Appendix 2: Degradation associated with some plastics found during surveys of three French collections

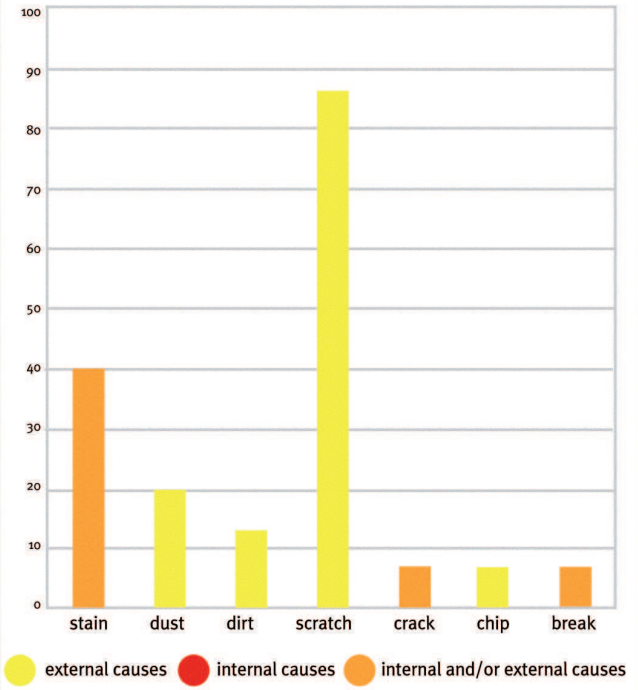
a. Poly(methyl methacrylate) (PMMA)

The surveys illustrate how PMMA is highly sensitive to scratching and dusting in the form of loose or adhering particles.
More than 80% of the objects present important scratches areas, which is the higher amount of degradation associated with any other material. Few examples of major mechanical concerns such as cracks, chips or breaks have been observed, despite of PMMAs shock fragilities.
Deposits of dust and dirt constitute the other significant group of degradation. They include both direct and indirect damages such as stains, which seem mostly resulting of deposits from inappropriate cleanings. Besides, visual consequences of deposits and stains are more important for transparent or translucent materials which form the broader part of the sampling.
No obvious evidence of chemical decay has been noticed.

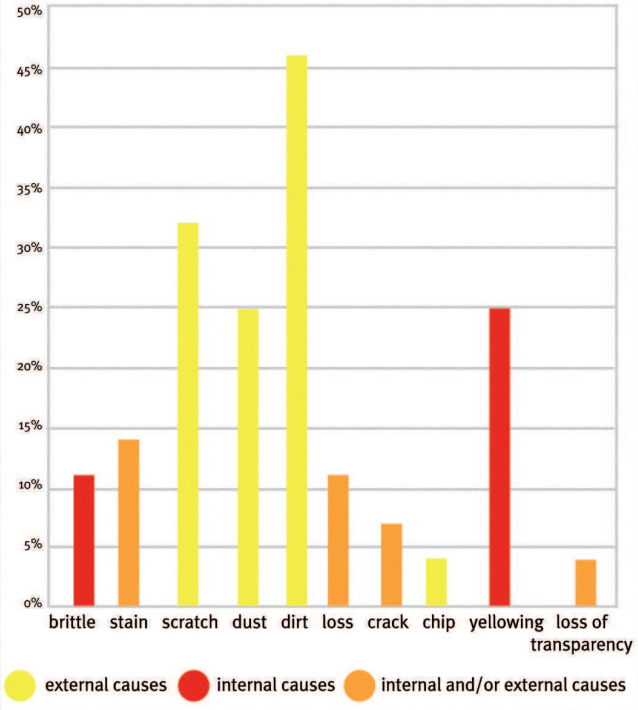
b. Polyesters

The polyester formulations contain a wide range of materials from polyethylene terephthalate (PET) found with recycled bottles to styrene modified polyesters use by some artists to include objects. The greater part of the sampling however is constituted of GRP.
Unlike PMMAs, polyesters showed some evidences of internal process of degradation, though listed as one of the healthiest plastics in the surveys overall results.
Scratches, dirt, dusts and all types of surface damages are the most frequent concerns but the selection contains a large amount of useful and used pieces of furniture that put the data into perspective.
More than 25% of the objects show a perceptible yellowing which is sometimes associated with an overall embrittlement.

a. Type and frequency of important or severe damage (15 objects)



b. Type and frequency of important or severe damage (28 objects)



c. Polyolefins: polyethylene (PE) and polypropylene (PP)

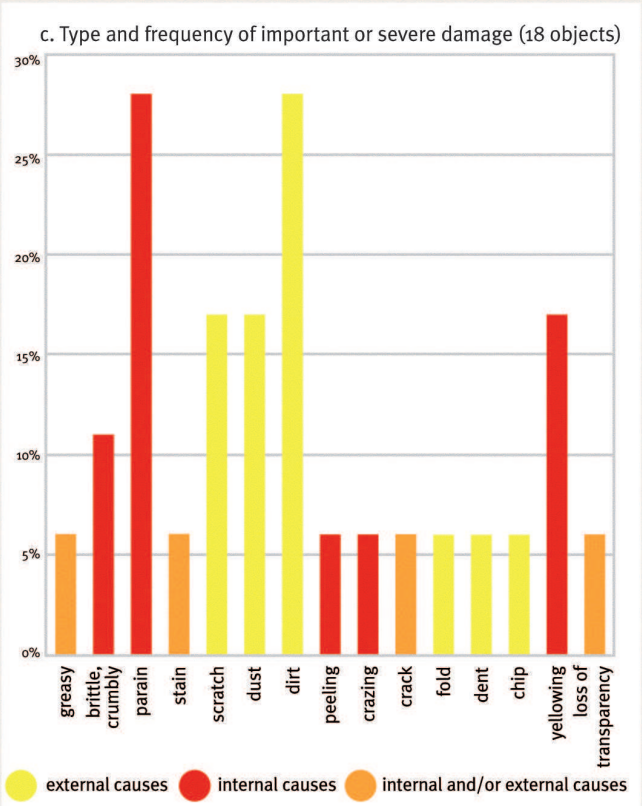
Damages observed on polyolefin objects are more varied whereas signs of accidental damages and internal decays are more or less balanced. Like for other plastics, scratches and deposits are of primary importance and more serious mechanical accidents have been reported, such as dent and chip on rigid materials, or folds on soft sheets.
Characteristic smell of paraffin is also noticed on the most degraded materials. It is often associated with internal decays, such as yellowing, peeling and other indicators of a weakening cohesion linked to chemical degradation process.

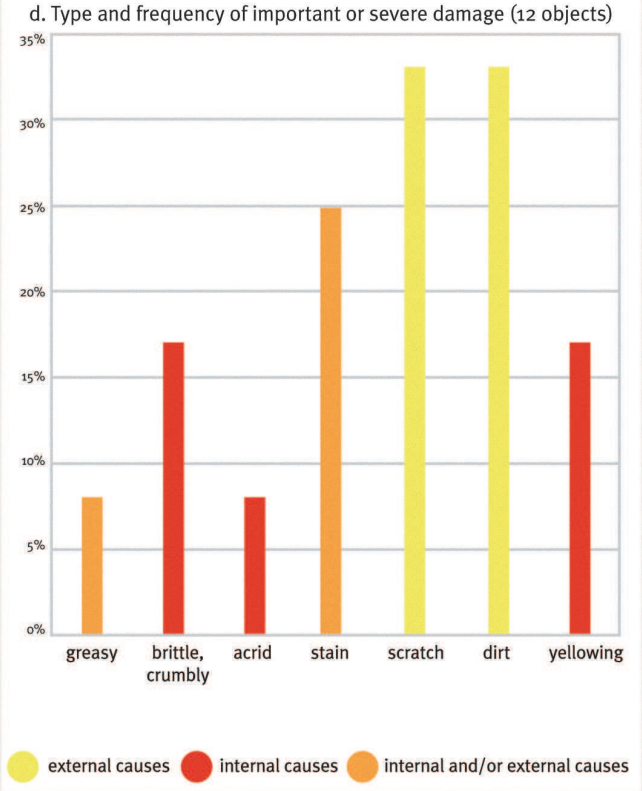
d. Polystyrene (PS)

The polystyrene sampling is made up of recycled objects mainly, which puts the high amount of scratches, stains, dust and dirt into perspective. On the other hand, few important mechanical damages have been observed, neither in the form of crumbling on expanded PS nor in the form of breaks or cracks on other PS, though PS are known to be rigid and breakable materials.
Sign of possible chemical alterations in the form of yellowing have also been noticed on some objects, but the sample size is too small for drawing relevant conclusion.

e. Polyurethanes (PUR)

The group of polyurethane objects is too small to paint a whole picture of PUR condition so that the data presented in the table must be interpreted as a mere indication. Moreover, the sampling contains both foams and imitation leather and both PUR ester and PUR ether which do not present the same conservation issues.
Nearly all the objects show worrying symptoms of chemical degradation though few of them have yet developed severe degradation. Discolouration linked with yellowing are the most common changes observed. They are correlated with a mechanical weakening at its first steps that makes the foams more brittle.



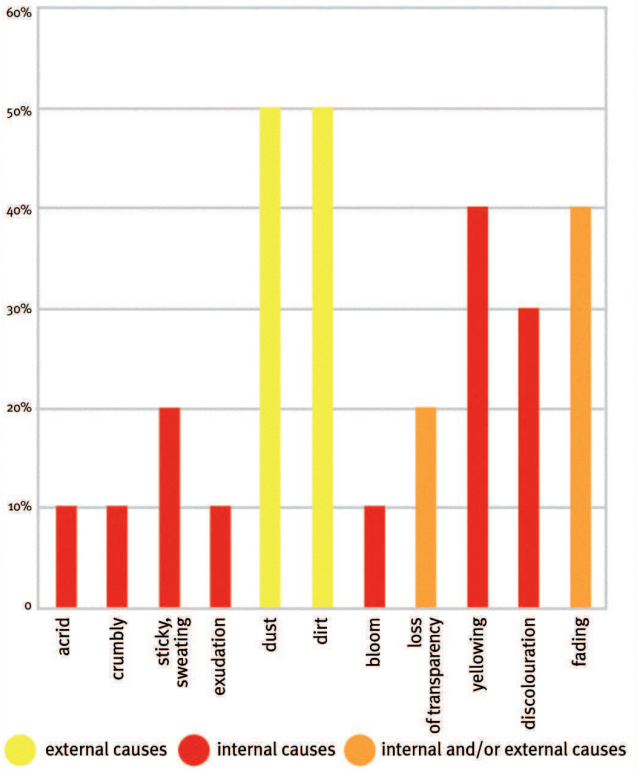


Bloom has also been noticed on the two imitation leather objects whose products were identified twice as resulting from polymer chain scission.
Like sticky imitation leather, porous material like foams are also very sensitive to dust when exposed to the open air. That is why the number of dirty objects is higher than for other any material.

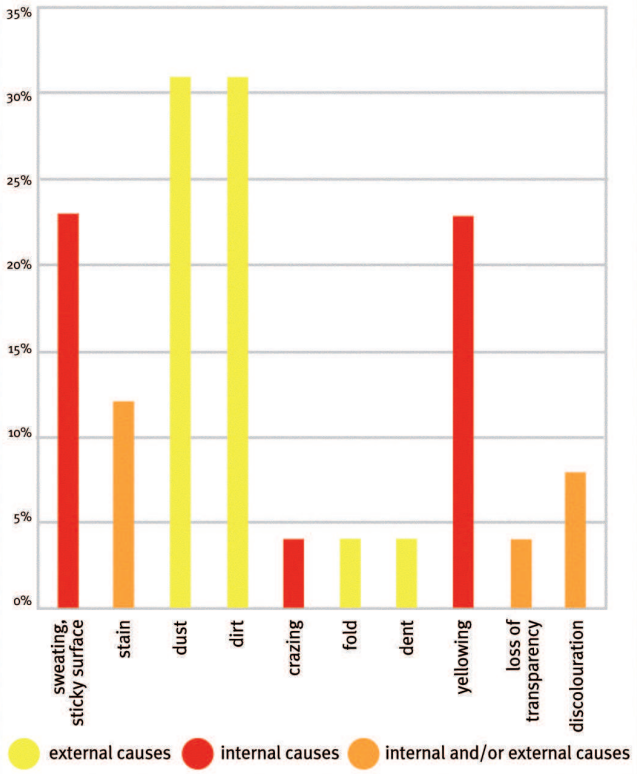
f. Poly(vinyl chloride) (PVC)

Although listed as one of the worst and most unstable materials, plasticised PVCs are widespread in the collections and is the most frequently found in the list of contemporary plastics found in the three museums.
Plasticised PVC is characterised by physical damage due to plasticiser molecules migrating from the matrix onto the surface and resulting in sticky sweating. Thus, the more flexible PVC then the more prone it is to degradation.
The phenomenon has been observed on about a quarter of the PVC samples and is closely related to other markers such as various smells of “plastic” emitted by phthalate plasticisers, whether sweating or not. Smells have not been reported in the table, being too far from the small glossary of odour existing in the condition form.
Some cases of slight bloom have also been observed on the surface of the objects as the result of sweating that has dried .
Obvious yellowing is also perceptible on a quarter of the sample and betrayed some on-going chemical degradation. On the other hand, no obvious evidence of decay attributable to hydrogen chloride evolution has been noticed on materials in the vicinity of the objects, though considered as a pollutant emitted by degrading PVC.
Some cases of secondary degradation due to weeping plasticisers such as dust adhering to the material have also been noticed even if the overall level of PVCs dirtiness is not so far from other materials. PVC sampling is at last distinguishable from other plastics by a low amount of scratches, probably due to mechanical resiliency of the high plasticised material,that can self-heal.

e. Type and frequency of important or severe damage (10 objects)



f. Type and frequency of important or severe damage (26 objects)



g. Cellulose nitrate (CN) and cellulose acetate (CA)

As to be expected, CN and CA present a number of objects and a wider range of degradation which confirms the well-known physical and chemical instabilities of both materials.
Even if scratches are ranked as the most common degradation, accidental damage is strikingly far less numerous than those due to internal decaying processes.
Evidence of CN and CA emitting nitrogen oxides and ethanoic acid (acetic acid) respectively have been observed on about a quarter of the objects. The data correlates well with visible alteration like blisters, corrosion on metallic elements and the severe damage also observed on wrapping materials made of polyethylene, in the form of yellowing and paraffin smell, or made of tissue paper (Figure 1).
Appreciable yellowing also affects 10% of the whole sample and is significantly more vivid on parts exposed to light, such as fan thumb savers.
Physical damage, due to plasticisers migration has been noticed. It shows up as sweating, solid exudate or bloom and leads to brittleness, crazing, shrinkage, warping or breaks which affect 30% of the whole sample set.
Accidental damages other than scratches and dirt have also been noticed, and often seem to result from inappropriate older actions, like irreversible markings applied with ink and varnish which have swelled the plastic, or various attempts of solvent cleaning which have changed the gloss and colour of some objects.

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g. Cellulose nitrate and acetate: Type and frequency of important or severe damages (62 objects)

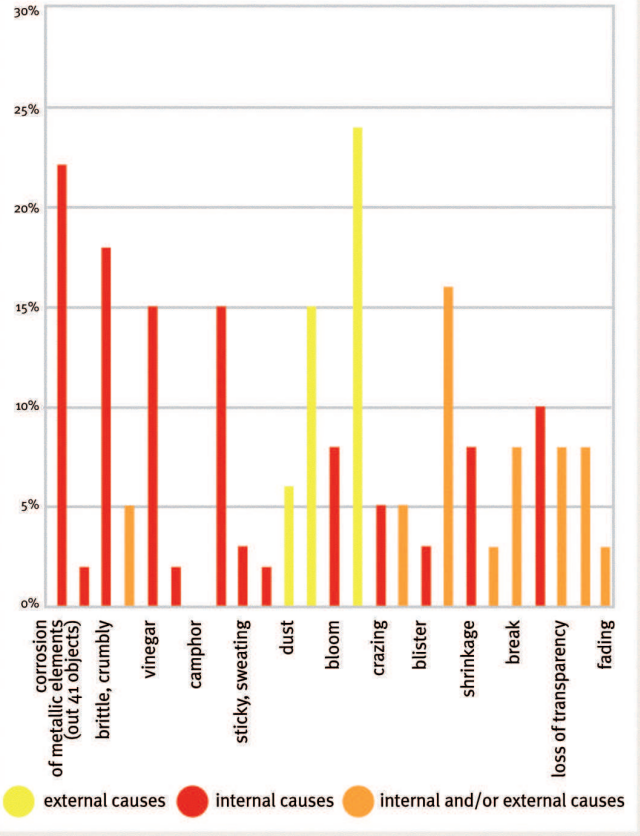

Figure 1. A tissue paper wrapping severely degraded by off-gassing from cellulose acetate objects (© C2RMF, photo Thomas Clot)