A new experimental method for strengthening weakened paper by alkaline treatment

By

Dr. Hussam El Din Abdel Hamid * & Wafika Noshi **

Introduction :

Old papers such as documents , manuscripts and printed book pages , that were manufactured in the eighteenth century and made of mechanical wood pulp appear now to suffer from remarkable weakness due to variable factors. Some internal factors lie in the paper composition , for example lignin as a natural impurity in plant sources from which papers are manufactured . Also residues of chemicals added during the manufacturing procedures such as alum and chlorine as bleaching agent . Other external factors affecting old paper badly are gaseous pollutant especially those of sulphur dioxide and nitrogenous oxides (Barrow, 1959) . Through time these factors have proved to be acidic deteriorative agents to old paper and have caused symptoms of weakness, whose effects appear as loss in mechanical strength especially those expressed by fold endurance tests (Edking, 1906).

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* & ** Faculty of Archaeology - Cairo university conservation Department .

The strengthening of weakened paper by alkaline treatment conducted in Germany in 1980 by using ammonium hydroxide solution gave encouraging results according to the following data (Koura, 1980) .

Paper composition	Folding endurance test	
	before Treatment	after treatment
100 % Mechanical pulp.	40	70
80% Mech. pulp + 20 sulphate pulp.	50	185
50% Mech. pulp - 50 sulph. pulp .	90	707*
100% sulphate pulp.	170	1200*

The improvement effect of the above alkaline treatment ; by NH_4OH Soln. expressed by folding endurence test reaches its maximum at 5 - 100 % sulphate pulp content (*) .

Later on the same author (Koura) extended his experiments by using other agents for strengthening Weakened newspaper and he obtained the following data (Koura, 1982)

Type of treatment	Folding endurance
Untreated paper	40
Water	47
62.5% H_2SO_4	69
45% Calcium thiocyanate	450
32% Na OH	550 (*)

Koura concluded that treatment with Na OH soln (32%) gives the best results*. This treatment was based on mercerization treatment of cotton fibers (Britt, 1964)

More work was done by koura (1983) by using sodium hydroxide solution for strengthening weakened newspaper and the obtained improvements in the mechanical properties represented mainly by folding endurance tests . But he observed considerable shrinkage of the treated paper , up to 15 % (Koura, 1983)

The aim of the present work is to contrive a new alkaline treatment for strengthening weakened paper to overcome shrinkage defect or minimize it , since the principle of keeping the original dimensions of the treated papers is very important in the field of conservation of old papers of historic value (Hussam , 1989) .

Materials and Methods :

1. *Preparation of the weakened paper samples by acid aging method-using paper samples of two types : news paper and whatman. (the acid used was H_2SO_4) - (Berry et al., 1977)*

-Experiment (A)

It includes using several acid concentrations such as 5, 10,20,30 and 40 % and fixed time of dip (one minute).

-Experiment (B)

It includes using fixed acid concentrations (40 %) and variable time of dips such as 0.5 , 1 , 2, 3, 4 and 8 hours .

After acid treatment in both experiments paper samples were washed in running tap water , until it become free of acid (Promocresol acid indicator was used for that reason).

The acid free paper samples were dried under press to be tested for folding endurance and brightness percentage .

2. Strengthening of the previously prepared weakened paper by treatment with KOH. Solution .

* KOH solution prepared in the concentrations 10, 20 , 30 , 50 and 60 %

* Time of dip is fixed to one minute at 40 - 45 ^{o}C .

* After treatment, paper samples are washed in running water , then dried under pressure between absorpent blotting papers. Finally these samples were tested for folding endurance*, tearing resistance** , percentage of brightness*** and changes in thier dimensions.

Results

1. Mechanical and physical tests to evaluate acid aged paper samples.

A. Acid aging includes changes in acid concentration and fixed time dips:

Acid Concentrations (%)	Time (D) 0	5	10	20	30	40
News paper :						
- Folding endurance	351	0	5	95	60	19
- Tearing resistance	67	41.6	45.5	50	33.6	32.2
- Brightness Percentage	69	67.5	67	48	52	50
Whatman paper****:						
- Folding endurance	24	1	0	6	20	22
- Tear resistance	96	42	42	82	80	76
- Brightness Percentage	85	75	61.5	62	62	62.5

* Folding endurance tester K.A. 63.114
** Tearing resistance elmendrof tester 505
*** Brightness tester Eset . G.
Central laboratory for standardization .. Ministry of Industry .. Cairo/ Egypt.
**** Standard whatman filter paper sheets qualitative (1) {Whatman limited . England }

Table (2)

B. Acid aging includes fixed acid concentration and variable time of dipping :

Acid Concentrations (%)	0	1/2	1	2	3	4	8
News paper :							
- Folding endurance	351	19	41	6.5	3	3	0
- Tearing resistance	67	32	25	24	20	30.8	22
- Brightness Percentage	69	51	51	50.5	48	47	40
Whatmann paper:							
- Folding endurance	24	22	17.5	13	10	8	0
- Tearing resistance	96	76	76	48	42	42	38.5
- Brightness Percentage	85	62.5	61.5	60	57	55	55

II. Mechanical and physical tests to evaluate strengthening of the weakened paper samples by KOH solution.

Fig. No. (1) : Folding Endurance :

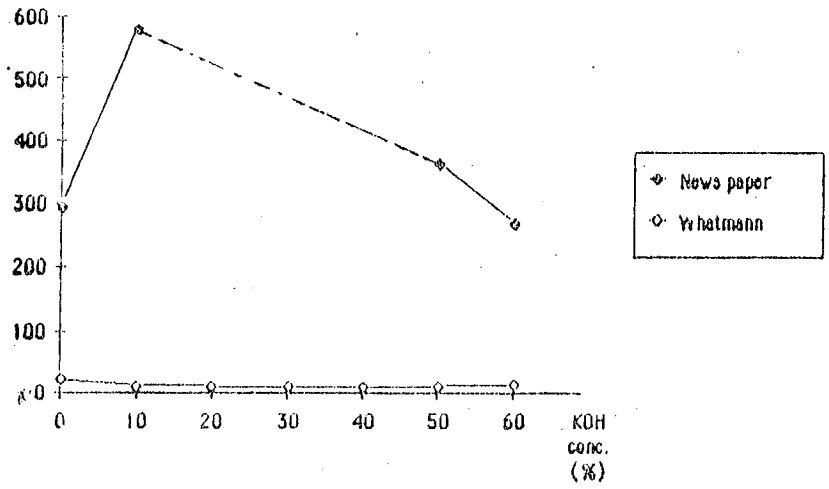


Fig. No. (2) : Tearing resistance:

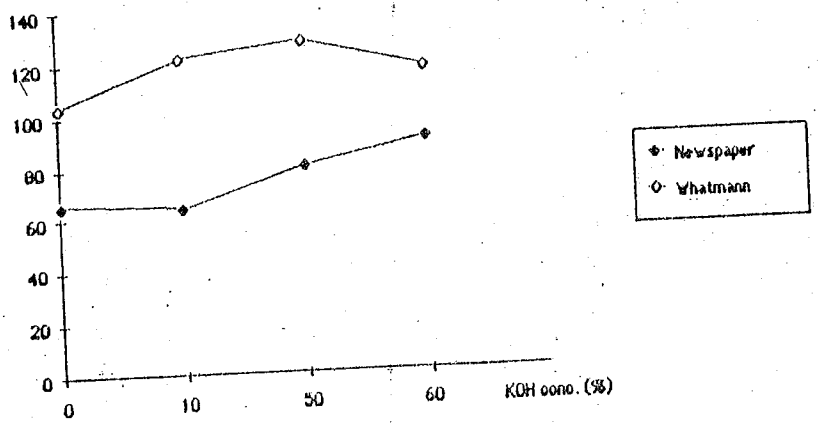


Fig.NO. 3 Brightness%

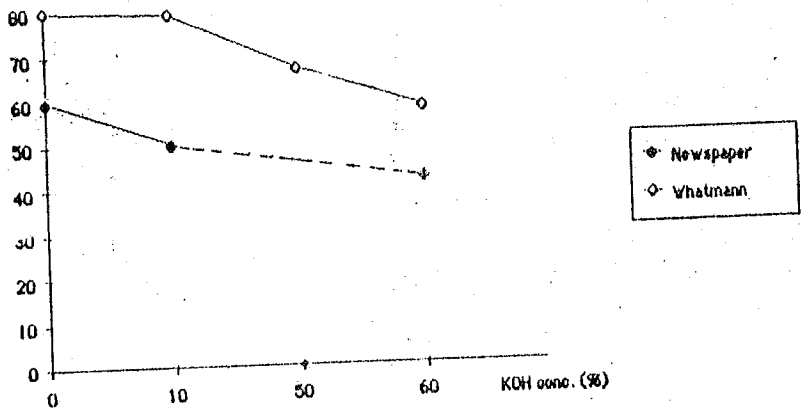
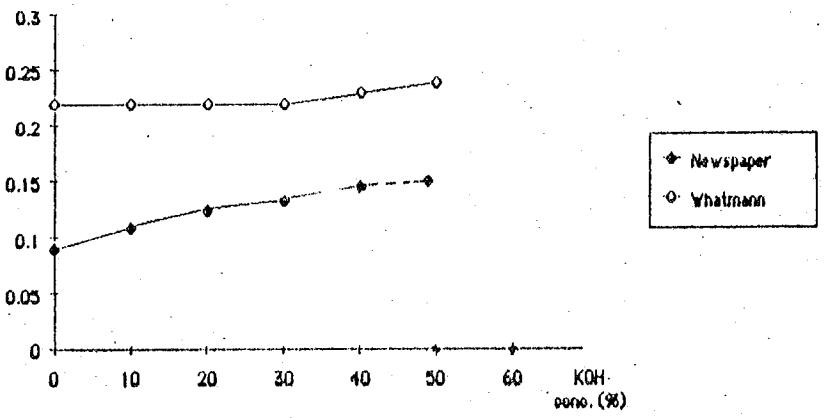


Fig.NO.4 Thickness/mm.



III. Dimension measurement of paper samples after KOH treatment.

KOH - Soln. Conc.	Dimension in C.C. Before Treatment	After Treatment	Shrinkage (%)
10%	10x10	10x10	0% (no shrinkage)
50 : 60 %	10 x 10	9.5 x 9.5	5%

IV. PH - value measurement of treated paper with KOH Solution.

(PH = 7.5)

Discussion

Weakness of paper means lack of flexibility , this character can be measured mainly by folding endurence tests - see Table (1 & 2) . Newspaper the most suitable paper to be weakened by acid aging .

Attaining a state of maximum weakness is favourable to testify strengthening methods . By acid aging ,the possible minimum weakness

value to be attained in the present work expressed by folding endurance test is a value of 3 in conditions of acid concentration 40 % and a time dip of 3 hours. At lesser values the paper would not tolerate experimental handling.

During acid aging the preliminary increase in values of folding endurance test (in table 1 & 2) may be due to a phenomenon known as parchmentization , where the papers attain some toughness by acid treatment, But by Further treatment, this initial toughness will break down due to cellulose degradation by acid by hydrolysis . (Gilmour , 1955) .

Refering to changes in Brightness of acid aged paper, we observed that the newspaper was more changable than whatman (see Table 1 & 2) .

The strengthening effect of the treatment of weakened news paper by KOH soln (10%) gives a maximum value according to folding endurance tests . While whith increased KOH. concentration there is a decrease of the improvement effect due to the effect of alkaline degradation . The improvement is not clear in the case of whatman paper samples Fig. No. (2)

The brightness percentage decreases by alkaline treatment (Fig. No. 3) , while Fig. No. 2. represents changes in tear resistance . Finally measurement of the paper samples dimensions after treatment revealed that no changes at 10 % KOH with both whatman and newspaper , while at 50 & 60 % KOH The shrinkage percentage was only 5 % i.e. one third of that obtained by koura (1983). Fig. No. 4. represents changes in thickness after treatment . Results are harmonious with that mensioned about dimensions.

Moreover, the alkaline treatment with KOH does not need neutralization step as in the case of the Koura method, since in the present work just simple cureful washing in running water in enough to make the paper neutral.

The present treatment can be useful in it's application to old weakened paper containing mechanical wood pulp or chemical pulp , with special consideration to sensitive inks and pigments which may be present .

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