

Bleaching in Paper Conservation: Survey Responses¹

Spring 2018, we distributed a survey concerning bleaching practices in paper conservation, which received 272 responses. Respondents already received the slightly summarized, overview of results which we now share on our homepage.

1 Introduction

The survey focussed on the approaches of paper conservators in their every-day bleaching practice. We wanted to see how important bleaching is in our profession and analyse the conservators' specific treatment preferences. The survey was conducted anonymously using an online tool. The collated results give an overview of bleaching practices. Wherever different options could be ticked, the answers are given as statistical percentage in relation to the total number of answers. In this case, numbers that represent the number of answers to a question, do not add up to one hundred percent.

The listed answers represent response frequencies numerically. They do not represent treatment guidelines or recommendations.

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¹ Senior M.A. semester project of Selina Dieter, July 2018. Citation information: Selina Dieter, Ute Henniges, Irene Brückle*. Bleaching in Paper Conservation: Survey Responses. Summary data from the unpublished M.A. research project of S. Dieter, Conservation of Works of Art on Paper, Library and Archives Materials, Stuttgart Academy of Art and Design, 2018. Accepted presentation at the XIVth Congress of IADA, Warsaw, 24. Sept. 2019: Ute Henniges*, Selina Dieter, Irene Brückle, Survey on bleaching: what are current practices?

2 General questions

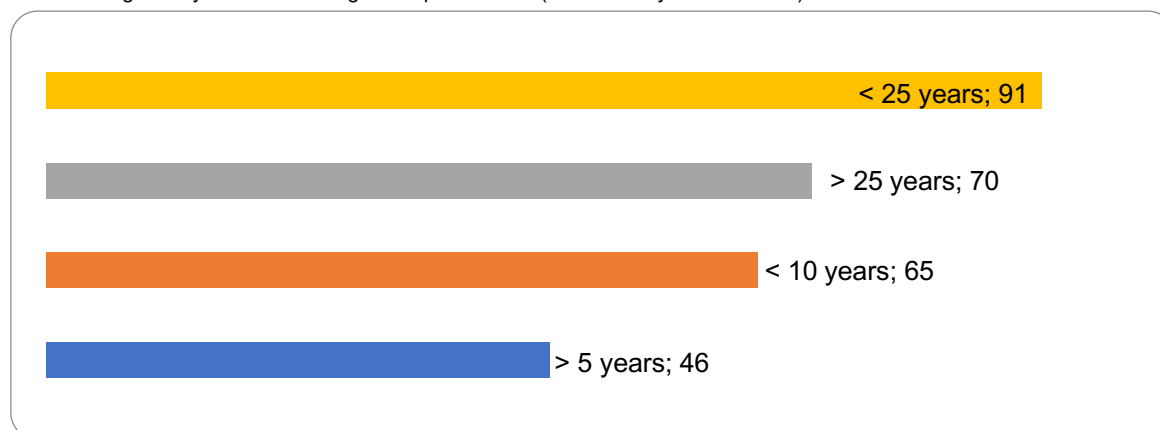
272 paper conservators from 38 countries took part in this survey:

In which country do you work in?

Country	Numerical response
United States of America	76
Germany	44
United Kingdom	24
The Netherlands	12
Australia, Austria, Canada, Ireland, Italy, Spain, Switzerland	7-9
Brazil, Denmark, Estonia, Finland, France, Hungary, India, Malta, Norway, Poland, Russia, Sweden, Turkey	2-6
Argentina, Belgium, Colombia, Dominica, Ecuador, Greece, Israel, Kuwait, Lithuania, Mexico, New Zealand, Peru, Singapore, Qatar	1

Most respondents worked in the profession more than 25 years:

For how long have you been working in the profession? (answered by a total of 272)



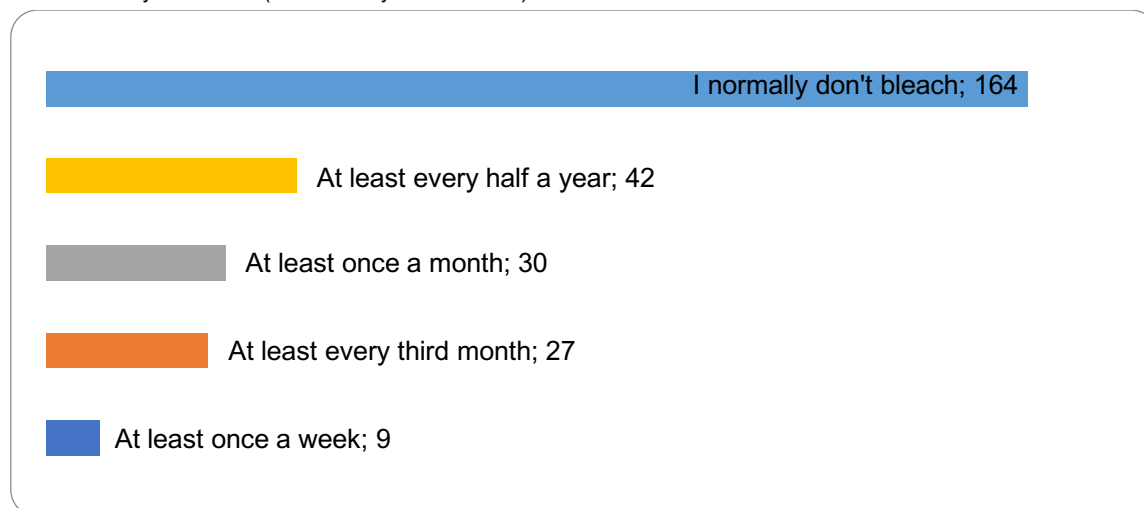
A little less than half of the participants are working free-lance or in private practice, followed by 79 conservators working in museums:

In which kind of institution do you work in?

Options (answered by a total of 272)	Numerical response	Statistical percentage
Private practice, free-lance	105	38.60
Museum	79	29.04
Library	60	22.06
Archive	47	17.28
Conservation centre (public)	20	7.35
Academia	15	5.51
Conservation centre (private)	10	3.68
Other	1	0.37

164 respondents (60%) stated that they usually do not bleach. These participants had only access to a limited number of follow-up questions. The second most frequent answer (42 respondents) indicate once bleaching at least every half-year:

How often do you bleach? (answered by a total of 272)



Black and white prints are bleached most frequently (107 respondents), followed by drawings (61) and colour prints (48):

What kind of objects do you bleach often?

Options (answered by a total of 108)	Numerical response	Statistical percentage
Black and white prints	107	99.07
Drawings	61	56.48
Colour prints	48	44.44
Modern art on paper	36	33.33
Hand-coloured prints	28	25.93
Archival material	24	22.22
Old master drawings	15	13.89
Paper in books	11	10.19
Other	7	6.48

The most popular bleaching agent is hydrogen peroxide followed by light bleaching and sodium borohydride. Other bleaches are in lesser use:

Which bleaching agents do you use?

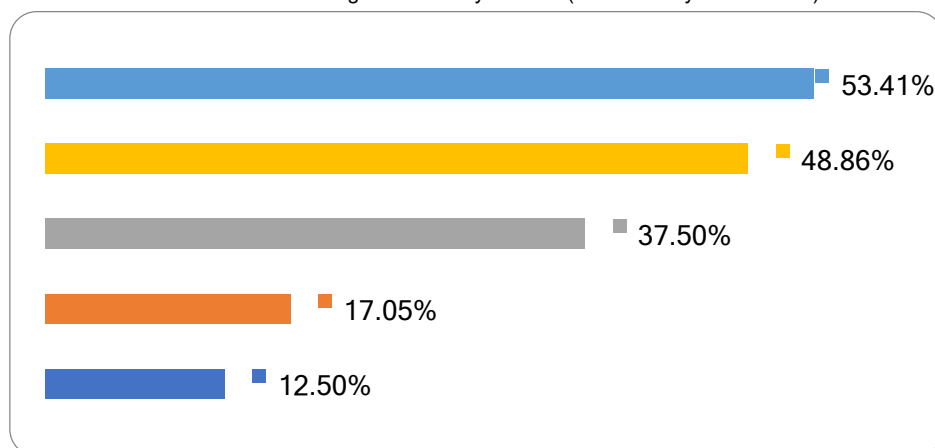
Options (answered by a total of 108)	Numerical response	Statistical percentage
Hydrogen peroxide	88	81.48
Light	67	62.04

Sodium borohydride	60	55.56
Calcium / sodium hypochlorite	18	16.67
Potassium permanganate	16	14.81
Chloramine T	7	6.48
Chlorine dioxide	6	5.56
Other chlorites	6	5.56
Other borohydrides	6	5.56

3 Which are the essential treatment parameters to consider when using hydrogen peroxide?

88 paper respondents use hydrogen peroxide as their bleaching agent of choice. The majority of respondents use this agent in a concentration between 0.5 and 3.0%:

Which concentration of the bleaching solution do you use? (answered by a total of 88)



94% of the hydrogen peroxide users test the water solubility of the objects' colour media as a pre-treatment step:

Which pre-treatments do you consider for bleaching?

Options (answered by a total of 88)	Numerical responses	Statistical percentage
Testing the water solubility of the media	83	94.32
Testing the absorbency of the paper	62	70.45
Testing for iron contamination	43	48.86
Other	12	13.64
Testing for gelatine sizing	11	12.50
None	2	2.27

61% the participants always wash or deacidify an object before hydrogen peroxide treatment, 33% do so 'often'. Calcium hydroxide and tap water are most commonly used:

Which agents for washing or deacidification do you use?

Options (answered by a total of 88)	Numerical response	Statistical percentage
Calcium hydroxide	60	68.18
Tap water	46	52.27
Ammonium hydroxide	23	26.14
Calcium hydrogen carbonate (calcium bicarbonate)	22	25.00
Other	19	21.59
Magnesium hydrogen carbonate (magnesium bicarbonate)	13	14.77

Post-bleaching treatment involves most commonly two water baths (65% of 87 participants), followed by three baths (35%) and one (7%) water bath:

How often do you wash the object to remove the bleaching agent?

Options (answered by a total of 87)	Numerical response	Statistical percentage
2 water baths	33	37.93
Other	23	26.44
3 water baths	19	21.84
1 water bath	12	13.79

About half of the respondents (49) introduce an alkaline reserve to the paper after bleaching, 40 (about 82%) of them use calcium hydroxide, 12 (25%) calcium hydrogen carbonate in an aqueous solution:

Which agents do you use to give an alkaline reserve to the paper?

Options (answered by a total of 49)	Numerical response	Statistical percentage
Calcium hydroxide	40	81.63
Calcium hydrogen carbonate (calcium bicarbonate)	12	24.49
Magnesium hydrogen carbonate (magnesium bicarbonate)	11	22.45
Ammonium hydroxide	2	4.08
Other	1	2.04

Many respondents, 18% out of 88, who use hydrogen peroxide as a bleaching agent, never resize an object after a bleaching treatment. About 42% of the conservators seldom carry out a resizing treatment and about 40% are resizing often to always after a bleaching treatment. To do so, both cellulose ethers and gelatine are used equally:

Which agents do you use to resize an object?

Options (answered by a total of 72)	Numerical response	Statistical percentage
Cellulose ethers	51	70.83
Gelatine	49	68.06
Other	5	6.94

Risks of hydrogen peroxide bleaching concerning the paper were identified as follows:

Are there special paper properties that are a risk to bleaching with hydrogen peroxide?

Options (answered by a total of 88)	Numerical response	Statistical percentage
Brittleness	60	68.18
Certain colorants	56	63.64
Iron ions	54	61.36
Toned paper	47	53.40
Short fibre pulp	45	51.14
Lignin	40	45.45
Thick paper	28	31.82
Strong uneven discoloration	24	27.27
Strong discolorations	23	26.14
Large size objects	14	19.32
Other	12	13.64
Gelatine sizing	8	9.09
None	1	1.14

About half of the participants observe that insufficient brightening occurs which might relate to the fact that the majority of respondents use less than 3% concentrations for bleaching, which makes the bleach controllable but also slow-acting. A local over-bleaching tendency, maybe also known as halos, is observed by 40%:

Do you have special observations on results witnessed with the bleaching agent hydrogen peroxide?

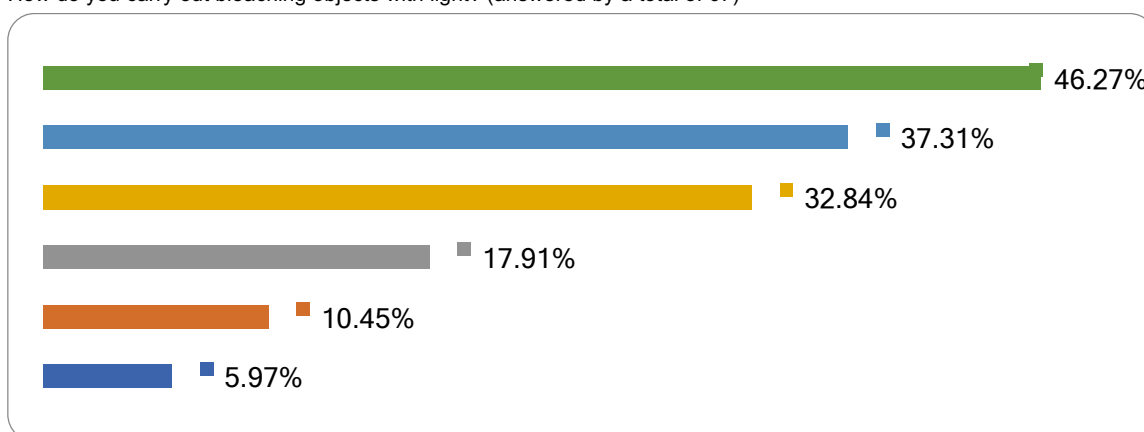
Options (answered by a total of 88)	Numerical response	Statistical percentage
Insufficient brightening	40	45.45
Local over-bleaching	35	39.77
Blistering	29	32.95
Undesired paper colour change	26	29.55

Colour reversion (also long term)	25	28.41
Sizing loss	19	21.59
Media alteration	16	18.18
Overall over-bleaching	13	14.77
None	6	6.81
Others	2	2.27

4 Which are the essential treatment parameters to consider when using light bleaching?

When it comes to the technique of light bleaching, a variety of procedures are to be mentioned. Most of the participants, 46% of 67, use natural sunlight outside of the studio:

How do you carry out bleaching objects with light? (answered by a total of 67)



A common duration of the bleaching treatment varies as about 40% of the people are first deciding on the light source and then on the duration of the treatment. 39% normally bleach with light for more than 2 hours:

How long does the bleaching treatment last?

Options (answered by a total of 67)	Numerical response	Statistical percentage
Depends on the light source	27	40.29
> 2 hours	26	38.81
< / = 2 hours	18	26.87
< / = 1 hour	9	13.43
Other	6	8.96

Tests carried out before the treatment most often concern the water solubility of media and the absorbency of the paper:

Which pre-treatments do you consider before bleaching?

Options (answered by a total of 67)	Numerical response	Statistical percentage
Testing the water solubility of the media	60	89.55
Testing the absorbency of the paper	46	68.66
Testing for iron contamination	23	34.33
Testing the gelatine sizing	11	16.42
Other	6	8.96
None	1	1.49

52 of 67 people wash or deacidify always before bleaching. This is followed by 10 people who marked 'often', and 5 people wash or deacidify seldom or never before treatment. The most commonly used aqueous solution is calcium hydroxide (79%). Both ammonium hydroxide (38%) and tap water (33%) are common as well. When asked which agents are used for keeping the object wet during the light bleaching treatment, about half of the people answered with calcium hydroxide, 37% are using tap water:

Which agents for keeping the object wet during the treatment do you use?

Options (answered by a total of 67)	Numerical response	Statistical percentage
Calcium hydroxide	35	52.24
Tap water	25	37.31
Other	19	28.36
Ammonium hydroxide	13	19.40
Calcium hydrogen carbonate (calcium bicarbonate)	7	10.45
Magnesium hydrogen carbonate (magnesium bicarbonate)	6	8.96

Washing and deacidifying the object after a light bleaching treatment is common with most of the participants (85%). To do so water baths are prepared as follows:

How often do you wash the object to remove the bleaching agent?

Options (answered by a total of 57)	Numerical response	Statistical percentage
2 water baths	21	36.84
1 water bath	20	35.09
3 water baths	11	19.30
Other	10	17.54

Only half of the group also introduces an alkaline reserve afterwards (54%). These 36 people mostly commonly use calcium hydroxide or calcium- or magnesium hydrogen/ bi-carbonate solutions:

Which agents do you use to give an alkaline reserve to the paper?

Options (answered by a total of 67)	Numerical response	Statistical percentage
Calcium hydroxide	31	86.11
Calcium hydrogen carbonate (calcium bi-carbonate)	7	19.44
Magnesium hydrogen carbonate (magnesium bicarbonate)	6	16.66
Ammonium hydroxide	1	2.78
Other	1	2.78

Resizing is done rather seldom (45%) to never (25%), the rest of 30% of the conservators polled are carrying it out 'often' and 'always'. With this bleaching agent gelatine is more common than cellulose ethers as resizing agent:

Which agents do you use to resize an object?

Options (answered by a total of 50)	Numerical response	Statistical percentage
Gelatine	40	80.00
Cellulose ethers	34	68.00
Other	1	2.00

Concerning problems of and with the bleaching agent, certain colorants seem to be the most problematic:

Are there special paper properties that are a risk to bleaching with light?

Options (answered by a total of 67)	Numerical response	Statistical percentage
Certain colorants	52	77.61
Lignin	42	62.69
Toned paper	42	62.69
Brittleness	36	53.73
Short fibre pulp	29	43.28
Iron ions	24	35.82
Large size objects	21	31.34
Strong discolorations	17	25.37
Thick paper	16	23.88
Strong uneven discoloration	15	22.39
Gelatine sizing	12	17.91

Other	1	1.49
None	1	1.49

When asked about certain observations on light bleaching results the largest group, 40% of the participants, mentioned insufficient brightening. In comparison about 27% of the people polled have never observed any problematic results:

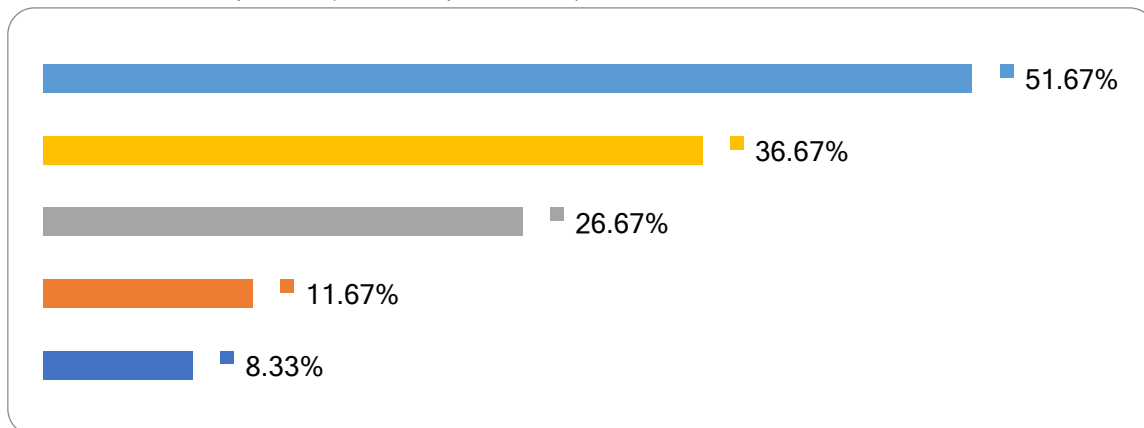
Do you have special observations on results witnessed with using light as a bleaching agent?

Options (answered by a total of 67)	Numerical response	Statistical percentage
Insufficient brightening	27	40.30
Sizing loss	19	28.36
None	18	26.89
Media alteration	14	20.90
Undesired paper colour change	10	14.93
Overall over-bleaching	7	10.45
Blistering	4	5.97
Local over-bleaching	4	5.97
Other	4	5.97
Colour reversion (also long term)	3	4.48

5 Which are the essential treatment parameters to consider when using sodium borohydride?

60 participants are using sodium borohydride as a bleaching agent. Half of this group prefers to use a concentration of 0.5% or less. A higher concentration of around 1.0% is popular with 22 people:

Which concentration do you use? (answered by a total of 60)



When asked about the pre-treatment steps before a bleaching session, nearly all of the conservators polled are testing the water solubility of the media (54 out of 60) and 43 are also testing the absorbency of the paper:

Which pre-treatments do you consider for bleaching?

Options (answered by a total of 60)	Numerical response	Statistical percentage
Testing the water solubility of the media	54	90.00
Testing the absorbency of the paper	43	71.67
Testing for iron contamination	29	48.33
Testing the gelatine sizing	11	18.33
Other	6	10.00
None	0	0.00

45 people are always washing or deacidifying their objects before the sodium borohydride bleaching treatment. 9 participants do this often, 3 seldom or never carry out these aqueous treatments. Preferred agents are calcium hydroxide with 72% and tap water with 37% of the participants:

Which agents for washing or deacidification do you use?

Options (answered by a total of 57)	Numerical response	Statistical percentage
Calcium hydroxide	41	71.93
Tap water	21	36.84
Ammonium hydroxide	16	28.07
Other	12	21.05
Magnesium hydrogen carbonate (magnesium bicarbonate)	9	15.79
Calcium hydrogen carbonate (calcium bicarbonate)	8	14.04

When the bleaching treatment is completed, 56 out of 60 people wash or deacidify their objects and half of the group adds an alkaline reserve, too. Three people do not carry out any aqueous treatment afterwards. The majority of repeated baths is two times with 37%, 3 water baths follows with 29% and 1 water bath is done by 23%:

How often do you wash the object to remove the bleaching agent?

Options (answered by a total of 56)	Numerical response	Statistical percentage
2 water baths	21	37.50
3 water baths	16	28.57
1 water bath	13	23.21
Other	10	17.86

As 30 people introduce an alkaline reserve to the paper afterwards, 53% of these do so often and 37% always carry out this additional immersion. The agent of choice is calcium hydroxide (83%). Calcium or magnesium hydrogen carbonate (calcium or magnesium bicarbonate) are only used by 23% and 20%:

Which agents do you use to give an alkaline reserve to the paper?

Options (answered by a total of 30)	Numerical response	Statistical percentage
Calcium hydroxide	25	83.33
Calcium hydrogen carbonate (calcium bicarbonate)	7	23.33
Magnesium hydrogen carbonate (magnesium bicarbonate)	6	20.00
Ammonium hydroxide	0	0.00
Other	0	0.00

Resizing is done rather seldom as 48% (of 60 people) say, and 22% never carry out this treatment step. Together 30% resize always or often. If so, gelatine is used by 40 people and/ or 29 choose cellulose ether:

Which agents do you use to resize an object?

Options (answered by a total of 47)	Numerical response	Statistical percentage
Gelatine	40	85.11
Cellulose ether	29	61.70
Other	2	4.26

Special properties that might become a risk when bleaching an object with sodium borohydride are, first of all, certain colorants as noted by 34 out of 60 participants:

Are there special paper properties that are a risk to bleaching with sodium borohydride?

Options (answered by a total of 60)	Numerical response	Statistical percentage
Certain colorants	34	56.67
Brittleness	27	45.00
Short fibre pulp	25	41.67
Lignin	23	38.33
Toned paper	23	38.33
Iron ions	21	35.00
Strong discolorations	16	26.67
Thick paper	14	23.33
Strong uneven discoloration	14	23.33
Gelatine sizing	11	18.33
Large size objects	9	15.00

Other	6	10.00
None	2	3.33

Half of the group has observed problems with blistering after using sodium borohydride as a bleaching agent. Moreover, local over-bleaching and on the other hand insufficient brightening was observed by 30% to 32% of the participants. More than half of the participants did not reach their expected goal while using this bleaching agent:

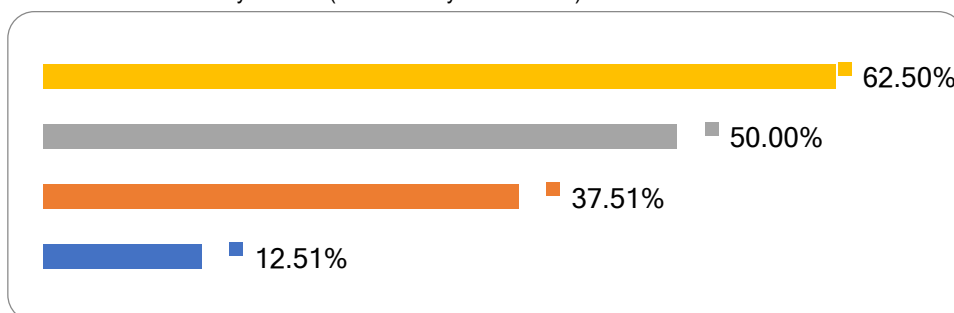
Do you have special observations on results witnessed with the bleaching agent sodium borohydride?

Options (answered by a total of 60)	Numerical response	Statistical percentage
Blistering	28	46.67
Insufficient brightening	19	31.67
Local over-bleaching	18	30.00
Undesired paper colour change	15	25.00
Sizing loss	12	20.00
Media alteration	12	20.00
None	7	11.67
Colour reversion (also long term)	6	10.00
Overall over-bleaching	5	8.33
Other	5	8.33

6 Which are the essential treatment parameters to consider when using potassium permanganate?

Potassium permanganate is used by 16 conservators. The most common concentration of this bleaching agent is less than 0.5% with 10 people. The concentrations of around 0.1% and 1.0% was also chosen by 6 and 8 conservators, respectively. Therefore, the range of concentrations used, seems to be variable:

Which concentration do you use? (answered by a total of 16)



81% respondents believe that testing the water solubility of media is important before the treatment, followed by 63% who test the absorbency of the paper:

Which pre-treatments do you consider for bleaching?

Options (answered by a total of 16)	Numerical response	Statistical percentage
Testing the water solubility of the media	13	81.25
Testing the absorbency of the paper	10	62.50
Testing for iron contamination	5	31.25
Testing the gelatine sizing	1	6.25
None	1	6.25
Other	0	0.00

94% of the participants carry out washing and deacidification often to always, 80% of those chose tap water as their preferred solution. Calcium hydroxide and calcium hydrogen carbonate are common with 38% and 33% percent of the group:

Which agents for washing or deacidification do you use?

Options (answered by a total of 15)	Numerical response	Statistical percentage
Tap water	12	80.00
Calcium hydroxide	6	37.50
Calcium hydrogen carbonate (calcium bicarbonate)	5	33.33
Other	1	6.25
Magnesium hydrogen carbonate (magnesium bicarbonate)	0	0.00
Ammonium hydroxide	0	0.00

All participants wash or deacidify after the bleaching treatment. In addition, 6 people polled also introduce an alkaline reserve to the paper. Commonly in this case, 3 water baths are carried out:

How often do you wash the object to remove the bleaching agent?

Options (answered by a total of 16)	Numerical response	Statistical percentage
3 water baths	5	31.25
2 water baths	4	25.00
Other	4	25.00
1 water bath	3	18.75

6 people introduce an alkaline reserve into the paper after the bleaching treatment. 5 of those do so often or always. Both calcium hydroxide and calcium hydrogen carbonate (calcium bicarbonate) are used for preparation, each voted for three times:

Which agents do you use to give an alkaline reserve to the paper?

Options (answered by a total of 6)	Numerical response	Statistical percentage
Calcium hydroxide	3	50.00
Calcium hydrogen carbonate (calcium bicarbonate)	3	50.00
Magnesium hydrogen carbonate (magnesium bicarbonate)	0	0.00
Ammonium hydroxide	0	0.00
Other	0	0.00

7 people are using sizing for stabilisation often, three stated 'always'. Two never consider this treatment and 4 people do so rarely. Cellulose ethers are the most preferred with 10 out of 14 participants, gelatine is used by 9 people:

Which agents do you use to resize an object?

Options (answered by a total of 14)	Numerical response	Statistical percentage
Cellulose ether	10	71.43
Gelatine	9	64.29
Other	1	6.25

A problematic paper property named by half of the group is brittleness. Certain colorants are problematic to 44% because the bleaching agent can alter inks and other colorants;

Are there special paper properties that are a risk to bleaching with potassium permanganate?

Options (answered by a total of 16)	Numerical response	Statistical percentage
Brittleness	8	50.00
Certain colorants	7	43.75
Toned paper	6	37.50
Iron ions	5	31.25
Short fibre pulp	5	31.25
Thick paper	5	31.25
Strong uneven discoloration	5	31.25
Other	5	31.25
Lignin	4	25.00
Strong discolorations	3	18.75
Gelatine sizing	3	18.75
Large size objects	3	18.75

None	0	0.00
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About 38% of the group who use sodium borohydride as a bleaching agent observed the loss of sizing and undesired paper colour changes. Also insufficient brightening seems to have occurred to 31%. Other problems do not seem to happen frequently:

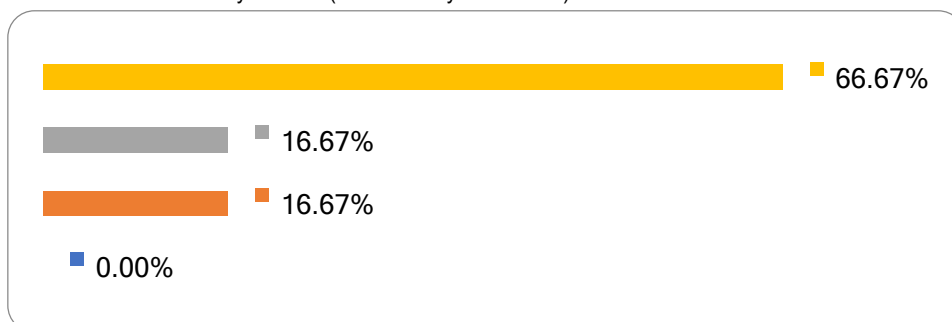
Do you have special observations on results witnessed with the bleaching agent potassium permanganate?

Options (answered by a total of 16)	Numerical response	Statistical percentage
Sizing loss	6	37.50
Undesired paper colour change	6	37.50
Insufficient brightening	5	31.25
Local over-bleaching	4	25.00
Media alteration	4	25.00
Overall over-bleaching	3	18.75
Blistering	3	18.75
None	3	18.75
Other	2	12.50
Colour reversion (also long term)	1	6.25

7 Which are the essential treatment parameters to consider when using chlorine dioxide?

6 conservators are using chlorine dioxide as (one of) their preferred bleaching agents. The majority of those, 67%, are preparing their bleaching solution around 0.2%. A higher concentration of more or less 1.0% has been chosen by one person each:

Which concentration do you use? (answered by a total of 6)



When carrying out the treatment, it is done for about 5 minutes, as stated by 3 people, 2 others maximally allow 15 minutes and one respondent allows more than 15 minutes:

How long does a treatment last?

Options (answered by a total of 6)	Numerical response	Statistical percentage
< / = 5 minutes	3	50.00

< / = 15 minutes	2	33.33
> 15 minutes	1	16.67
< / = 10 minutes	0	0.00

Nearly all of the participants test the water absorbency of the paper (5); colour media are tested by 4 people. Iron contamination and gelatine sizing are less popular test goals:

Which pre-treatments do you consider for bleaching?

Options (answered by a total of 6)	Numerical response	Statistical percentage
Testing the absorbency of the paper	5	83.33
Testing the water solubility of the media	4	66.67
Testing for iron contamination	2	33.33
Testing the gelatine sizing	2	33.33
Other	1	16.67
Non	0	0.00

When asked which water-based treatments are done before bleaching, a mixture of solutions was mentioned including distilled or demineralised water. Tap water and calcium hydroxide are popular with about 33% of the group:

Which water-based treatments do you do before bleaching?

Options (answered by a total of 6)	Numerical response	Statistical percentage
Other	3	50.00
Tap water (without processing)	2	33.33
Calcium hydroxide	2	33.33
Ammonium hydroxide	1	16.67
Calcium hydrogen carbonate (calcium bicarbonate)	1	16.67
Magnesium hydrogen carbonate (magnesium bicarbonate)	1	16.67

All conservators who are using chlorine dioxide wash and/ or deacidify after a bleaching treatment. This is commonly done with two to three water baths (33% each):

How often do you wash the object to remove the bleaching agent?

Options (answered by a total of 6)	Numerical response	Statistical percentage
2 water baths	2	33.33
3 water baths	2	33.33
1 water bath	1	16.67
Other	1	16.67

Two respondents introduce an alkaline reserve 'often' to 'always' and use calcium hydroxide to do so. 5 respondents carry out an anti-chlorine treatment after bleaching, two of them mentioned sodium borohydrides, acetic acid, sodium thiosulfate and sodium thiosulfite each were ticked once:

Which agent do you use to give an anti-chlorine treatment??

Options (answered by a total of 5)	Numerical response	Statistical percentage
Sodium borohydrides	2	40.00
Acetic acid	1	20.00
Sodium thiosulfate	1	20.00
Sodium thiosulfite	1	20.00
Other	0	0.00
Sodium dithionite	0	0.00

2 of 6 people often carry out resizing. Two others do not resize at all. When it is done, either cellulose ethers (3 people) or gelatine (2) are used:

Which agents do you use to resize an object?

Options	Numerical response	Statistical percentage
Cellulose ether	3	75.00
Gelatine	2	50.00
Other	1	25.00

Lignin and certain colorants are considered most problematic with 4 people:

Are there special paper properties that are a risk to bleaching with chlorine dioxide?

Options	Numerical response	Statistical percentage
Lignin	4	66.67
Certain colorants	4	66.67
Toned paper	3	50.00
Gelatine sizing	3	50.00
Short fibre pulp	2	33.33
Thick paper	2	33.33
Iron ions	2	33.33
Large size objects	2	33.33
Brittleness	1	16.67
Strong discolorations	1	16.67
Strong uneven discoloration	1	16.67
Other	1	16.67
None	0	0.00

Most respondents did not see any undesired results with this bleaching agent. One third (2 people each) mentioned colour reversion, overall over-bleaching, being hazardous and hard to control.

Do you have special observations on results witnessed with using chlorine dioxide as a bleaching agent?

Options	Numerical response	Statistical percentage
Colour reversion (also long term)	2	33.33
Overall over-bleaching	2	33.33
Hazardous	2	33.33
Hard to control	2	33.33
Special treatment procedure	2	33.33
Other	2	33.33
Blistering	1	16.67
Undesired paper colour change	1	16.67
Sizing loss	0	0.00
Media alteration	0	0.00
Insufficient brightening	0	0.00
Local over-bleaching	0	0.00
None	0	0.00