ICN-Information Institute Collectie Nederland

nr.1

Condition rating for paper objects with iron-gall ink

Iron-gall inks represent the most used writing media for manuscripts dating from the late antiquity until the beginning of the 20th century. Because also artists used these inks, they can be found not only in the archives and libraries, but also in the collections of drawings all over the world.
Iron-gall inks can cause deterioration of the material, on which they were applied – mainly paper or parchment. The complicated degradation process is usually called 'ink corrosion' or 'ink burn'.
Since 1994 the Netherlands Institute for Cultural Heritage (ICN) has been carrying out research into the causes and the mechanism of degradation in order to develop an adequate conservation treatment for ink corrosion. To facilitate decision making concerning preservation, a condition rating system has been developed. Based on different stages of visible progress of degradation, a classification in four condition ratings allows a fast and easy determination of the condition of the object.
The advice for storage and handling depends on the condition of the artefacts.

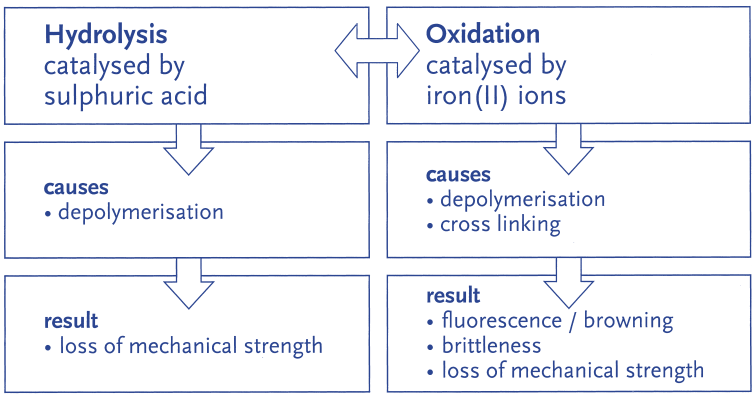
Iron-gall inks

Iron-gall inks belong to the group of metallic inks as their colouring matter is a metal-organic complex. Four essential constituents to prepare an iron-gall ink are required: as vehicle, a liquid like water or wine; as binder, gum arabic and as colouring matter iron(II) sulphate in combination with a plant material containing tannins (e.g. oak galls).
When iron(II) ions react with tannin or gallic acid, a coloured product is formed immediately, which oxidizes in the air to a dark coloured complex, a ferric gallate. Sulphuric acid is formed as a by-product. Most of the ink recipes lead to an excess of iron(II) sulphate. As a result, not all the iron(II) sulphate is used up in the reaction and free iron(II) ions will remain present in the solution. In order to obtain special properties, sugar, wine, urea, vinegar, etc. are added to the inks. Writing with iron-gall ink on paper means transferring a liquid consisting of various different compounds to the support.

Ink corrosion

The natural ageing process of paper is enhanced by components of the iron-gall inks. Ink corrosion is the result of two major degradation processes: acid-catalysed hydrolysis (excess sulphuric acid) and iron(II)-catalysed oxidation of cellulose (excess of iron(II) ions).

Acid hydrolysis of cellulose: The sulphuric acid present in the ink does not evaporate from the paper support in the course of time like volatile organic acids do. It catalyses acid hydrolysis of the cellulose, resulting in chain scission of the cellulose polymer. This process continues over the centuries, unless the acid is neutralised, either by paper additives or by conservation treatments.

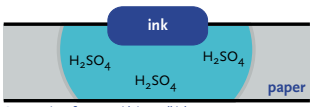


Iron(II)-catalysed oxidation of cellulose: Transition metals such as iron or copper can catalyse oxidation of cellulose which causes chain scission and cross linking of the cellulose polymer. This results in a reduced water absorption, fluorescence and colour changes in the paper.

Location of the degradation: Upon ageing, certain ink components migrate into the paper support. Sulphuric acid diffuses far into the surrounding paper, whereas iron(II) ions remain within the immediate vicinity of the inked areas. Thus acid hydrolysis is responsible mainly for the degradation of the paper surrounding the ink, whereas iron(II)-catalysed oxidation is located only very close to the inked areas.

Hydrolysis

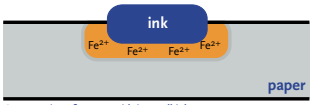
Sulphuric acid
migrates far into the surrounding paper



Cross section of a paper with iron-gall ink

Oxidation

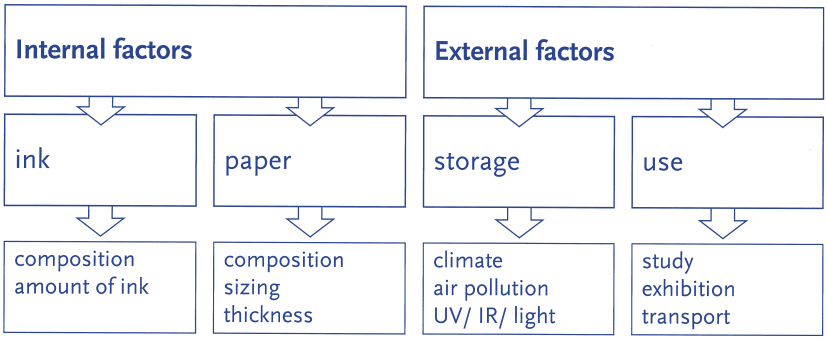
Iron(II)ions
migrates only into the immediate vicinity of the inked areas



Cross section of a paper with iron-gall ink

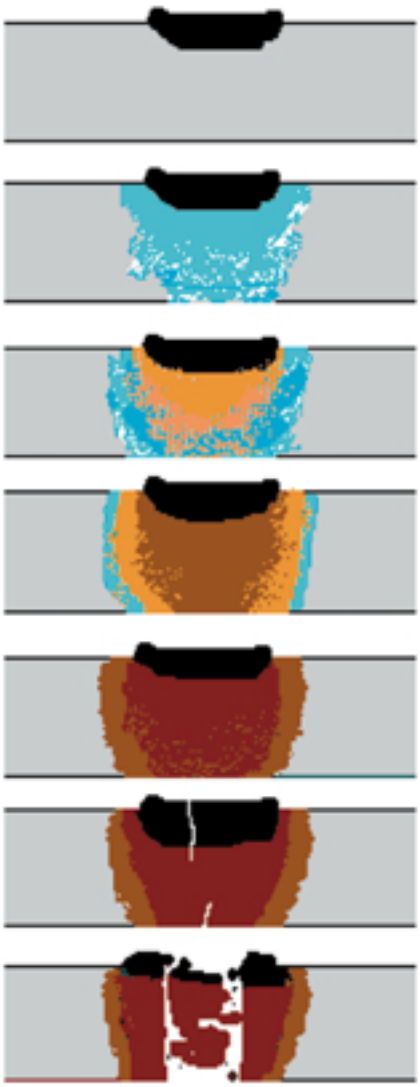
Main factors affecting the extent of damage

The composition of the ink and the paper principally determine the condition of the artefacts. Subsequently, inadequate storage and intensive use decrease the condition. The main factors influencing the extent of damage can be divided into internal and external factors.



Ink corrosion - visible progress - a model

Research has shown that the visible progress of ink corrosion is similar for all examined papers. In order to illustrate this process, a model has been developed which shows the cross section of an iron-gall inked paper during its ageing process.



1
Non degraded

2
Paper starts to fluoresce greenish around the ink, the fluorescing area extends to the verso of the paper

3
The colour of the greenish fluorescing turns to a yellow hue, in daylight this area appears light brown

4
In daylight, the verso is discoloured to a light brown tone, under UV still fluorescing halos are visible

5
No fluorescence, the light brown tone on the verso intensifies to a dark brown

6
Ink line cracks when touched

7
Serious loss of material

The interpretation of the appearance of originals is usually more complicated, because often degradation does not progress evenly through the entire object. Some ink lines may have degraded more than others.

Condition rating

For an effective planning of passive or active conservation measures, it is essential to gain a clear view of the extent of damage present in a collection. Based on the presented model, a system for the practical classification of ink-corroded paper objects has been developed. The system classifies four conditions, ranging from 'good' to 'bad' condition. In order to provide a fast and exact classification, only those phenomena characteristic of ageing observed on all examined originals were included in the rating system.

Directions for examination and classification

Examine the *verso* of the object under visible light, because visible changes appear mainly on the reverse side of the paper.

Always consider the most degraded area for assigning the rating of the whole object.

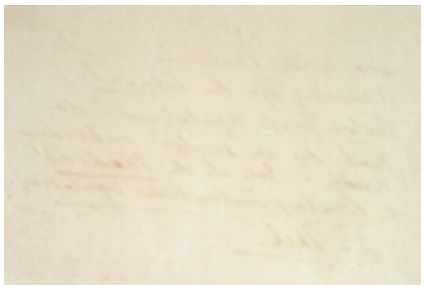
Directions for storage and handling of objects

Changing temperature and relative humidity accelerate ink corrosion.
- Keep storage conditions as constant as possible (aim for 50% RH and 18°C).

Ink-corroded items are susceptible to damage from ultraviolet and visible light.
- Eliminate UV radiation and store as dark as possible.

Air pollutants (NO_x, SO_2, ozone) accelerate ink corrosion.
- Store items in folders / boxes using archival quality storage materials.

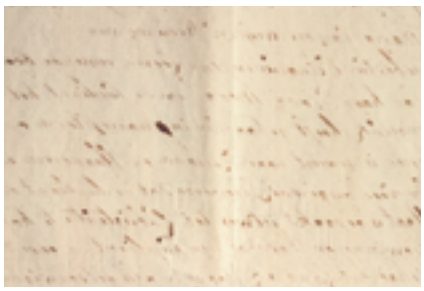
Condition Rating 1



Good condition
- no or light brown discoloration at the inked areas

Handling does not cause any damage
- normal careful handling

Condition Rating 2



Fair condition
- dark brown discoloration at the inked areas
- no mechanical damage

Handling *might* cause mechanical damage
- special care in handling necessary

Condition Rating 3

Poor condition
- mechanical damage (cracks) at the inked areas

Handling increases mechanical damage
- restrict use to qualified personnel in order to avoid loss of information
- support the object when handling

Condition Rating 4

Bad condition
- serious loss of substance

Handling will increase loss of substance
- restrict handling to museum / library / archive staff only
- support the object when handling

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