Art, CCBB Art Center in Brasília, Aarhus Art Center in Denmark, Galerie Civica Trento in Italy, and at The Digital Art Center in Israel.

Karen Marie Andersen
Karen Marie is the Research and Development Manager for the Danish based global company Papyro-Tex A/S, a highly specialised manufacturer of embossed plastic sheeting. She is educated as a chemical engineer, working in the paint and lacquer industry, before joining Papyro-Tex.



SMK

PRIMI unites artists, industrial plastic developers, polymer scientists and art conservators in a quest to examine how extreme usage of plastics by artists provides new insights for innovation and material science. Challenging both the plastic industry and the museum institution, the cross-disciplinary project proposes a new approach to innovation based on Extreme Users and Weird Knowledge.