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RESEARCH ARTICLE

Enhanced optical, chemical and mechanical properties for different cellulosic fibers treated by different concentrations of polymers

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Abstract

Different types of cellulosic fibers were used to prepare paper sheets, soluble starch and polyvinyl alcohol solutions with different concentrations were added to paper sheets on surface on both sides. The sheets before and after adding polymer solutions on surface had been subjected to several tests. Mechanical properties increased in case of paper sheets treated with polyvinyl alcohol or soluble starch comparing with untreated. Generally in all cases of paper sheets made from different pulps, the mechanical properties reached their optimum improvement in presence of 1.5% polyvinyl alcohol solution or soluble starch. Brightness greatly enhanced by addition of polyvinyl alcohol while starch had greatly effect on opacity. It was clear that soluble starch had more efficient in improving mechanical properties in paper sheets. Paper sheets made from wood pulp treated with soluble starch or polyvinyl alcohol gave the best results compared with that prepared from bleached bagasse pulp and that from mixed pulp. Crystallinity index from the ratio A1435cm^{-1}/ A 900 cm^{-1} in infrared spectra indicating that, treated paper sheets contain more hydrogen bonds between the hydroxyl groups in cellulosic chain and polymers, and X-ray diffractometry proved all the above where X-ray data showed that treated paper sheets was accompanied by a significant increase in the fraction of crystalline polymer compared with untreated, and the crystal dimensions apparently increased until all favorable stereochemical adjustment were completed. The morphology of fibers proved that, fibers of the sized paper were tight and smooth. These showed that the sizing emulsion permeated into the paper fibers and interacted with the paper fibers by physical and chemical effects, which strengthened the binding force and bond energy among the fibers, thus enhancing the physical strength of the paper.

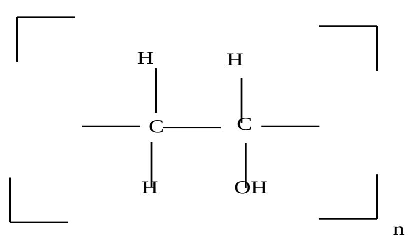
INTRODUCTION

Paper is a thin material mainly used for writing upon, printing upon or for packaging. Sizing is the application of a material, generally an adhesive, to paper to impart certain desirable qualities. Sizing protects the fibers from breakdown due to oxidation. In addition, since other commonly used fillers can inhibit bonding between fibers thereby weakening the sheet, sizing adds adhesive qualities and strength to paper. Methylcellulose and alkyl ketene dimer (AKD) are popular sizes today for hand papermaking. They are stable, inexpensive and easy to obtain and resist vermin. They affect paper in different ways that are subtle or obvious depending on the amounts used.
Internal sizing refers to the addition of this substance to the pulp during manufacture principally in order to decrease wettability. Surface sizing agents are commonly used to provide water-resistance (prevent paper from blurring with water or ink) and printability (offset, inkjet) to paper by surface application (Xuechuan , Xiaoli, Longfang, Taotao, & Sufeng, 2014; Moutinho, Ferreira, & Figueiredo, 2011). These agents are applied to a wide variety of paper / paper board (fine paper, newspaper, ink-jet printing paper, linerboard, and so on). Surface sizing is the application of

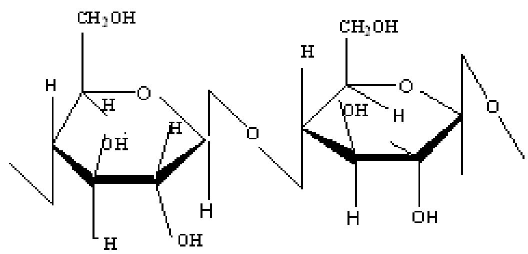
a film-forming material to the surface of the sheet, subsequent to sheet formation. Surface sizing solutions consists of mainly modified starches and sometimes other hydrocolloids, such as gelatine, or surface sizing agents such as alkyl ketene dimer (AKD) or acrylic co-polymers. Surface sizing agents are amphiphilic molecules, having both hydrophilic (water-loving) and hydrophobic (water-repelling) ends. The sizing agent adheres to substrate fibers and forms a film, with the hydrophilic tail facing the fiber and the hydrophobic tail facing outwards, resulting in a smooth finish that tends to be water-repellent. Sizing improves the surface strength, printability, and water resistance of the paper or material to which it is applied. In the sizing solution, optical brightening agents (OBA) may also be added to improve the opacity and whiteness of the paper or material surface.

Starch is the most common adhesive used in the restoration laboratories in Europe till now. Since starch is a good reversible and improved the strength properties such as folding, tensile strength, tear and bursting of the paper due to increase in the hydrogen bonding between the fiber, when added during conservation by pulp suspension (Fairbrass, 1955 and Zappala, 1996). Starch (Magda, Amal, & Samar, 2010) has no degradative effect on paper. The glucose monomers in starch and cellulose (paper fiber) differ only in configuration of their ether linkages and so are well suited as adhesive. Starch contains both amylase (straight chain) and amylopectin (branched chains) molecules and the proportions of these influence the bulk properties of the adhesive. The preparation of starch was at 85-90ºC, so the starch derivatives which soluble in lower temperature may be introduced a modified adhesive starch (zappala, 1996). Polyvinyl alcohol had been used as an ageing resistance agent (Basta, 2004).

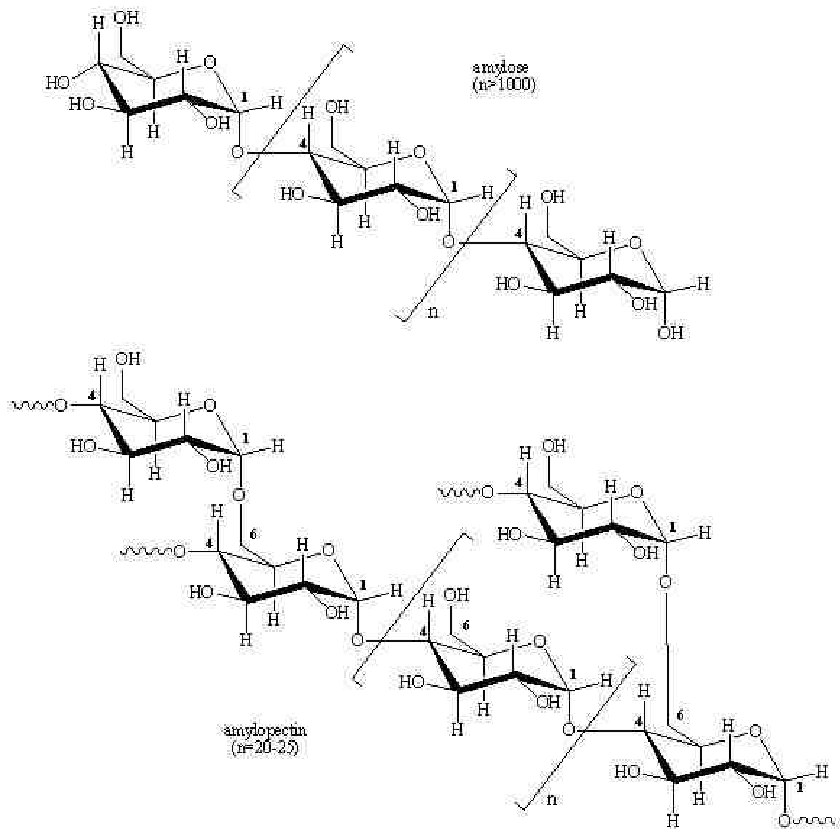
Polyvinyl alcohol, first synthesized in Germany in 1925, was commercially introduced in the United state by the Du Pont company in 1999. Polyvinyl alcohol has an excellent performance as a carrier for fluorescent brightness and provided paper with high brightness in comparison with carboxymethylcellulose, Soya proteins and styrene acrylates (Khalid et al., 2012). Polyvinyl alcohol (PVA) is colorless, flammable, odorless and tasteless, clear, white granular fine particles. It is water soluble, slightly soluble in ethanol, but insoluble in other organic solvents. Generally, its molecular weight is between 26,300 and 30,000 unit and a degree of hydrolysis of 85.5–89% (Ibrahim, Abo-Shosha, Elnagdy, & Gaffar, 2002; Ibrahim, El-salmawi, & Ibrahim, 2005; Sexena, 2004). The ability of this polymer makes it easily accessible for numerous applications, such as paper, wood, leather and textile industries, cosmetics and agribusiness. With respect to biological applications, PVA has been found to be non-immunogenic, i.e., not involving antibody creation, non-mutagenic and non-carcinogenic for human beings. Thus, PVA can be considered as highly efficient polymer for biotechnology (Burkinshaw & Kumar, 2008a, 2008b; Pourciel et al., 2003). Polyvinyl alcohol has been aggressive in various branches of science and technology, such as textile sizing and finishing agent, emulsifier, photosensitive coating, paper adhesives and finishing chemicals for wood and leather. For food packaging application PVA has also been developed as a barrier film (Burkinshaw & Kumar, 2010; Jang & Lee, 2003). The chemical structures of Cellulose, polyvinyl alcohol and starch are given bellow.



Polyvinyl alcohol.



Cellulose



Starch
10-20% amylose (1-4-α-D-glucopyranoside) polymer
and
80-90% amylopectin (1-4, 1-6'-α-D-glucopyranoside)
>100 branched, interconnecting chains of 20-25 glucose units

The aim of this work was investigating flocculation of cellulosic fibers following addition of soluble starch and polyvinyl alcohol So, mechanical and physical properties of paper sheets, infra red spectroscopy, X-ray diffraction and scanning electron microscopy had been studied.

Materials

Bleached bagasse, unbleached mixed (rice straw and 25%bagasse), and wood pulps, were used as a base furnish to prepare papers, supplied by Edfo Paper Mill, Upper Egypt. Polyvinyl alcohol ((provided by Hoechst, degree of hydrolysis mol.% 99.4+0.4, ester number mg KOH/g, 8+5, residual acetyl content% m/m, 0.5+o.4, Ash %, calculated as Na_2O, 0.5) and soluble starch were used as additives.

Paper making

The pulps were chemically analyzed for α-Cellulose, pentosans, lignin, and ash, according to standard methods (Basta, 2004).

The pulps were beaten in a Jokro beater at 6% consistency until they reached 45°SR. After paper sheet formation, the papers were conditioned for 24 hr., at 50% RH and 20°C (Basta, 2004). Soluble starch and polyvinyl alcohol solutions with different concentrations were added to paper sheets on surface on both sides using roll- spreading bars (or rolls) rotating at high speeds and lightly touching the paper were used. The papers sheets pressed like in the paper formation and then dried with the help of a rotating drum (Waleed, 1992; Olfat, Magdi, Maha,& Waleed, 2000). The papers were conditioned for 24 hr., at 50% RH and 20°C. The sheets before and after adding polymer solutions on surface had been subjected to the following tests.

Mechanical properties

Mechanical properties of the paper, namely tensile strength, breaking length and burst strength had been measured ((Samar, 1996; Basta, 2004). For each test, at least five measurements were carried out.

Physical Properties

Physical property of the produced paper sheets namely opacity and brightness had been measured (Nabila, Altaf, Samira,& Samar, 1996). For each test, at least five measurements were carried out.

Chemical analysis of paper sheets

Most of the analytical methods used in this work were carried out according to the German standard (Samar, 1996).

Infrared spectra

The infrared spectra for treated and untreated prepared papers fiber were measured by using Fourier transform infrared spectrometer (FT/IR-6100, Jasco, Japan). All spectra were recorded in the range (4000 – 400 cm^{-1}), the number of scans was 128, and the resolution was 4 cm^{-1} and scan speed 2 mm /s. Infra-red spectra of the papers fiber were obtained in reflection % to analyze the chemical composition.

Scanning electron microscopy

Scanning electron microscopy (SEM) were conducted on JEDL JEM-100 S electron microscope using the gold – Sputtering technique.

X-ray diffractions

Diffraction patterns were obtained using a Brukur D8 Advance X-ray diffractometer (Germany). The diffraction patterns were recorded using copper (Ka) Target with a secondary monochromator at 40 kV and 40 mA. The crystallinity index (CrI) was calculated via: (Gümüskaya, Usta,& Kirci, 2003).

CrI= [(I002-Iam) /I002], where I002 is the intensity of the 002 peak (at about 2ɵ = 26) and Iam is the intensity corresponds to the peak at about 2ɵ = 18.

Results and Discussion

Table (1) shows chemical analysis of different types of pulps.

Mechanical and physical properties of untreated paper sheets made from different types of pulps

Table (2) shows mechanical properties (tensile strength, breaking length, burst strength) and physical properties (opacity and brightness) of untreated paper sheets made from different types of pulps (bleached bagasse, unbleached mixed rice straw and 25% bagasse and wood). From Table (2), it was clear that, paper sheets made from wood pulp gave optimum value in case of mechanical properties (tensile strength, breaking length, burst strength) then that obtained from bleached bagasse pulp then that obtained from unbleached mixed (rice straw and 25% bagasse) pulp, this was attributed to chemical analysis of pulps as shown in Table (1).

Also, from Table (2), it was clear that, paper sheets made from wood pulp gave optimum value in case of brightness properties then that obtained from bleached bagasse pulp then that obtained from unbleached mixed (rice straw and 25% bagasse) pulp, this was attributed to chemical analysis of pulps and lignin percentage. But in case of opacity properties paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp gave optimum value then that obtained from bleached bagasse pulp then that obtained from wood pulp, this was attributed to lignin and ash percentages.

Table (1): Chemical analysis of different types of pulps.

Type of pulp	Lignin %	Pentosan %	Alpha Cellulose %	Ash %
Bleached bagasse	0.9	24.0	67.2	0.8
Unbleached mixed (rice straw and 25% bagasse)	1.9	23.9	72.5	1.6
Wood	traces	9.0	89.5	0.5

Table (2): Mechanical and physical properties of untreated paper sheets.

Type of paper	Mechanical properties			Physical properties	
	Tensile strength, kg	Breaking length, m	Burst strength, kg/ Cm^2	Opacity%	Brightness%
Paper sheets made from bleached bagasse pulp	2.250	2205.88	0.90	90.45	74.4
Paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp	1.700	1666.66	0.58	99.00	42.0
Paper sheets made from Wood pulp	3.500	3431.37	2.60	89.90	75.2

Mechanical and physical properties of treated paper sheets made from bleached bagasse pulp

Table (3) shows mechanical (tensile strength, breaking length and burst strength) and physical properties (opacity and brightness) of treated paper sheets made from bleached bagasse pulp by adding different concentrations of polyvinyl alcohol and soluble starch solutions on surface of paper sheet.

From Table (3), it was clear that addition of 1.5% polyvinyl alcohol solution gave the best results in mechanical properties (tensile strength, breaking length and burst strength). The improvement in the strength properties of paper sheets made from bleached bagasse pulp in presence of polyvinyl alcohol is attributed to the physical adsorption of the polyvinyl alcohol on the surface and between the fibers, forming films around the fibers; these films enhanced binding of the fibers. Therefore, the drying process of the paper sheets bounds the fibers together not only via hydrogen bondings between the fibers, but also through the formation of fiber-polymer-fiber bonds, but further increase in concentration of polyvinyl alcohol solution decreased these properties, this may be related to the high viscosity at higher polymer solution percentages. This prevented the penetration of the polymer through the fibers

(Nabila, Altaf, Samira,& Samar, 1996). Optical properties increased by increasing percentage of polyvinyl alcohol solution; this was related to physical properties of polymer.

Also from Table (3) it was clear that treated paper sheets made from bleached bagasse by addition of 1.5% soluble starch solution on surface of paper sheets gave the best results in strength properties. Optical properties (opacity and brightness) increased by increasing percentage of soluble starch solution.

By comparing the results of polyvinyl alcohol and soluble starch, it was clear that soluble starch gave the best results; this may be related to physical and chemical properties of soluble starch comparing with those of polyvinyl alcohol. The glucose monomers in starch and cellulose (paper fiber) differ only in configuration of their ether linkages and so are well suited as adhesive. Starch contains both amylase (straight chain) and amylopectin (branched chains) molecules and the proportions of these influenced the bulk properties of the adhesive, but polyvinyl alcohol gave the best results in case of brightness properties, this may be attributed to physical properties of polymer.

Table (3): Mechanical and physical properties of treated paper sheets made from bleached bagasse.

Concentration of polymer solution	Mechanical properties			Physical properties	
	Tensile strength, kg	Breaking length, m	Burst strength, kg/ Cm^2	Opacity%	Brightness%
1.0% polyvinyl alcohol	3.7	3627.45	0.95	90.80	74.45
1.5% polyvinyl alcohol	3.9	3823.52	1.20	93.44	74.65
2.0% polyvinyl alcohol	3.4	3333.33	1.05	93.50	74.80
2.5% polyvinyl alcohol	2.5	2450.98	0.75	93.88	75.75
0.5%soluble starch	3.5	3431.37	0.90	93.88	72.90
1.0% soluble starch	3.6	3528.00	1.00	93.90	73.20
1.5% soluble starch	4.1	4019.60	1.40	93.94	74.90
2.0% soluble starch	3.8	3725.48	0.85	93.98	74.90

Mechanical and physical properties of treated paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp

Table (4) shows mechanical (tensile strength, breaking length and burst strength) and physical properties (opacity and brightness) of treated paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp by adding different concentrations of polyvinyl alcohol and soluble starch solutions on surface of paper sheet.

From Table (4), it was clear that mechanical properties (tensile strength, breaking length and burst strength) increased by increasing concentration of polyvinyl alcohol solutions. It was supposed that fixation of the polyvinyl alcohol onto/or within the cellulose structure is accompanied by the formation of semi-inter-penetrated network structure which results in providing high stiffness and pilling resistance (Khalid et al., 2012).

Optical properties increased by increasing concentration of polyvinyl alcohol solution; this was related to physical properties of polymer. Also from Table (4) it was clear that, mechanical properties of treated paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp increased by increasing concentration of soluble starch solution. Optical properties (opacity and brightness) increased by increasing concentration of soluble starch solution. By comparing the results of polyvinyl alcohol and soluble starch, it was clear that soluble starch gave the best results; this may be related to physical and chemical properties of soluble starch comparing with those of polyvinyl alcohol as mentioned above. But polyvinyl alcohol gave the best results in case of brightness properties; this may be attributed to physical properties of polymer.

Table (4): Mechanical and physical properties of treated paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp.

Concentration of polymer solution	Mechanical properties			Physical properties	
	Tensile strength, kg	Breaking length, m	Burst strength, kg/ Cm^2	Opacity %	Brightness%
1.0% polyvinyl alcohol	2.0	19607.84	0.60	99.60	42.50
1.5% polyvinyl alcohol	2.2	2156.86	0.75	99.65	42.64
2.0% polyvinyl alcohol	2.2	2156.86	0.70	99.77	42.80
2.5% polyvinyl alcohol	2.3	2254.90	0.50	99.72	42.90
0.5% soluble starch	2.1	2058.82	0.70	99.61	42.90
1.0% soluble starch	2.2	2156.86	0.70	99.65	43.40
1.5% soluble starch	2.4	2352.94	0.80	99.67	43.60
2.0% soluble starch	2.6	2549.01	0.60	99.70	43.80

Mechanical and physical properties of treated paper sheets made from wood pulp

Table (5) shows mechanical (tensile strength, breaking length and burst strength) and physical properties (opacity and brightness) of treated paper sheets made from wood pulp by adding different concentrations of polyvinyl alcohol and soluble starch solutions on surface of paper sheet. From Table (5), it was clear that addition of 1.5% polyvinyl alcohol gave the best results in mechanical properties (tensile strength, breaking length and burst strength). The improvement in the strength properties of paper sheets made from wood pulp in presence of polyvinyl alcohol was attributed to the same reason mentioned above, but further increase in percentage of polyvinyl alcohol solution decreased these properties, this may be related to the high viscosity at higher polymer percentages. This prevented the penetration of the polymer through the fibers. Optical properties increased by increasing concentration of polyvinyl alcohol solution; this was related to physical properties of polymer as mentioned above. Also from Table (5) it was clear that, treated paper sheets made from wood pulp by addition of 1.5% soluble starch solution on surface gave the best results in strength properties. Opacity properties increased by increasing percentage of soluble starch solution, but a slightly decrease in brightness had been observed by increasing percentage of soluble starch; this is attributed to chemical analysis of wood pulp (Table 1) and physical properties of starch. By comparing the results of polyvinyl alcohol and soluble starch, it was clear that soluble starch gave the best results; this may be related to physical and chemical properties of soluble starch comparing with those of polyvinyl alcohol. But polyvinyl alcohol gave the best results in case of brightness properties; this may be attributed to physical properties of polymer. Tables (3,4,5) investigated that paper sheets made from wood pulp treated with soluble starch gave the best results comparing with that prepared from bleached bagasse pulp and that from mixed pulp.

Table (5): Mechanical and physical properties of treated paper sheets made from wood pulp.

Concentration of polymer solution	Mechanical properties			Physical properties	
	Tensile strength, kg	Breaking length, m	Burst strength, kg/ Cm^2	Opacity%	Brightness %
1.0% polyvinyl alcohol	4.4	4313.72	3.35	90.10	75.70
1.5% polyvinyl alcohol	6.2	6078.43	3.45	90.55	75.75
2.0% polyvinyl alcohol	6.2	6078.43	3.35	90.70	75.80
2.5% polyvinyl alcohol	6.1	5980.39	2.95	90.82	75.80
0.5%soluble starch	6.6	6470.58	2.65	90.18	75.10
1.0% soluble starch	6.9	6764.70	3.30	90.68	75.20
1.5% soluble starch	7.5	7352.94	3.40	90.70	75.30
2.0% soluble starch	6.4	6274.51	3.30	91.00	75.30

Infrared spectra

Table (6) shows the ratio A 1435 cm^{-1}/ A900 cm^{-1} which represents the crystallinity index for paper sheets made from different pulps. Crystallinity index increased in case of paper sheets obtained from bleached, unbleached mixed(rice straw and 25% bagasse) and wood pulps which treated with polyvinyl alcohol or with soluble starch compared with untreated, indicating that treated paper sheets contain more hydrogen bonds between the hydroxyl groups in cellulosic chain and polymers. From Table (6) it was clear that treated paper sheets made from wood pulp gave the best results comparing with that prepared from bleached bagasse pulp and that from mixed pulp.

Table (6): The ratio A1435 cm^{-1}/ A 900 cm^{-1} which represents the crystallinity indexes for the paper sheets made from different pulps

Type of pulp and concentration of polymer solution	crystallinity indexes	Type of pulp and concentration of polymer solution	crystallinity indexes
Untreated paper sheets made from bleached bagasse pulp	0.9350	Untreated paper sheets made from bleached bagasse pulp	0.9350
Paper sheets made from bleached bagasse pulp treated with 1.5% polyvinyl alcohol	0.9670	Paper sheets made from bleached bagasse pulp treated with1.5% soluble starch	0.9715
Untreated paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp	0.5001	Untreated paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp	0.5001
Paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp treated with 1.5% polyvinyl alcohol	0.5902	Paper sheets made from unbleached mixed (rice straw and 25% bagasse) pulp treated with 1.5% soluble starch	0.6230
Untreated paper sheets made from Wood pulp	1.3120	Untreated paper sheets made from Wood pulp	1.312
Paper sheets made from Wood pulp treated with1.5% polyvinyl alcohol	1.7986	Paper sheets made from Wood pulp treated with 1.5% soluble starch	1.9990

Scanning electron microscopy

Photographs of Fig.1(a,b,c) comparing with that in Fig.2(a-f) it was obvious that paper sheets obtained from bleached or unbleached mixed (rice straw and 25% bagasse) or wood pulps treated with polyvinyl alcohol or with soluble starch, presented certain adhesion between the fibers, and had more compact structure than untreated sheets, showing a clearer pulp with no fibrillation or filaments between the fibers, no cracks or voids, thus the crack does not have a straight path because it has to move around the fiber cells and ultimately stops (Samar, Monazah, Zenat,& El-Samahy, 2014).

Figures (1,2) show the morphology of fibers. The fibers of the sized paper were tight and smooth. These showed that the sizing emulsion permeated into the paper fibers and interacted with the paper fibers by physical and chemical effects, which strengthened the binding force and bond energy among the fibers, thus enhancing the physical strength of the paper. From the morphology of the fibers in the surface of the paper, it can be seen that the surface of unsized papers was rather crude and unpolished, whereas the surface of sized papers looks very smooth and glossy in the micrograph (Guo et al., 2013).

Figure (1): Photographs of untreated paper sheets

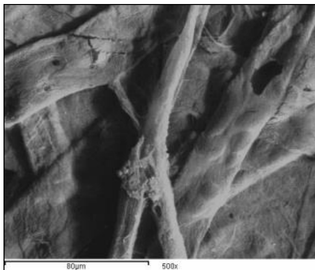
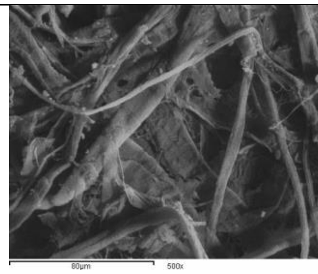
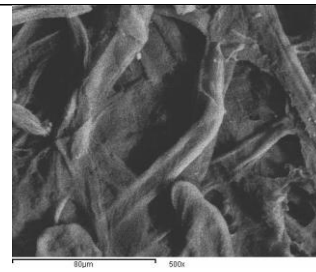
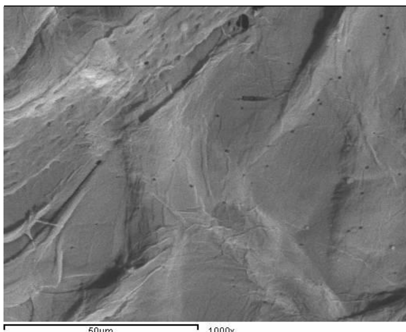
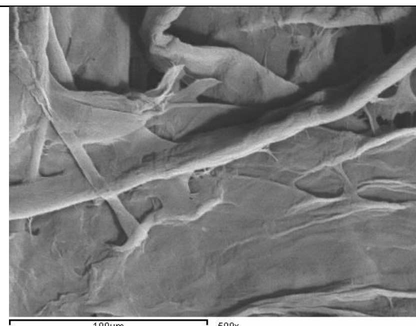
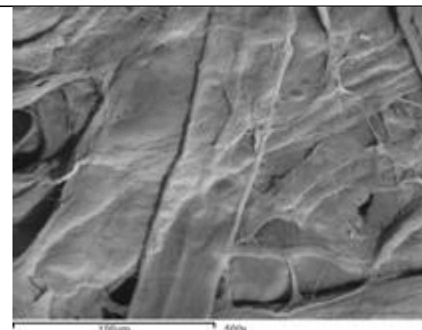
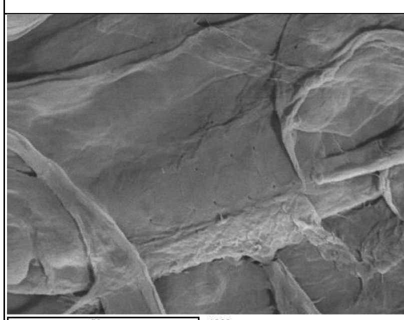
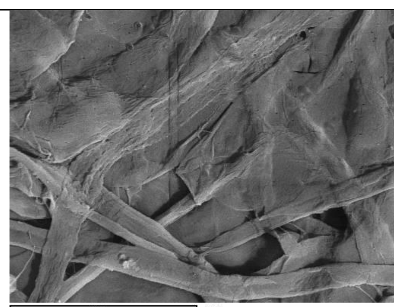
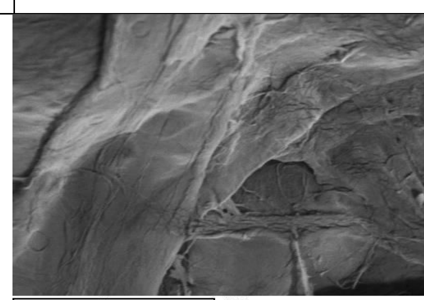
 (a) Paper sheets from bleached bagasse pulp	 (b) Paper sheets from mixed pulp	 (c)Paper sheets from wood pulp

Figure (2): Photographs of treated paper sheets

 (a) Bleached bagasse pulp treated with 1.5% polyvinyl alcohol	 (b) Paper sheets from mixed pulp treated with 1.5% polyvinyl alcohol	 (c) Paper sheets from wood pulp treated with 1.5% polyvinyl alcohol
 (d) Paper sheets from bleached bagasse pulp treated with 1.5% soluble starch	 (e) Paper sheets from mixed pulp treated with 1.5% soluble starch	 (f) Paper sheets from wood pulp treated with 1.5% soluble starch

X-Ray diffraction

In order to analyze the crystallinity of the celluloses obtained in this work, X-ray diffractometry was carried out. X-ray data showed that treated paper sheets was accompanied by a significant increase in the fraction of crystalline polymer compared with untreated, and the crystal dimensions apparently increased until all favorable stereochemical adjustment were completed (Figs.3,4), thus X-ray diffractometry proved the results in infrared spectra. Thus, it was clear that treated paper sheets made from wood pulp gave the best results comparing with that prepared from bleached bagasse pulp and that from mixed pulp, where the value of crystallinity index was (1.7986) for paper sheets made from wood pulp treated with 1.5% polyvinyl alcohol solution and (1.9990) for paper sheets made from wood pulp treated with 1.5% soluble starch solution.

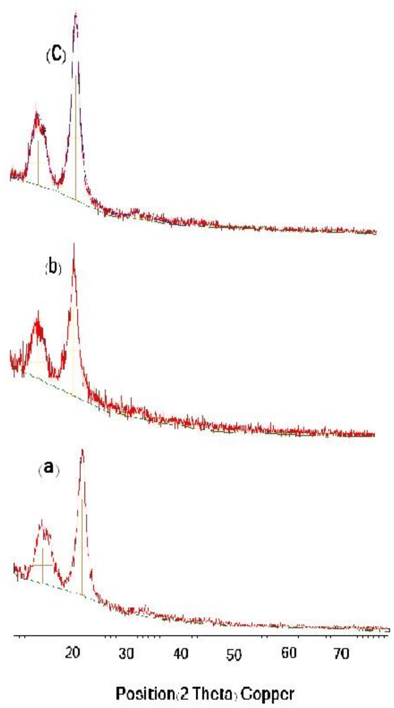


Figure (3): X-Ray diffraction patterns of untreated paper sheets made from

(a) bleached bagasse pulp, (b) mixed pulp, (c) wood pulp.

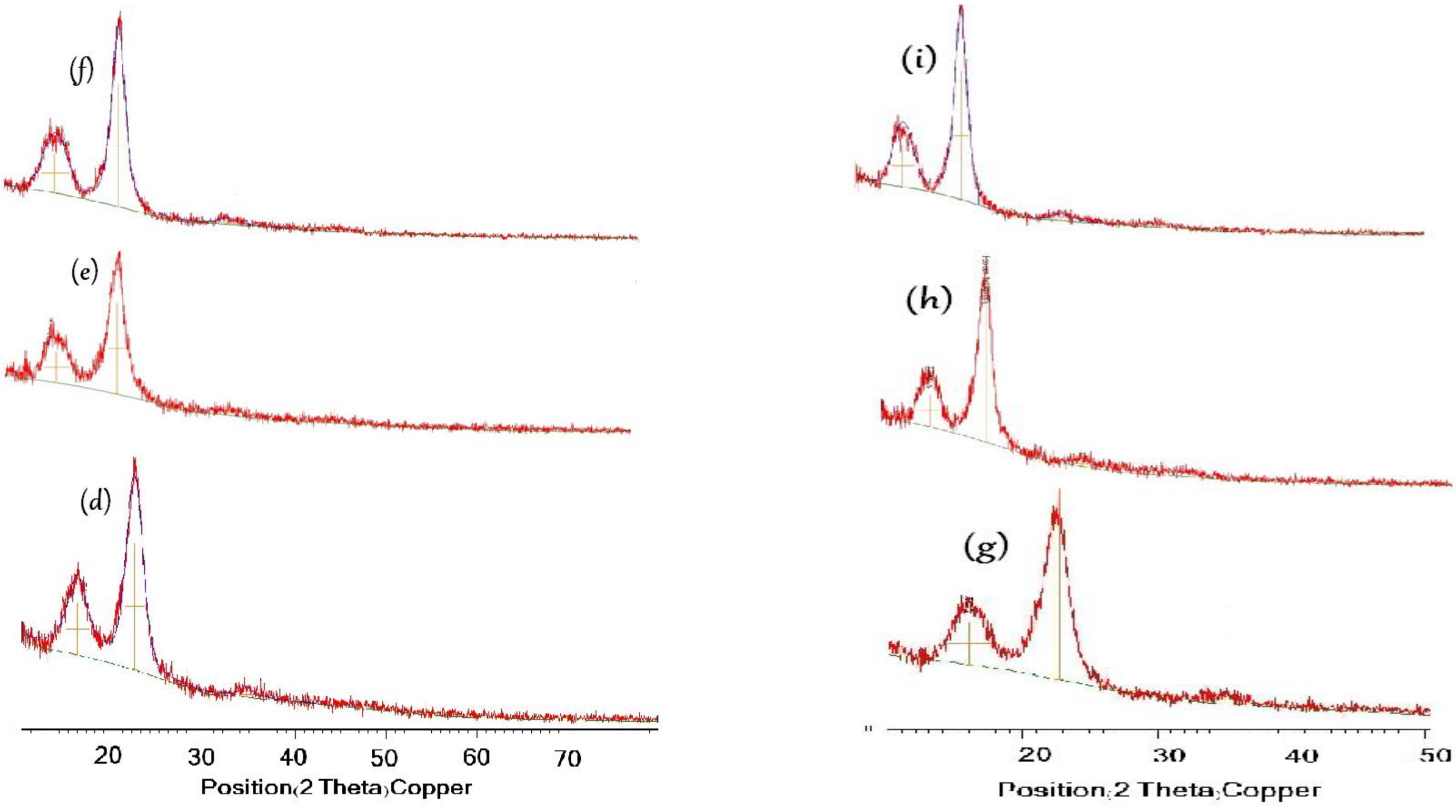


Figure (4): X-Ray diffraction pattern of paper sheets made from (d) bleached bagasse pulp treated with 1.5% polyvinyl alcohol, (e) mixed pulp treated with 1.5% polyvinyl alcohol, (f) wood pulp treated with 1.5% polyvinyl alcohol, (g) bleached bagasse pulp treated with 1.5% soluble starch, (h) mixed pulp treated with 1.5% soluble starch and (i) wood pulp treated with 1.5% soluble starch.

Conclusion

1.Mechanical properties increased in case of paper sheets treated with polyvinyl alcohol or soluble starch comparing with untreated.

2. Paper sheets treated with soluble starch gave the best results in mechanical properties comparing with those treated with polyvinyl alcohol, but polyvinyl alcohol gave the best results in case of brightness properties.

3. Paper sheets made from wood pulp treated with soluble starch gave the best results comparing with that prepared from bleached bagasse pulp and that from mixed pulp.

4. Crystallinity index increased in case of paper sheets obtained from bleached, unbleached mixed (rice straw and 25% bagasse) and wood pulps which treated with polyvinyl alcohol or with soluble starch compared with untreated, indicating that, paper sheets contain more hydrogen bonds between the hydroxyl groups in cellulosic chain and polymers . Paper sheets made from wood pulp treated with soluble starch gave the best results comparing with that prepared from bleached bagasse pulp and that from mixed pulp and treated with polyvinyl alcohol. Also X-ray

diffractometry explained and proved that. X-ray data showed that treated paper sheets was accompanied by a significant increase in the fraction of crystalline polymer compared with untreated, and the crystal dimensions apparently increased until all favorable stereochemical adjustment were completed.

5. The morphology of fibers proved that, where the fibers of the sized paper were tight and smooth. These showed that the sizing emulsion permeated into the paper fibers and interacted with the paper fibers by physical and chemical effects, which strengthened the binding force and bond energy among the fibers, thus enhancing the physical strength of the paper.

References

Basta A.H. (2004) Performance of improved polvinyl alcohol as ageing resistance agent of rosin sized paper and in restoration purpose. Restaurator 25, 129-140.

Burkinshaw S. M. & Kumar, N. (2008a). A polyvinyl alcohol aftertreatment for nylon6,6. Part 2: Complex formation. Dyes and Pigments, 77, 86–91.

Burkinshaw S. M. & Kumar, N. (2008b). Polyvinyl alcohol as an after treatment. Part1: Initial studies. Dyes and Pigments, 77, 81–85.

Burkinshaw S. M. & Kumar, N. (2010). Polyvinyl alcohol as an aftertreatment. Part 3: Direct dyes on cotton. Dyes and Pigments, 8, 124–132.

Fairbrass S. (1996) Sticky problems for conservators of art on paper. J. adhesion and adhesives,15, 115-120.

Gümüskaya, E., Usta, M., Kirci, H., (2003). The effects of various pulping conditions on crystalline structure of cellulose in cotton linters. Polym. Degrad. Stab. 81, 559-564.

Guo Y. H., Guo J. J., Li S. C., Li X., Wang G. S. and HuangZ. (2013). Properties and Paper Sizing Application of Waterborne Polyurethane emulsions synthesized with TDI and IPDI, Colloids and Surfaces A: Physicochem. Eng. Aspects. 427(20), 53-61.

Ibrahim, M. S., El-Salmawi, K. M. & Ibrahim, S. M. (2005). Electron-beam modification of textile fabrics for hydrophilic finishing. Applied Surface Science, 241, 309–320.

Ibrahim, N. A., Abo-Shosha, M. H., Elnagdy, E. I. & Gaffar, M. A. (2002). Eco-friendly durable press finishing of cellulose-containing fabrics. Journal of Applied Polymer Science, 84, 2243.

Jang, J. & Lee, D. K. (2003). Plasticizer effect on the melting and crystallization behavior of polyvinyl alcohol. Polymer, 44, 8139–8146.

Khalid Mahmood Zia, Mohammad Zuber, Ali Rizwan, Tahir Jamil, Shazia Tabasum, Muhammad Shahid (2012) Modification of cellulosic fabric using polyvinyl alcohol—Part-I: Physicochemical properties. Carbohydrate polymers 87 2063– 2067.

Magda G.,Amal H. and Samar H. (2010). Consolidation paper by some binders and evaluating their efficiency. Journal of nature and science, 8,2, 207-217.

Moutinho I. M. T., Ferreira P.J. T. and Figueiredo F. M. L. (2011). Paper Surface Chemistry as a Tool to improve Inkjet Printing quality, BioResources 6 (4), 4259-4270.

Nabila A. El-Shinawy, Altaf H. Basta, Samira F. Yacoub and Samar H. Mohamed (1998). Internal treatment of paper sheets from wood and bagasse pulps with polyvinyl alcohol, Polym.-plast.Technol. Eng.,37(2),141-173.

Olfat Y. Mansour, Magdi Z. Sefain, Maha M. Ibrahim, Waleed K. El-Zawawy, (2000). Paper Coating Miture: Preparation, Application, and Study of Their Rheological Properties. Journal of Applied Polymer Science, Vol. 77, pp.: 1666-1678.

Pourciel, M. L., Launay, J., Sant, W., Conedera, V., Martinez, A. & Boyer, P. T. (2003). Development of photo-polymerisable polyvinyl alcohol for biotechnological applications. Sensors and Actuators, 94, 330–336.

Samar H. Mohamed, M.Sc. (1996). Improving physical and mechanical properties of paper sheets by adding some additives, Benha University.

Samar H. Mohamed, Monazah G. Khafagi, Zenat A. Nagieb and El-Samahy M. A.(2014). Investigation studies of microwave effect on structure of cellulosic fibers. International Journal of Advanced Research,2, 6, 129-138.

Sexena, A. (2004). Closed cycle textile dyeing: Full-scale. Polymer Sciences, 5, 63–76.

Waleed K. El-Zawawy, M. Sc. , (1992). Cellulose Derivatives and their Effects on Coating Composites, Faculty of Science, Cairo University.

Xuechuan W., Xiaoli H., Longfang R., Taotao Q. and Sufeng Z. (2014).. Study of the Preparation , Characterization and Sizing Performance of Modified Collagen-Surface Sizing Agent), BioResources 9(1), 1255-1266.

Zappala M. (1996). Modified starches library and archives conservation effect on paper. International conference conservation and restoration of archival and library materials, 891-906.