Problem plastics, types of deterioration & where you find it

Types of deterioration and where you find it:

Type of deterioration	What causes it?	Where will you find it?
Blistering	Acidic vapours given off during deterioration create bubbles.	**Cellulose nitrate** **Cellulose acetate**
Bloom	Additives migrating to the surface and becoming solid.	**Cellulose nitrate** **Cellulose acetate**
Brittleness	Chemical deterioration of the polymer chain or loss of plasticiser.	**Affects all plastics** **Phenol formaldehyde starts off brittle**
Cracking	Physical damage of hard plastics and those thermoplastics which have lost plasticiser.	**Polystyrene** **PMMA** **Phenol formaldehyde** **Urea formaldehyde** **Cellulose nitrate** **Cellulose acetate**
Crazing	Random microscopic cracks at the surface or internally caused by internal stresses, uses of solvents, loss of plasticiser.	**Cellulose nitrate** **PMMA** **Casein**
Crumbling	Exposure to oxygen and ozone.	**Polyurethane foam** **Cellulose nitrate** **Cellulose acetate**
De-laminating	Occurs when two different materials react differently to their environment.	**Could happen to most plastics but particularly seen with:** **Cellulose nitrate** **Cellulose acetate**
Discolouration	Acidic or alkali vapours and/or UV light.	**PVC** **Epoxy resins** **Super glues** **Nylons** **Cellulose nitrate** **Cellulose acetate** **Phenol formaldehyde** **Early PMMA**
Fraying	Due to chemical break down of polymer chains.	**Nylon** **Cellulose acetate** **Polypropylene**
Warping	Loss of plasticiser, polymer breakdown, heat and pressure.	**Cellulose nitrate** **Cellulose acetate** **PVC** **Polyethylene** **Polypropylene** **Nylon** **Polystyrene**
Weeping	Plasticisers migrating to the surface, degradation products migrating to the surface. Linked to warping.	**Cellulose nitrate** **Cellulose acetate** **PVC** **Polyurethane foam**

Other indicators:

Odours	**Vinegar:** Ethanoic (acetic) acid produced by degrading cellulose acetate. **Mothballs:** Camphor plasticiser in cellulose nitrate but not always an indication of degradation. **Sharp & acidic:** Nitric acid or hydrochloric acid from cellulose nitrate or PVC respectively. **Sweaty & 'plasticy':** Phthalate plasticisers in PVC and cellulose acetate have a characteristic smell, instantly recognisable as something 'plastic'
Corrosion	Gradual acid release from PVC, cellulose nitrate and cellulose acetate can cause metal components to corrode. Corrosion can therefore be a warning sign that degradation has started.
Disintegrating tissue	Degrading PVC, cellulose acetate and cellulose nitrate release acidic vapours strong enough to attack cellulose on paper-based products. This will make them brittle and eventually they will crumble. As with corrosion this deterioration of wrappings might be the first sign that an object is deteriorating.
Heat	Celluloid (cellulose nitrate) film is highly combustible and requires a licence if you wish to store it. This material should not enter the museum. It should be copied onto another medium use specific storage (see NFA work).

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Problem plastics to identify:

- Cellulose nitrate:
  - Period of production: extensively during 1860s – 1930s.
  - Uses:
    - Imitation tortoiseshell & ivory
    - Combs
    - Knife handles
    - Jewellery
    - Costume accessories
    - Toys
  - Deterioration:
    - Chemical: Light and moisture cause CN to lose nitrate as nitrogen oxides. Water and oxygen then turn these into acids which accelerate the polymer's deterioration. RH is thought to have the most effect on this but even when light sources are removed photo-degradation can still occur.
    - Physical: camphor, which is used as a plasticiser yellows with age. It is also readily lost from the structure which leaves the plastic brittle and prone to cracking. Crazing is an indication of chemical deterioration to the polymer structure.

- Cellulose acetate:
  - Period of production: extensively during 1928 – 1970s (but still used occasionally today e.g. designer spectacles)
  - Uses:
    - Moulded goods
    - Toys
    - Buttons
    - Tool handles
    - Camera bodies
    - Car steering wheels
    - Combs
    - Spectacles
  - Deterioration:
    - Chemical: Similar to CN it releases acidic products as it deteriorates. Due to distinctive smell this deterioration has been called 'vinegar syndrome'. This smell is often the first warning that CA is breaking down and can happen in as little as 24 hours.
    - Physical: The ester plasticisers can weep. These can create greater acidic environments as well as warping of the plastic.

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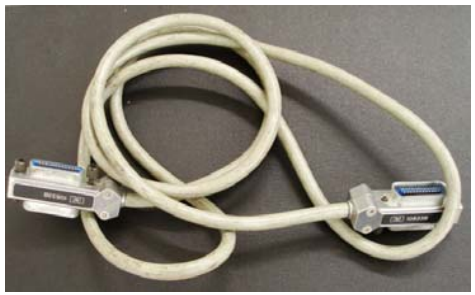
- Plasticised PVC:
  - Period of production: 1940s – present
  - Uses:
    - Toys
    - Dolls (e.g. Barbie)
    - Shoes
    - Rainwear
    - Cables (computers & other electrical items)
  - Deterioration:
    - Chemical: Light causes increased double-bonds which in turn cause PVC to yellow and darken. Hydrochloric acid can also be given off during this process. Oxygen can also encourage degradation.
    - Physical: This occurs when additives migrate to the surface of the object, blooming or weeping. This weeping is characterised by a sweet smell. The loss of plasticiser can lead to cracking because the plastic shrinks and becomes more rigid.



- Polyurethane Foam:
  - Period of production: 1940s - present
  - Uses:
    - Toys
    - Packaging
    - Sports gear
    - Textiles
    - Fake leather
    - Cushioning
  - Deterioration:
    - Chemical: Oxidation causes discolouration followed by a loss of mechanical properties. Degradation is accompanied by a pungent odour. The foams deteriorate much faster due to their greater surface area. Moisture can also cause degradation in polyester-based PU and this affects the plastic's physical properties.

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How do you identify these materials?

Cellulose nitrate: Can be identified by its degradation products but if in good condition questions to ask are:

Is the object from the 1930s or older? **No** → **Probably not CN**
Yes
↓

Does the object fit one of the 'uses' for CN?
No → **Not CN**
Yes
↓

Does the object smell acidic or of camphor?
No → **Not CN**
Yes
↓

Treat as CN and store as suggested below:

Storage implications:

- Storage should be ventilated:
  - Preferably the air should be filtered. This increases the cost of storage. *Add £30 (1 hour) to acquisition cost.*
  - Do not store in closed containers or cabinets.
- Do not wrap
- Keep in dark storage
- Keep in a cool store
- RH ideally 35-40%.
- Handle with gloves (risk of acid burns)
- **If deterioration is visible recommend that the object is not collected**

Cellulose acetate: Can be identified by it's degradation products but in good condition questions to ask are:

→
Is the object from the 1930s – 1970s? **No** **Probably not CA**
Yes
↓

Does the object fit one of the 'uses' for CA?
No → **Not CA**
Yes
↓

Is the material hard? **No** → **Not CA**
Yes
↓

Does it smell acidic when rubbed with a finger?
No → **Not CA**
Yes
↓

Treat as CA and store as suggested below:

Storage implications:

- Does not require as much ventilation as CN because this can encourage plasticiser loss.
  - Preferably the air should be filtered. This increases the cost of storage. *Add £30 (1 hour) to acquisition cost.*
  - Do not store in closed containers or cabinets.
- Do not wrap (as this can draw plasticisers out)
- Requires the same environmental conditions as CN.
- Handle with gloves (risk of acid burns)
- **If deterioration is visible recommend that the object is not collected**

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PVC:

Is the object more recent than 1940? **No** → **not PVC**
Yes ↓

Does the object fit one of the 'uses' for PVC?
No → **not PVC**
Yes ↓

Is the object flexible? **No** → **not PVC**
Yes ↓

Can the surface be easily marked? **No** → **not PVC**
Yes ↓

Does it smell of 'plasticiser'? **No** → **not PVC**
Yes ↓

Treat as PVC and store as suggested below:

Storage implications:

- Keep in a cool store
- Keep in dark storage
- Do not wrap or have in contact with a material that could mark the soft and potentially deteriorating surface.
- Do not store in contact with expanded polystyrene: Therefore, remove any electrical items suspected of containing PVC from original polystyrene packaging.
- Becomes brittle with age so may require modifications to storage conditions. *Add £30 (1 hour) to acquisition cost.*
- **If deterioration is visible and the main material of the object is PVC recommend that the object is not collected.**

Polyurethane Foam:

Is the object more recent than 1940? No → not PU foam
Yes ↓

Does the object fit one of the 'uses' PU foam?
No → not PU foam
Yes ↓

Is it a soft, open celled foam? No → not PU foam
Yes ↓

Treat as PVC and store as suggested below:

Storage implications:

- Keep in a cool store
- Keep in dark storage
- Oxygen is the main deterioration factor and so without it's exclusion the foam will degrade.
- Oxygen free storage could be an option but this will increase the estimate conservation costs considerably because of the materials and maintenance needed.
- Two acquisition cost options:
    - *For oxygen free environment add £60 (2 hours).*
    - *For assumed need for treatment during lifetime add £30 (1 hour) and up depending on object size.*
- **If deterioration is visible and PU is the main or essential material recommend that the object is not collected.**